Electronic Medical Record in the ICU: Promise and Pitfalls

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Multidisciplinary Epidemiology and Translational Research in Intensive Care and Perioperative Medicine (METRIC - PM)
Disclosure

• Research support from NIH, CMS and Mayo Clinic
• Provisional patent application for critical care related software tools has been submitted by Mayo Clinic
• No financial relationships with any commercial companies and no other relevant disclosures
Learning Objectives

- Review current data of Electronic Medical Records (EMR) implementation
- Outline of challenges in designing informatics supports for the ICU
- Explore novel informatics technologies (dashboards, smart alarms)
- Introduce patient centered electronic environment for the ICU
Target milestones towards “Meaningful Use”

- Electronic capture
- Coded format
- Communication for care coordination
- Track key clinical conditions
- Reports: clinical quality & public health

Stage 1 (2011)

Stage 2 (2013)

Stage 3 (2015)

- Disease management
- Clinical Decision Support
- Medication Management
- Patients’ access to their info
- QI and research
- Communication with public health agencies

Improve performance
Support care process
Key health system outcomes

### US EMR Adoption Model<sup>SM</sup>

<table>
<thead>
<tr>
<th>Stage</th>
<th>Cumulative Capabilities</th>
<th>2013 Q2</th>
<th>2013 Q3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 7</td>
<td>Complete EMR; CCD transactions to share data; Data warehousing; Data continuity with ED, ambulatory, OP</td>
<td>2.1%</td>
<td>2.2%</td>
</tr>
<tr>
<td>Stage 6</td>
<td>Physician documentation (structured templates), full CDSS (variance &amp; compliance), full R-PACS</td>
<td>10.0%</td>
<td>11.1%</td>
</tr>
<tr>
<td>Stage 5</td>
<td>Closed loop medication administration</td>
<td>18.7%</td>
<td>20.9%</td>
</tr>
<tr>
<td>Stage 4</td>
<td>CPOE, Clinical Decision Support (clinical protocols)</td>
<td>14.6%</td>
<td>15.1%</td>
</tr>
<tr>
<td>Stage 3</td>
<td>Nursing/clinical documentation (flow sheets), CDSS (error checking), PACS available outside Radiology</td>
<td>34.5%</td>
<td>31.9%</td>
</tr>
<tr>
<td>Stage 2</td>
<td>Ancillaries - Lab, Rad, Pharmacy - All Installed</td>
<td>9.0%</td>
<td>8.4%</td>
</tr>
<tr>
<td>Stage 0</td>
<td>All Three Ancillaries Not Installed</td>
<td>7.2%</td>
<td>6.9%</td>
</tr>
</tbody>
</table>

Data from HIMSS Analytics<sup>TM</sup> Database © 2013

N = 5,439  N = 5,437
First reported use computers in ICU - 1964

Experience With a Digital Computer for Study and Improved Management of the Critically Ill

Max H. Weil, MD, Herbert Shubin, MD, and Will Rand, MA

University of Southern California Medical School Shock Research Unit at Los Angeles County General Hospital.

- arterial and venous pressure, the electrocardiogram, body and air temperatures, and urinary output.

Plotters and electric typewriters generated graphic and tabular output.

JAMA, Nov 28, 1966 • Vol 198, No 9
1985

Display: 9-inch electroluminescent
Resolution: 512x256 matrix
Weight: 25 pounds
16-bit processor: 12.5 MHz
RAM: 5MB

2013

Display: 9.7-inch LED IPS LCD
Resolution: 2048×1536 16m
Weight: 1.44 pounds
64-bit, dual core: 1 GHz
RAM: 1Gb
Which one is EMR?
Problem: Database centered EMR
Problem: Database centered EMR
Overall satisfaction with EMR: audit in a tertiary care institution

Courtesy Dr Herasevich, unpublished data
Value of this data?

<table>
<thead>
<tr>
<th>LAB AG Continuous</th>
<th>Reference Range</th>
<th>Most Recent</th>
</tr>
</thead>
<tbody>
<tr>
<td>eGFR-Afric...</td>
<td>&gt;60 mL/min</td>
<td>02oct11</td>
</tr>
<tr>
<td>Creatinine...</td>
<td>0.6-1.4 mg/dL</td>
<td>02oct11</td>
</tr>
<tr>
<td>Albumin...</td>
<td>3.5-5.0 g/dL</td>
<td>21jul11</td>
</tr>
<tr>
<td>Bili Urea...</td>
<td>6-21 mg/dL</td>
<td>05oct11</td>
</tr>
<tr>
<td>BUN/Creat...</td>
<td>23</td>
<td>02oct11</td>
</tr>
<tr>
<td>Chloride...</td>
<td>100-108 mmol/L</td>
<td>04aug11</td>
</tr>
<tr>
<td>Chloride...</td>
<td>100-108 mmol/L</td>
<td>05oct11</td>
</tr>
<tr>
<td>Calcium...</td>
<td>10-20 mmol/L</td>
<td>02oct11</td>
</tr>
<tr>
<td>Calcium...</td>
<td>4.45</td>
<td>05oct11</td>
</tr>
<tr>
<td>Calcium...</td>
<td>4.45</td>
<td>05oct11</td>
</tr>
<tr>
<td>Lactate...</td>
<td>0.6-2.3 mmol/L</td>
<td>02oct11</td>
</tr>
<tr>
<td>Lactate...</td>
<td>0.6-2.3 mmol/L</td>
<td>02oct11</td>
</tr>
<tr>
<td>ENZYMES AG...</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amylase...</td>
<td>2-102 Int/mL</td>
<td>20jul11</td>
</tr>
<tr>
<td>Lipase</td>
<td>2-300 Int/mL</td>
<td>20jul11</td>
</tr>
<tr>
<td>ENDOCRIN...</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TSH, Sens.</td>
<td>0.30-5.60 mIU/L</td>
<td>20jul11</td>
</tr>
<tr>
<td>Aldosterone...</td>
<td>0.00-0.01 ng/mL</td>
<td>20jul11</td>
</tr>
<tr>
<td>Cortisol...</td>
<td>18 8</td>
<td>04oct11</td>
</tr>
<tr>
<td>Cortisol.30...</td>
<td>20 8</td>
<td>04oct11</td>
</tr>
<tr>
<td>Cortisol.60...</td>
<td>32 8</td>
<td>04oct11</td>
</tr>
<tr>
<td>Microbiology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Streptococ...</td>
<td>Negative</td>
<td>29sep11</td>
</tr>
<tr>
<td>CARDIOACT...</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Digoxin...</td>
<td>1.5 8</td>
<td>30aug11</td>
</tr>
<tr>
<td>MIS...</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saliylates...</td>
<td>2-20 mg/dL</td>
<td>21jul11</td>
</tr>
<tr>
<td>Vancomycin...</td>
<td>23.4 8</td>
<td>03oct11</td>
</tr>
<tr>
<td>Metals 51 AG...</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

LACK OF INFORMATION
Value of this data?

Non-Selective INFORMATION
Indiscriminate Data Display Impedes Decision Making

Information Overload

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Per Patient</th>
<th>Per 24 bedded ICU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labs</td>
<td>60</td>
<td>1440</td>
</tr>
<tr>
<td>Drug Orders</td>
<td>10</td>
<td>240</td>
</tr>
<tr>
<td>Microbiology</td>
<td>2</td>
<td>48</td>
</tr>
<tr>
<td>X ray</td>
<td>2</td>
<td>48</td>
</tr>
<tr>
<td>Vitals</td>
<td>1950</td>
<td>46800</td>
</tr>
</tbody>
</table>

Pickering and Herasevich – Data generated in first 24 hours of ICU admission – Unpublished
Brain Freeze

How the deluge of information paralyzes our ability to make good decisions

BY SHARON BEGLEY
Not only health care…

In New Military, Data Overload Can Be Deadly

At Langley Air Force Base in Virginia, teams monitor what they have nicknamed "Death TV" — live video from Afghanistan.

By THOM SHANKER and MATT RICHTEL
Published: January 16, 2011
Alert Fatigue

Survey of alarms in an intensive therapy unit*

Only eight out a total 1455 soundings indicated potentially life treating problems

Alert Fatigue: CPOE

The hospital where I work has recently turned to an electronic medical record system—EPIC. Literally every time you enter a medication for a patient, multiple alerts pop up. Most of these are absurd and needless, for instance warning you of exceeding maximum recommended daily doses for medications that have no maximum recommended daily dose, and so on and so on. Over time, the multiple needless repeated warnings very much risk distracting you from any potential meaningful warning buried in their midst.

In other words, the systems are only as good as their programming. And the programming for most of these systems, in my experience, is very much wanting.

— Ed
Alert Fatigue: CPOE

Physicians’ Decisions to Override Computerized Drug Alerts in Primary Care

Saul N. Weingart, MD, PhD; Maria Toth, MD, PhD; Daniel Z. Sands, MD, MPH; Mark D. Aronson, MD; Roger B. Davis, ScD; Russell S. Phillips, MD

Physicians **overrode 91.2% of drug allergy** and **89.4% of high-severity drug interaction alerts.**

Poorly designed electronic systems can kill!
EMR Manufacturers

Experts in……
• Database building
• Building software around databases
• Selling software
• Maintaining software

Profoundly ignorant of ……
• The clinical decision making process
• Ideal workflow
• Their impact on patient centered outcomes

Patient outcomes come first. Clinicians must engage with and direct their engineers…
Need for additional expertise: Clinical Informatics recognized as subspecialty

- In 2012 ABMS recognized Clinical Informatics as clinical subspecialty
Features associated with success of an informatics support

• Local user involvement

• No need for additional (duplicate) data entry

• Provision of decision support at time of decision making

• Provision of a recommendation, not just an assessment

• Integration with charting or order entry system

• Promotion of action rather than inaction

• Justification of decision support via research evidence

• Provision of decision support results to patients
Key Elements for Successful Implementation of Informatics tools

• Simplicity and availability
• No requirement for major changes
• The endorsement by local leaders
• Sense of ownership among staff
• Engagement of bedside clinicians involved in research and QI

Clemmer T J Crit Care 2004
# Need for standards: controlled terminology

<table>
<thead>
<tr>
<th>Code</th>
<th>Area</th>
<th>Maintainer</th>
</tr>
</thead>
<tbody>
<tr>
<td>National Drug Codes (NDC)</td>
<td>Product identifiers for <strong>human drugs</strong>.</td>
<td>National Council for Prescription Drug Programs (NCPDP)</td>
</tr>
<tr>
<td>Systematized Nomenclature of Medicine--Clinical Terms (SNOMED CT)</td>
<td><strong>Comprehensive</strong> multilingual clinical <strong>terminology</strong></td>
<td>International Health Terminology Standards Development Organisation (IHTSDO)</td>
</tr>
<tr>
<td>Logical Observation Identifiers Names and Codes (LOINC)</td>
<td>Codes for identifying <strong>laboratory</strong> and clinical <strong>test</strong> results</td>
<td>Regenstrief Institute, Inc.</td>
</tr>
<tr>
<td>RxNorm</td>
<td>Recommended national standard for <strong>medication</strong> vocabulary</td>
<td>National Library of Medicine (NLM)</td>
</tr>
<tr>
<td>The Unified Medical Language System (UMLS)</td>
<td><strong>Integrates</strong> and distributes key <strong>terminology</strong>, classification and coding standards</td>
<td>National Library of Medicine (NLM)</td>
</tr>
</tbody>
</table>
Determinants of Safe Health Care Delivery: Cognitive Ergonomics

Pickering B et al. Applied Clinical Informatics 2010
Need for Ambient Intelligence

The hospital of the future: building intelligent environments to facilitate safe and effective acute care delivery

Brian W Pickering¹ ², John M Litell² ⁴, Vitaly Herasevich¹ ² and Ognjen Gajic² ³
Definition of Ambient Intelligence

• Ambient intelligence (AmI) and smart environments (SmE)

“Environment that proactively, but sensibly, assists people in their daily lives”
ICU Data Mart: A Non-IT Approach

A TEAM OF CLINICIANS, RESEARCHERS AND INFORMATICS PERSONNEL AT THE MAYO CLINIC HAVE TAKEN A HOME-GROWN APPROACH TO BUILDING AN ICU DATA MART BY VITALY HERASEVICH, DARYL J. KOR, MAN LI, AND BRIAN W. PICKERING
Methodology for developing and testing of clinical ambient intelligence

1. Field observation
2. Surveys & interviews
3. Workflow & workshops
4. Simulated tests
Clinician’s vision of a patient centered information system
Novel Representation of Clinical Information in the ICU

Developing User Interfaces which Reduce Information Overload

B.W. Pickering\textsuperscript{1,2}; V. Herasevich\textsuperscript{3,2}; A. Ahmed\textsuperscript{2}; O. Gajic\textsuperscript{2,2}

Control

Experimental

Data Cloud

Extract High Value Data

BOTH PATIENT KNOWLEDGE AND MEDICAL KNOWLEDGE

Information Packages Constructed

Holistic Picture Emerges
### Ambient Warning and Response Evaluation (AWARE)

**A) Organ Identifier and status**
- **HR**: 103
- **MAP**: 74
- **CVP**: 5
- **Fluids in [7 hours]**: 29
- **Active Meds**: asprin, metredoprol

**B) Historical Contextual Data**
- **UOP [5 hours]**: 224
- **UOP [24 hours]**: 1188
- **Fluid Balance [in...]**: -343
- **Admission Weight**: 117
- **Creatinine**: 3.3
- **Procedures/Notes**: Progress, Consult

**C) Current Organ Physiological Status**
- **SPO2**: 92%
- **PP Ratio**: 1.82
- **PCO2**: 33
- **ECG**: Blood Loss [4 h...]
- **Int Dext1**: West R
- **Int Dext2**: Fluid L
- **Int Dext4**: Int Juq R
- **Sedentil Scan**: N/A

**D) Status of relevant investigation**
- **Procedures/Notes**: Consult (2007)
- **Procedures/Notes**: PFT (2010)

**E) Provider Actions/support**
- **BPO**: 18
- **Active Meds**: Proin, Clofibrate, Heparin, Clorazepate, Dolasetron, Onapristone, Masera, Budesonide, Prodessional, Prabidil, Prohegan, Pradaxa, Pradaxa, Pradaxa, Pradaxa
- **Notes**: Hospital Admission Note, Emergency Medicine Visit

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MAYO CLINIC
Situation awareness: geographically organized multipatient viewer
Smart Alarms: Notification only if the clinician’s response does not match patient needs

Herasevich et al. Crit Care Med 2011
Testing Ambient Intelligence: Safe Environment

Pickering B et al. Applied Clinical Informatics 2010
Reduced cognitive load and errors

Improved Efficiency

Ahmed A et al Crit Care Med 2011
MAYO CLINIC

Project Title: “Patient-centric electronic environment for improving acute care performance”
Geographic Reach: Minnesota, Massachusetts, New York and Oklahoma
Funding Amount: $16,035,264
Estimated 3-Year Savings: $81,345,987
Cloud AWARE
AWARE Study Sites

Mayo Clinic, Rochester, MN
Montefiore Med. Center, Bronx, NY
Lawrence General Hospital, Lawrence, MA
University hospital, Oklahoma
Paradigm shift in EMR development

- Database centered
- Provider centered
- Patient centered
A future generation of EMR

EMR needs to exploit the advantages offered by the digitalization of the ICU environment and at the same time reduce unintended consequences.

Key functionalities will include:

1. an ability to detect the clinical context in which they are operating;

2. reduce information overload by configuring the user interface to preferentially display subsets of task specific data to bedside providers at the point of care;
A future generation of EMR

3. provide TRUE decision support;

4. provide systems surveillance of health care delivery and real time feedback on performance with reference to established standards of care;

5. be seamlessly integrated into the environment and workflow in a manner which exploits our understanding of distributed cognitive function and “choice architecture” to optimize patient-centered outcomes;

Courtesy Dr Herasevich
A future generation of EMR

6. secondary data use in the development of sophisticated models of critical illness syndromes which will form the basis of comparative effectiveness research and “in silico” clinical trials;

7. support cost effective administrative decision making through the automated measurements and analysis of processes of care essential to quality improvement initiatives;

8. support the identification and recognition of patients with potential or established critical illness outside critical care areas for the purpose of timely intervention and enrollment in clinical research trials.
WHAT WOULD HELP MRS. JOHNSON TO BREATHE EASIER?
LESS CIGARETTES?
LUNG LAVAGE?
INHALERS?

EYE CONTACT WOULD BE A GOOD START!
Multidisciplinary Epidemiology and Translational Research in Intensive Care

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gajic.ognjen@mayo.edu