Cybermedicine

Warner V. Slack, M.D.

Center for Clinical Computing,
Harvard Medical School, and
Beth Israel Deaconess Medical Center
Seven Principles of Clinical Computing

- Information should be captured directly at computer terminals located at the point of each transaction, not on pieces of paper.
Seven Principles of Clinical Computing

- Information captured at a terminal or automated device anywhere in the hospital or clinic should be available immediately, if needed, at any other terminal.
Seven Principles of Clinical Computing

The response time of the computer should be rapid.
Seven Principles of Clinical Computing

- The computer should be reliable and accurate.
Seven Principles of Clinical Computing

- The computer programs should be friendly to the user and reinforce the user’s behavior.
There should be a common registry for all patients.
Seven Principles of Clinical Computing

Confidentiality should be protected.
Clinical Computing

- Registration
- Laboratories
- Clinical Departments
- Finance
- Clinical use
Clinical Use

- Provides clinical information upon request
- Gives support with decisions
- Assists with communication
- Assists with clinical practice
- Assists with education
Clinical Use

- Provides clinical information upon request
Patient ID: Poxtun, Monnotte

9999999  Paxton, Minnette 04/21/03 F 97 111-11-1111

(Access Restricted)

Arthur Marguetite Richard M Townsend

OK? Y //
**Current Medications**

<table>
<thead>
<tr>
<th>Medication</th>
<th>Dose</th>
<th>Route</th>
<th>Schedule</th>
<th>Start (End)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>IV’s and injectibles</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cefazolin</td>
<td>2 GM</td>
<td>IV PIGGY</td>
<td>QBH</td>
<td>08/16</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>PO and Non-injectibles</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acyclovir</td>
<td>200 MG</td>
<td>PO CAP</td>
<td>SX/D</td>
<td>08/13</td>
</tr>
<tr>
<td>Clotrimazole</td>
<td>10 MG</td>
<td>PO TAB TC</td>
<td>QID</td>
<td>08/13</td>
</tr>
<tr>
<td>Potassium Chloride</td>
<td>40 MEQ</td>
<td>PO TAB</td>
<td>QD</td>
<td>08/19</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>PRN, Let-call, and Single dose</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acetaminophen</td>
<td>650 MG</td>
<td>PO TAB</td>
<td>FS Q4H”24HR</td>
<td>08/13</td>
</tr>
<tr>
<td>Bisacodyl</td>
<td>10 ML</td>
<td>PR SUPP</td>
<td>FS PRN</td>
<td>08/18</td>
</tr>
<tr>
<td>Glotzer’s Solution</td>
<td>100 ML</td>
<td>IRR IRR</td>
<td>LC</td>
<td>08/13</td>
</tr>
<tr>
<td>Nystatin</td>
<td>6000 UNITS</td>
<td>PO SUSP</td>
<td>LC PRN QID</td>
<td>08/13</td>
</tr>
<tr>
<td>Prochlorperazine</td>
<td>10 MG</td>
<td>PO TAB</td>
<td>PRN Q6H</td>
<td>08/13</td>
</tr>
</tbody>
</table>
Clinical Use

- Gives support with decisions
Clinical Use

- Gives support with decisions
  - Advice and consultation
Clinical Use

- Gives support with decisions
  - Advice and consultation

Acid-Base Evaluation
ELECTROLYTE AND ACID-BASE EVALUATION:

Saturday March 17, 2001 2:37 pm

To enter your own values, enter “_” (underscore)

Patient ID:
Clinical Use

- Gives support with decisions
  - Advice and consultation
    - Acid-Base Evaluation
    - Drug Information
Drug Information

- Hospital Formulary Information
- Infectious Disease - Therapy and Guidelines
- Medications - Descriptions, Interactions, Costs
- Physician Desk Reference - PDR
Clinical Use

- Gives support with decisions
  - Advice and consultation
  - Acid-Base Evaluation
  - Drug Information
  - Clinical Formulas
Clinical Formulas

1. Alveolar-Arterial Oxygen Difference
2. Free Water Deficit or Sodium Deficit
3. Calcium Correction for Hypoalbuminemia
4. Creatinine Clearance
5. Fractional Excretion of Sodium
6. QT Interval Correction
7. Body surface Area and Body Mass Index
8. Hemodynamics
9. Bayes’ Theorem
## Free Water Deficit or Sodium Deficit

### Calculations

<table>
<thead>
<tr>
<th>Component</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free H2O Deficit</td>
<td>$\text{Free H2O Deficit} = \text{TBW} - \text{TBW} \times \text{(Desired Na/Measured Na)}$</td>
</tr>
<tr>
<td>NA Deficit</td>
<td>$\text{NA Deficit} = \text{TBW} \times \text{(Desired Na - Measured Na)}$</td>
</tr>
<tr>
<td>TBW</td>
<td>$\text{TBW} = WGT \times [0.6 \text{ (Male)} \text{ or } 0.5 \text{ (Female)}]$</td>
</tr>
</tbody>
</table>

### Example Values

- **Weight:** 57 kg
- **Male or Female?:** Female
- **Current Serum Na:** 160 mEq/L
- **Desired Na:** 140 mEq/L

### Free H2O Deficit Calculation

$$\text{Free H2O Deficit} = 3.6 \text{ Liters}$$

### Notes:

1. Correct about half of total deficit in first 24 hours
2. Correction rate should be $0.5 \text{ mEq/L/hr}$ ($12 \text{ mEq/day}$)
3. Recompile deficit frequently
4. Add insensible fluid losses to computed values

### Reference

- Look at References?: No
Clinical Use

- Gives support with decisions
  - Advice and consultation
    - Acid-Base Evaluation
    - Drug Information
    - Clinical Formulas
    - HIV ProtoCall
Welcome to ***HIV ProtoCall***

An information guide to research drugs for human immunodeficiency virus infection and associated opportunistic infections.

Press <Enter>
Clinical Use

- Gives support with decisions
  - Advice and consultation
  - Acid-Base Evaluation
  - Drug Information
  - Clinical Formulas
  - HIV ProtoCall
  - Withdrawal of therapy
Withdrawal of Therapy

Life-Sustaining Treatment Guidelines

1. Overview
2. Definitions
3. Treatment Options
4. Documentation

Please choose and option:
Withdrawal of Therapy

Overview

1. Policy Statement
2. DNR vs. CPR not Indicated
3. Withholding/Withdrawing Other Treatment
4. Support and Counseling

Choose option(s), or ‘A’ for All:
Clinical Use

- Gives support with decisions
  - Advice and consultation
  - Bibliographic retrieval (PaperChase)
PaperChase

(MEDLINE now has over nine million references to articles from over forty-three hundred journals)

LOOK FOR:

For HELP, type ? and press <ENTER>
Clinical Use

- Gives support with decisions
  - Advice and consultation
  - Bibliographic retrieval (PaperChase)
  - Searching the clinical database
ClinQuery covers 495,448 admissions from 1984 through 01/31/01.

Please enter the year or range of years (e.g. 85-90) you are going to search.

Year(s): 1999
Look For:  age

1. Admin/Demography  
2. Laboratory Results  
3. Blood Bank  
4. Medications  
5. Surgical Pathology  
6. Radiology  
7. Cardiac Cath  
8. Outpatient  
9. Diagnosis/procedure  
10. DRG

Or enter ? for more information
<table>
<thead>
<tr>
<th>Choice</th>
<th>Values</th>
<th>Admissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1)</td>
<td>&lt;=--- .9</td>
<td>5145</td>
</tr>
<tr>
<td>2)</td>
<td>1.0-9.9</td>
<td>1</td>
</tr>
<tr>
<td>3)</td>
<td>10.0-17.9</td>
<td>91</td>
</tr>
<tr>
<td>4)</td>
<td>18.0-19.9</td>
<td>261</td>
</tr>
<tr>
<td>5)</td>
<td>20.0-29.9</td>
<td>2723</td>
</tr>
<tr>
<td>6)</td>
<td>30.0-39.9</td>
<td>5614</td>
</tr>
<tr>
<td>7)</td>
<td>40.0-49.9</td>
<td>3427</td>
</tr>
<tr>
<td>8)</td>
<td>50.0-59.9</td>
<td>3602</td>
</tr>
<tr>
<td>9)</td>
<td>60.0-64.9</td>
<td>1847</td>
</tr>
<tr>
<td>A)</td>
<td>65.0-69.9</td>
<td>2009</td>
</tr>
<tr>
<td>B)</td>
<td>70.0-79.9</td>
<td>4278</td>
</tr>
<tr>
<td>C)</td>
<td>80.0 --&gt;</td>
<td>3961</td>
</tr>
</tbody>
</table>

Choices:
Clinical Use

- Gives support with decisions
  - Advice and consultation
  - Bibliographic retrieval (PaperChase)
  - Searching the clinical database
  - Alerts and reminders
Clinical Use

Assists with communication
Clinical Use

- Assists with clinical practice
Clinician’s Option:

1. Admissions or Labs by Service, Firm or Team
2. Adverse Drug Reaction Reporting
3. Confidential Counseling for House Staff
4. Cross Coverage Options
5. Incomplete Medical Records
6. Personal Patient Lookup
7. Resident/Medical Student Log
8. View Clinician’s Hospitalized Patients
Clinician’s Options

- Confidential counseling for house staff
House Staff Support and Consultation

From time to time a House Officer or Fellow may have a personal matter that motivates him or her to seek professional counseling.

Psychiatric consultation and referral that is confidential and independent of administrative reporting is readily available.

Please feel free to call or page any of the psychiatrists listed on the next screen.

Your call will remain confidential.
<table>
<thead>
<tr>
<th>Academic Year</th>
<th>Accesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>388</td>
</tr>
<tr>
<td>1996</td>
<td>380</td>
</tr>
<tr>
<td>1997</td>
<td>382</td>
</tr>
<tr>
<td>1998</td>
<td>424</td>
</tr>
<tr>
<td>1999</td>
<td>330</td>
</tr>
<tr>
<td>2000</td>
<td>287</td>
</tr>
</tbody>
</table>
Clinical Use

- Assists with education
Clinical Use

- Assists with education
  - ECG case of the week
1. 12/30/96
First line of description
83 yr old woman with CHF. What is the likely etiology? Clue: axis

2. 12/30/96
First line of description
86 yr old man with slow pulse.

3. 12/30/96
First line of description
29 yr old man with chest pain/dyspnea. Diagnosis still possible despite artifact.
The patient is an elderly woman with a known history of left bundle branch block who presented to the emergency ward with shortness of breath.

Do you wish to view the wave format (approx 30 seconds)? (Y/N) Y///
00/02/93

**Intervals**
- PR
- QRS
- QT/QTc
- P
- QRS
- T

**Axes**
- aVR
- aVL
- aVF

Values:
- PR: 148
- QRS: 116
- QT/QTc: 344/390
- P: 51
- QRS: 26
- T: 73
ANSWER TO THIS QUIZ

DX: Sinus bradycardia, LBBB with primary st-t wave changes

The ECG demonstrates a left bundle branch block morphology with primary biphasic and inverted t waves in leads 2, 3, and F. Uncomplicated bundle branch blocks should have “secondary” t wave changes. That is the stt waves should be opposite in direction to the major vector of the QRS. For example, if this ECG with LBBB was uncomplicated the stt waves in the inferior leads would be upright. This patient has inverted t waves suggesting that a “primary” or ischemic process is evolving in the inferior distribution.

She did in fact rule in for a myocardial infarction with a CK of 700 and 21% MB fraction. This message is that ischemic ECG changes can be read in the presence of a bundle branch block.
Clinical Use

- Assists with education
  - ECG case of the week
  - Universal precautions
Welcome to your training in standard/universal precautions

To quit <tab>  To continue <enter>
Successful Completion

First time 881 (89%)
At a later date 70 (7%)
Preference - Computer vs. Infection Control Personnel

- No Preferences: 7%
- Infection Control: 2%
- Computer: 91%
Percentage of Physicians

Worthwhile
Interesting
Time About Right

89
60
78

Reaction to Computer Interview
Nursing Option

1. Condition Display
2. Dietary Orders
3. Functional Health Pattern Assessment
4. Last Primary Nurse
5. Patient Classification System
6. Pre-operative Telephonic Enter/Edit
Evaluating Cybermedicine
Use of the system by voluntary users
Beth Israel Deaconess Use of Patient Lookup: Inpatients and Outpatients

<table>
<thead>
<tr>
<th>Year</th>
<th>Inpatient Lookups</th>
<th>Outpatient Lookups</th>
</tr>
</thead>
<tbody>
<tr>
<td>1984</td>
<td>4,080</td>
<td>12,688</td>
</tr>
<tr>
<td>1988</td>
<td>13,229</td>
<td>27,707</td>
</tr>
<tr>
<td>1992</td>
<td>21,497</td>
<td>34,614</td>
</tr>
<tr>
<td>1994</td>
<td>27,023</td>
<td>30,264</td>
</tr>
<tr>
<td>1998</td>
<td>35,229</td>
<td>44,383</td>
</tr>
<tr>
<td></td>
<td>Inpatients</td>
<td>Outpatients</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>------------</td>
<td>-------------</td>
</tr>
<tr>
<td>All Labs – Most Recent Results</td>
<td>17,018</td>
<td>10,044</td>
</tr>
<tr>
<td>Demographics</td>
<td>3,277</td>
<td>9,420</td>
</tr>
<tr>
<td>Chemistry</td>
<td>4,310</td>
<td>4,793</td>
</tr>
<tr>
<td>Radiology</td>
<td>2,681</td>
<td>6,028</td>
</tr>
<tr>
<td>Narrative Notes</td>
<td>1,163</td>
<td>3,893</td>
</tr>
<tr>
<td>Cardiology</td>
<td>1,548</td>
<td>2,697</td>
</tr>
<tr>
<td>Pathology</td>
<td>528</td>
<td>3,562</td>
</tr>
<tr>
<td>Microbiology</td>
<td>1,990</td>
<td>1,001</td>
</tr>
<tr>
<td>Hematology</td>
<td>1,014</td>
<td>1,786</td>
</tr>
<tr>
<td>Blood Bank</td>
<td>743</td>
<td>439</td>
</tr>
<tr>
<td>Pharmacy</td>
<td>753</td>
<td>282</td>
</tr>
<tr>
<td>Neurophysiology</td>
<td>96</td>
<td>251</td>
</tr>
<tr>
<td>Pulmonary Function</td>
<td>108</td>
<td>187</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>35,229</strong></td>
<td><strong>44,383</strong></td>
</tr>
</tbody>
</table>
Passwords to the CCC Cybermedicine System at Beth Israel Deaconess

(winter 2000/2001)

<table>
<thead>
<tr>
<th>Category</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Staff Physicians</td>
<td>1,034</td>
</tr>
<tr>
<td>Nurses</td>
<td>1,983</td>
</tr>
<tr>
<td>Clinical Fellows</td>
<td>258</td>
</tr>
<tr>
<td>House Officers</td>
<td>630</td>
</tr>
<tr>
<td>Medical Students</td>
<td>395</td>
</tr>
<tr>
<td>Group</td>
<td>Count</td>
</tr>
<tr>
<td>-----------</td>
<td>-----------</td>
</tr>
<tr>
<td>Students</td>
<td>2,134</td>
</tr>
<tr>
<td>Residents</td>
<td>9,385</td>
</tr>
<tr>
<td>Fellows</td>
<td>1,396</td>
</tr>
<tr>
<td>Staff</td>
<td>2,455</td>
</tr>
<tr>
<td>Nurses</td>
<td>10,980</td>
</tr>
<tr>
<td>Others</td>
<td>3,650</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>30,000</strong></td>
</tr>
</tbody>
</table>
Use of the system by voluntary users
Attitude toward the system
## Effect on Work

<table>
<thead>
<tr>
<th></th>
<th>Accuracy</th>
<th>Speed</th>
<th>Ease</th>
<th>Interest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definitely worse</td>
<td>4</td>
<td>15</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>Probably worse</td>
<td>13</td>
<td>24</td>
<td>13</td>
<td>10</td>
</tr>
<tr>
<td>No difference</td>
<td>88</td>
<td>54</td>
<td>48</td>
<td>147</td>
</tr>
<tr>
<td>Probably better</td>
<td>204</td>
<td>192</td>
<td>182</td>
<td>190</td>
</tr>
<tr>
<td>Definitely better</td>
<td>236</td>
<td>260</td>
<td>294</td>
<td>195</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>545</td>
<td>545</td>
<td>545</td>
<td>545</td>
</tr>
</tbody>
</table>
E-mail Questionnaire Results

- 89% felt e-mail made life easier
- 11% felt e-mail made life harder
- 61% felt e-mail had a humanizing influence
- 13% felt e-mail had a dehumanizing influence
Use of the system by voluntary users
Attitude toward the system
Effect of the system on the quality of medical care
If it can be agreed that doctors for the most part engage in their diagnostic efforts with good reason and good will and with beneficial results for their patients...
Indirect Evidence

...then the computing system that offers them the information they have requested, with more ease, speed, reliability, and accuracy than is otherwise possible, is improving the quality of care.
Direct Evidence

The time to act on important clinical events, such as the need for a vaccination or change in a medication causing adverse side effects is significantly reduced when the physician is reminded or alerted by the computer of the need to act.
Direct Evidence

Bates, Kuperman, Teich, et al:
Physicians at BWH now routinely use the computing system to order laboratory tests and prescribe medications...
Direct Evidence

Bates, Kuperman, Teich, et al:

Errors have been dramatically reduced at BWH with their order entry and alerting system; e.g., serious errors in medications have been reduced by 55 percent.
To Err is Human
(Institute of Medicine Report, fall 1999)
“...as many as 98,000 people die in any given year from medical errors that occur in hospitals.”
Errors in Medicine

The extent of the problem is debatable

but

Most would agree there is a problem
Errors in Medicine

Two approaches to mistakes by doctors:
To expose and criticize
or, far better,
To make it as easy as possible for the doctor to practice good medicine
Errors in Medicine

My argument: We know enough already to reduce substantially important errors in medicine through the good use of cybermedicine.
If the cybermedicine programs provide the results of diagnostic studies immediately upon request, with abnormal and critical values highlighted to avoid their being overlooked;
Errors in Medicine

If the cybermedicine programs offer unsolicited alerts and reminders about clinical events that need attention, either immediately or in the near future;
Errors in Medicine

If the cybermedicine programs offer advice and consultation, when requested, about diagnosis and treatment;
Errors in Medicine

If the cybermedicine programs offer ready access to current, reliable medical literature;
Errors in Medicine

If the cybermedicine programs offer access to information about the diagnosis and treatment of patients from the past (with protection of confidentiality) for comparison with the diagnosis and treatment of patients in the present;
Errors in Medicine

If the cybermedicine programs assist with (or better, eliminate) administrative chores, thereby freeing more time for medical matters.
Errors in Medicine

And if the cybermedicine programs have educational value,
Errors in Medicine

Then the doctor is far less likely to make mistakes in the practice of medicine.
• Use of the system by voluntary users
• Attitude toward the system
• Effect of the system on the quality of medical care
• The Teaching Power of Cybermedicine
In the tradition of John Dewey, who advocated “learning by doing,” cybermedicine promotes learning in the context of caring for real patients.
e.g., if a medical student caring for an elderly man is informed by the computer that the patient has a low serum Na, a low BUN, and a chest film that shows hilar adenopathy with pleural effusion...
Teaching

the student can request computer-based consultation on diagnosis and treatment (data from the labs are transferred to the consultation programs automatically)…
Teaching

and discover (or be reminded) that the findings are suggestive of oat cell carcinoma of the lung with inappropriate secretion of antidiuretic hormone...
Teaching

and then use ClinQuery to find information on other patients with these abnormalities...
Teaching

use PaperChase to search for related articles in the medical literature...
Teaching

and use electronic mail to communicate with other students, house officers, or staff physicians, all from the same computer terminal.
Use of the system by voluntary users
Attitude toward the system
Effect of the system on the quality of medical care
The Teaching Power of Cybermedicine
Effect of the System on Hospital Finances
Time needed to collect bills in relation to use of computing programs at Beth Israel Hospital

**Registration Programs**

**Clinical Programs**
Time needed to collect bills in relation to use of computing programs at Brigham & Women’s Hospital

![Graph showing time to collect bills (in days) for fiscal years 1982 to 1988 for different program types: Registration, Clinical, and Financial.](image-url)
Use of the system by voluntary users
Attitude toward the system
Effect of the system on the quality of medical care
The Teaching Power of Cybermedicine
Effect of the System on Hospital Finances
Cost of the System
Measures in Use for Protection of Patient Confidentiality

- All users are told that the password is equivalent to a legal signature, and that under no circumstances should it be shared with anyone.
Access can be restricted by password and by terminal location.
Physicians’ passwords are issued by the Executive Director’s office when the physician is given hospital credentials.
Individuals who have access to the Beth Israel Deaconess computerized patient information system can obtain records pertaining to the care and treatment of hospital patients. Under Massachusetts law and the hospital’s patient confidentiality policy, such records are confidential.

We ask you to sign the following agreement.

Press <Enter>
Measures in Use for Protection of Patient Confidentiality

- Terminals are frozen if illegal passwords are entered a few times.
Measures in Use for Protection of Patient Confidentiality

- Users are automatically signed off after a time-out period of approximately five minutes.
Measures in Use for Protection of Patient Confidentiality

Access from home by telephone dial-up requires a second password.
Measures in Use for Protection of Patient Confidentiality

- The computer system stores each access to patient information indexed by person, professional role (staff doctor, nurse, resident, student, other), location, type of information retrieved, date, and time.
All patients (and their doctors) can request a list of persons who have looked at their records.
Employees who use the computer system have an option under Utilities that displays the names of persons who have looked at their electronic record.
Utility Options

- Telephone Directory: 462
- Doctor’s Office Directory: 182
- View Lookups of Own File: 176
- How to use the Computer Terminal: 46
Terminals automatically display confidentiality warnings if a user looks at a record of a VIP.

Terminals randomly display confidentiality warnings from time to time for all patients.
End response by pressing return key. For help type ?

Patient ID: **Townsend, Minnette**

99999999 Paxton, Minnette 04/21/03 F 97 111-11-1111

(Access Restricted)

Arthur Marguette Richard M Townsend

OK? Y //

To protect each patient’s confidentiality only those who are responsible for a patient’s care should use this option. We record the identity of each user of patient lookup and will give this information to the patient or the patient’s physician upon request.

Type ‘Y’es to proceed, otherwise press return. N//
In the Hands of Strangers

For purposes of reimbursement, hospitals and clinics are now required to send confidential clinical information, linked to charges, to a broad array of third-party payers—strangers who are beyond the control of the hospital, clinic, doctor, or patients. Are they to be trusted?
Announcing the only foolproof, guaranteed indecipherable, absolutely confidential hospital records security system:

DOCSCRIPT!

CONFIDENTIAL

[Handwritten signatures and notes]

[Signature: J. K. M.D.]