Electronic Health Records - What Data Can be Automatically Collected from Laboratory Instruments and Bedside Monitors?

Reed Gardner
Electronic Health Records (EHR)

What Data can be
Automatically Collected from
Laboratory Instruments and
Bedside Monitors?

Reed M. Gardner PhD
Emeritus Professor & Former Chair
Department of Medical Informatics
University of Utah & LDS Hospital

Reed.Gardner@hsc.utah.edu

Monday 17 April 2006 – University of New Mexico – Health Sciences Library & Informatics Center
This ICU Bedside Scene illustrates the complexity of clinical data acquisition

1. Bedside Monitor with ECG rate and rhythm data, pulse oximeter and direct blood pressure measures.
2. IV Pumps with physiologically active medications and changing drip rates.
3. Ventilators with 2 PC screen displays requiring 50 to 80 keystrokes to enter data for each change in “ventilator settings”.

It is silly to have nurses or therapists read data from a computer screen and manually enter data into an Electronic Health Record (EHR) – Errors & Delays.
The ultimate quality of the Electronic Health Record (EHR) depends on the quality of data acquired during clinician-patient encounters. There is a “golden moment” for capturing accurate, structured information – when the clinicians enter the data into the EHR. This moment never comes back and EHR systems must make it as easy as possible for clinicians to record high quality information.

Medical Information Bus – What is it?

In the early 1980’s professionals from leading medical institutions with strong Medical Informatics programs came together with industrial experts to work on the requirements for acute care data communications. Results of the effort was the development of IEEE 1073 – Medical Information Bus.

Medical Information Bus – Designed to Solve Data Acquisition Problems

“…Absence of interface standards for bedside devices precluded the connection of most bedside devices to patient monitoring computer systems and alarm networks.”

During a Quality Improvement Study at LDS Hospital, we found that there were Medication Errors occurring which should have been prevented by the HELP System. On closer analysis, we found that only 59% of the Medications given were charted in “real-time” – within 1 minute of when they were given. As a consequence the features built into the HELP system to prevent these errors became “non-functional.”

Medication Errors
Prevented by “real-time” Bedside Charting

1. Early dose
2. Late dose
3. Missed dose
4. Wrong medication
5. Med given after discontinued
6. Wrong route
7. Wrong patient

Technology Today – Compared to MIB
IEEE 1073 of the late 1990’s

We have the Universal Serial Bus (USB) which makes it easy to interface data acquisition devices, printers, Flash Drives…quickly and easily to computers.

Also Bluetooth Wireless Interfaces.

However, IEEE 1073 patient ID and data transmission standards are needed to acquire the data.
**Point-of-Care Technology Recommendations**

1. Learn from the MIB experience.
2. Automate data acquisition.
3. Integrate data from Point-of-Care to optimize accurate and timely patient data acquisition.
4. Integrate the Point-of-Care Technologies data into an Electronic Health Record (EHR).
5. Optimize Computerized Decision Support to provide optimal patient care, be it in the ICU, clinic or in the patient’s home.
PHYSIOLOGICAL SIGNALS

TRANSDUCER
POWER SOURCE
AMPLIFIER & SIGNAL CONDITIONING
ANALOG TO DIGITAL CONVERTER

DISPLAY

PHYSIOLOGICAL SIGNAL FEATURE EXTRACTION

MICROPROCESSOR

To ICU Computer System
Current “Manual” Method

1. Heart Rate = 180 beats per min
2. How do you select the rate from 10,800 beats/hr or 21,600 beats for 2hrs?
3. How do you decide?
4. Would you do it differently if it were:
   - An Adult?
   - A Child?
   - A Newborn?
SIGNIFICANT DECREASE IN SpO2

% SpO2 Decrease

Duration (Minutes)

(10 RN, 5 RT, 5 MD)
Monitor 13%
Laboratory 33%
Drugs I/O IV 22%
Blood Gas 9%
Observation 21%
Other 2%
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9/30/1999 12:41pm
Patient A: Corrected Tidal Volume
MIB vs. Automated and Manual Charting
(Filter: Moving Median, Tcrit*: 1 min.)

ml.

0  200  400  600  800  1000  1200

HR

0  4  8  12  16  20  24

MIB
AUTOMATED
MANUAL
Patient A: Corrected Tidal Volume
MIB vs. Automated and Manual Charting
(Filter: Moving Median, Tcrit*: 3 min.)
An Example of an Oximetry Recording System

% Saturation

15-minute Median

5-minute Median (Event Detection)

Time (HH:MM)
IV Pump Drip Rate Assessment
Comparison of Computerized “Manual Charting” with MIB Data Collection

Site – Cottonwood Hospital Medical ICU

Time & Duration – Spring 2002 - 2 Months

Analysis – Nathan Hulse – MI Student

Data Collection – Kyle Johnson & Reed
Autonomic Drugs: Charting Lag

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<th>Bin</th>
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Minutes (n = 285)
**Autonomic Drugs: Charting Accuracy**

**Bin** | **Frequency** | **Cumulative %**
---|---|---
0 | 21 | 9.50%
30 | 178 | 90.05%
60 | 16 | 97.29%
90 | 5 | 99.55%
120 | 1 | 100.00%
150 | 0 | 100.00%
180 | 0 | 100.00%
210 | 0 | 100.00%
240 | 0 | 100.00%
More | 0 | 100.00%

Drugs included: Dopamine, Isoproterenol, Norepinephrine, Vecuronium
Fusing Multiple Monitor Signals to Reduce Excessive Alarms in the Intensive Care Unit

2004

Kasey B. Poon, M.D.

MS Project in Medical Informatics
Problems

Excessive Alarms
Multiple, Redundant Monitor Signals

The Studies
– Raison et al.

• “The occurrence of false alarms from automated patient monitor systems is a common clinical problem.”

• 1968
Problems (cont’d.)

Studies (cont’d.)

• “. . . the level of monitoring in ICUs generates a great number of false-positive alarms.”
• 5.9% of all alarms resulted in call to a physician
• PPV=27%
Studies (cont’d.)


- 86% false-positive alarms
- 6% clinically irrelevant true alarms
- 8% clinically relevant true alarms
Problems (cont’d.)

Studies (cont’d.)

– Deactivating Alarms

  • Too many false alarms
  • Confusion
  • Peace and quiet
  • Unpleasant alarm tone
A Solution?


- “Combined” signal: ECG + arterial pressure
- Reduction of false alarms
Solution (cont’d.)
- RSF: Robust Sensor Fusion
- Fused HR as good or better
- Redundancy can improve HR estimation
- Reduced incidence of false alarms
Kasey Poon’s Study

Collaboration with GE/Marquette
Fusion vs. Standard Algorithms
Data Collection

LDS Hospital
GE/Marquette Solar 8000 Models
QI/Patient Care Improvement Project
April – September, 2001
ECG
Heart Rate: 79 [50..150]
Arrhythmia LETHAL
ST Analysis OFF

ART
Mean: 60 [50..140]
Systolic: 92 [50..200]
Diastolic: 44 [20..120]
PPR: 81 [50..150]

CVP
Mean: 18 [-99..360]

SpO2
Signal Strength: ***
Saturation: 95 [89..105]
PPR: 82 [50..150]

RESP
Respiration Rate: -32768 [5..50]
Lead II fail
Resp Lead II Fall

4: wf_id = 27, chan_id = 13: ART
5: wf_id = 26, chan_id = 16: CVP
6: wf_id = 39, chan_id = 23: SaO2
7: wf_id = 23, chan_id = 25: Resp
**Data**

109 ICU Patients from LDS Hospital

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Data (cont’d.)

1902.25 Patient-hours
Continuous Physiologic Waveform Recording
Two-second Sampling Frequency for Data Analysis
–3,424,050 Data Points
Data (cont’d.)

ECG
– Heart rate
– Heart rhythm

Intra-arterial Catheter
– Heart rate
– Blood pressure

Pulse Oximeter
– Heart rate
– Blood oxygenation
Data (cont’d.)

Alarm Recordings
  – Start and end time
    • alarm duration
    • resolution $\rightarrow \frac{1}{4}$-second
  – Type
Data (cont’d.)

Alarm Types
– Ventricular tachycardia (VT)
– Ventricular fibrillation (VF)
– Asystole
– Low heart rate (LHR)
– High heart rate (HHR)

Physician Confirmation
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Kasey’s Conclusions
Fusion Algorithm Superior to Standard
– More true positive alarms
– Fewer false positives
– Higher positive predictive value
– Greater sensitivity
– Greater specificity
STILL NOT PERFECT – Reed Note!!!
So what are the advantages of Computerized Data Collection?

1. More complete documentation.
2. Data recorded in digital format.
3. Computerized decision support.
4. Data repository for research use.
4700XXX PUBLIC, JOHN Q. E799 58yr M Dx: CAD
Max 24hr WBC= 9.4 ↓ (14.3) Admit: 07/15/03.01:30 Max 24hr Temp=38.1 ↓ (38.2)
RENAL FUNCTION: Impaired, CrCl = 35, Max 24hr Cr= 1.7 ↑ ( 1.6) IBWeight: 70kg
ANTIBIOTIC ALLERGIES: Penicillins,
CURRENT ANTIBIOTICS:
1. 07/30/03 13days FLUCONAZOLE IN NS (DIFLUCAN), IVPB 200. Q 24 hrs
2. 08/02/03 13days IMIPENEM/CILASTATIN (PRIMAXIN), VIAL 500. Q 12 hrs
3. 08/08/03 4days LEVOFLOXACIN/D5W(LEVAQUIN), PIGGYBACK 250. Q 24 hrs
IDENTIFIED PATHOGENS SITE COLLECTED
p Enteric bacilli Sputum 08/07/03.11:13
ANTIBIOTIC SUGGESTION DOSAGE ROUTE INTERVAL
Imipenem 500mg IV *q12h (infuse over 1hr)
Suggested Antibiotic Duration: 10 days
* Adjusted based on patient’s renal function.
=p= Susceptibilities based on antibiogram or same pathogen w/ susceptibilities.
NOTE: Cephalosporins, imipenem and penicillins can cross react if allergy includes urticaria or bronchial spasms or laryngeal spasms. Alternate choice:
Levofloxacin *250mg IV q24h (500mg initial dose)
<1>Micro, <2>OrganismSuscept, <3>Drug Info, <4>ExplainLogic, <5>Empiric Abx, 
<6>Abx Hx, <7>ID Rnds, <8>Lab/Abx Levels, <9>Xray, <10>Data Input Screen, 
<Esc>EXIT, <F1>Help, <0>UserInput, <.>OutpatientModels, <+orF12>ChangePatient, 
ORDER:<*>Suggested Abx, <Enter>Other Abx, </>D/C Abx, <->Modify Abx,
Conclusions

1. There are still unlimited opportunities for improvement and automation of data medical data collection.
2. Nurses, Pharmacists, Physicians and other care givers must all work together to gather the needed data.
3. A change in “culture” must occur for us to develop the best methods.
4. Teamwork of care providers is the best way to make progress.