# Implementing Decision Support within CPOE and EMR Systems: Vanderbilt Experience


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**Contributors to the work described include:**

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**Work supported by Vanderbilt University Medical Center and grants from the U.S. National Library of Medicine**

# Conflict of Interest Disclaimer

**Vanderbilt University has entered into a licensing agreement with McKesson-HBOC for WizOrder and potentially other informatics-related products developed at Vanderbilt.**

**Vanderbilt University, The Informatics Center, Dr. Miller's Department, and various individuals benefit financially from this licensing arrangement. Related to the licensing agreement, Dr. Miller (among others) receives royalties from Vanderbilt University.**

**As an author/developer of INTERNIST-I and QMR at the University of Pittsburgh, Randolph A. Miller, M.D., in the past received royalty income from sales of the commercial version of QMR. These were donated to charitable institutions.**

# Early Case Report:
# The Imperfectability of Man

**Shakespeare, W. *The Merchant of Venice.* 1597; Act I, Scene ii**

**If  to do were as easy as to know**
**what were good to do,**
**chapels had been churches, and**
**poor men's cottages princes' palaces.**

**... I can easier teach twenty what**
**were good to be done than**
**to be one of the twenty**
**to follow my own teaching.**

**1 Patient-Specific Information**
Core "Portable" Patient Summary:
Problems, Allergies, Meds
Local Electronic Patient Record
Orders: Active/Inactive

**2 Local Knowledge**
"Best of Care" Pathways
Institutional policies & costs
Drug interactions & formulary
Physician preferences

IDEA

Patient Care Provider at Decision Point

ACTION

**Decision Support Integrated into Workflow**

**3 Global Knowledge**
Medical literature
Diagnostic databases regarding diseases
National guidelines
Patient databanks with outcome data

**4 Algorithms to enhance care**
Reminders, Alerts
Quality checks
Self-Generated Monitors
Decision support programs

# WizOrder purpose and demographics

**WizOrder** was **developed at Vanderbilt** by DBMI faculty and Informatics Center staff to help **ensure the highest quality of care for** our **patients**, **reducing medical errors.**

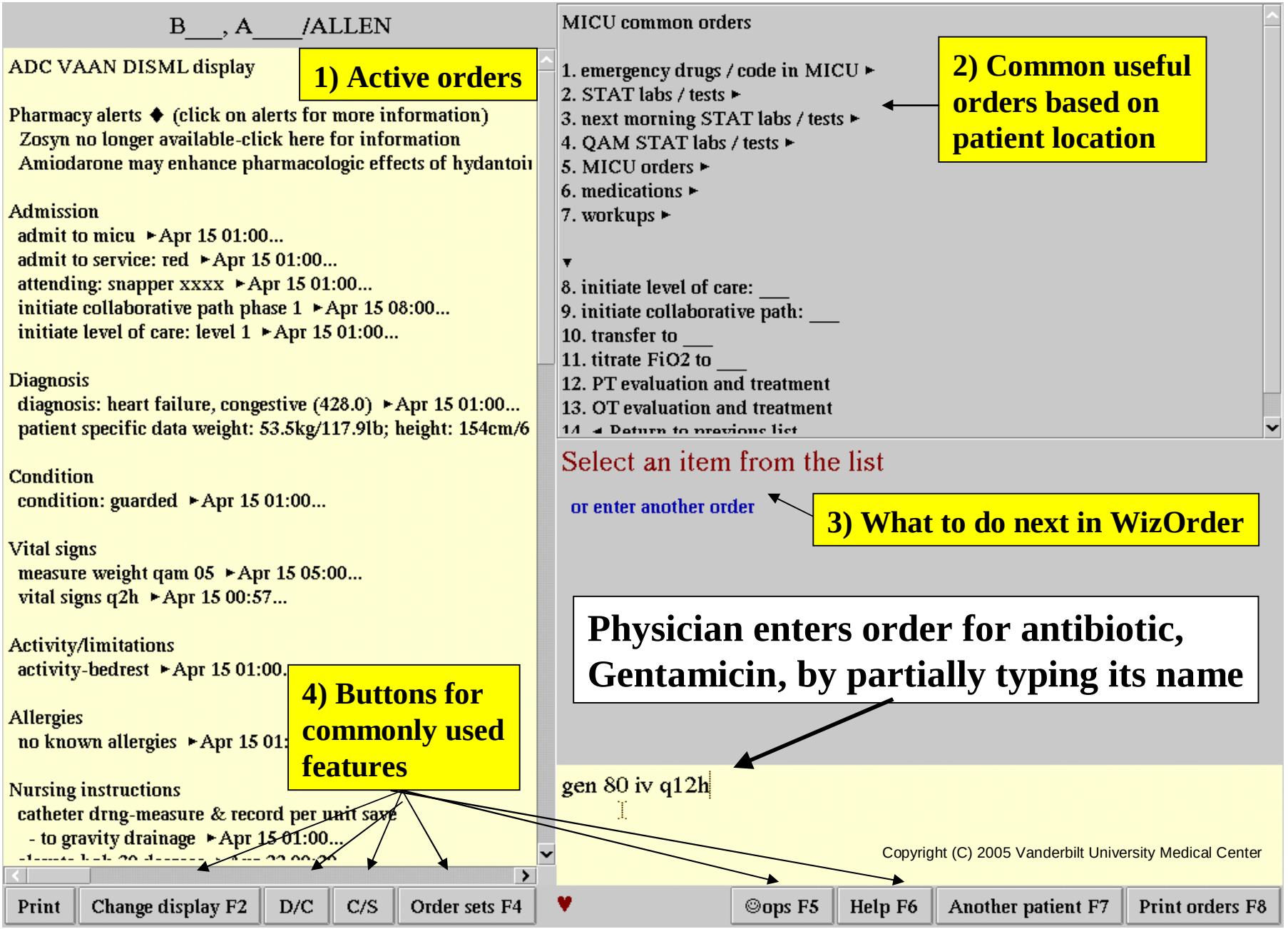
**It provides "point-of-care"** relevant **information resources** to **enhance and support clinicians' decision-making** at the time of **order entry.**

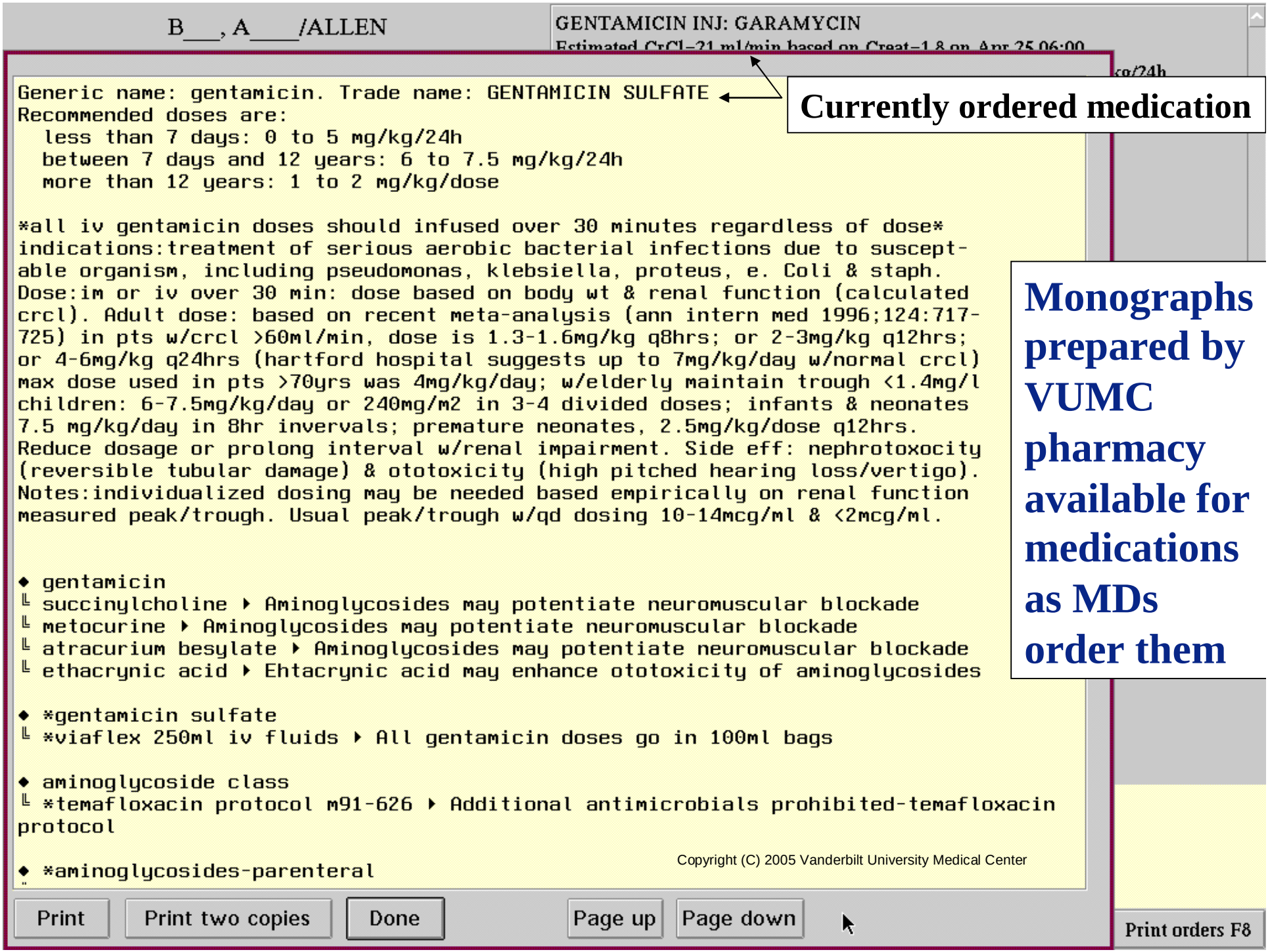
**It has been refined by ongoing clinical feedback from House staff, nurses, attending MDs, committees, others at VUMC for the past 10 years.**

**WizOrder** is **now used on all beds** at VUH by**:**
**Medicine, Surgery, Pediatrics, ED, and OB/GYN services.**

Over **15,000 orders/day, 75% by MDs**, rest by clinical staff

# WizOrder Main Screen Layout: Simple, fixed format: functionally oriented, designed with users




B___, A____/ALLEN
GENTAMICIN INJ: GARAMYCIN
Estimated CrCl=21 ml/min based on Creat=1.8 on Apr 25 06:00
Generic name: gentamicin. Trade name: GENTAMICIN SULFATE
Recommended doses are:
less than 7 days: 0 to 5 mg/kg/24h
between 7 days and 12 years: 6 to 7.5 mg/kg/24h
more than 12 years: 1 to 2 mg/kg/dose
*all iv gentamicin doses should infused over 30 minutes regardless of dose*
indications:treatment of serious aerobic bacterial infections due to suscept-
able organism, including pseudomonas, klebsiella, proteus, e. Coli & staph.
Dose:im or iv over 30 min: dose based on body wt & renal function (calculated
crcl). Adult dose: based on recent meta-analysis (ann intern med 1996;124:717-
725) in pts w/crcl >60ml/min, dose is 1.3-1.6mg/kg q8hrs; or 2-3mg/kg q12hrs;
or 4-6mg/kg q24hrs (hartford hospital suggests up to 7mg/kg/day w/normal crcl)
max dose used in pts >70yrs was 4mg/kg/day; w/elderly maintain trough <1.4mg/l
children: 6-7.5mg/kg/day or 240mg/m2 in 3-4 divided doses; infants & neonates
7.5 mg/kg/day in 8hr invervals; premature neonates, 2.5mg/kg/dose q12hrs.
Reduce dosage or prolong interval w/renal impairment. Side eff: nephrotoxocity
(reversible tubular damage) & ototoxicity (high pitched hearing loss/vertigo).
Notes:individualized dosing may be needed based empirically on renal function
measured peak/trough. Usual peak/trough w/qd dosing 10-14mcg/ml & <2mcg/ml.
◆ gentamicin
╚ succinylcholine ▸ Aminoglycosides may potentiate neuromuscular blockade
╚ metocurine ▸ Aminoglycosides may potentiate neuromuscular blockade
╚ atracurium besylate ▸ Aminoglycosides may potentiate neuromuscular blockade
╚ ethacrynic acid ▸ Ehtacrynic acid may enhance ototoxicity of aminoglycosides
◆ *gentamicin sulfate
╚ *viaflex 250ml iv fluids ▸ All gentamicin doses go in 100ml bags
◆ aminoglycoside class
╚ *temafloxacin protocol m91-626 ▸ Additional antimicrobials prohibited-temafloxacin
protocol
◆ *aminoglycosides-parenteral
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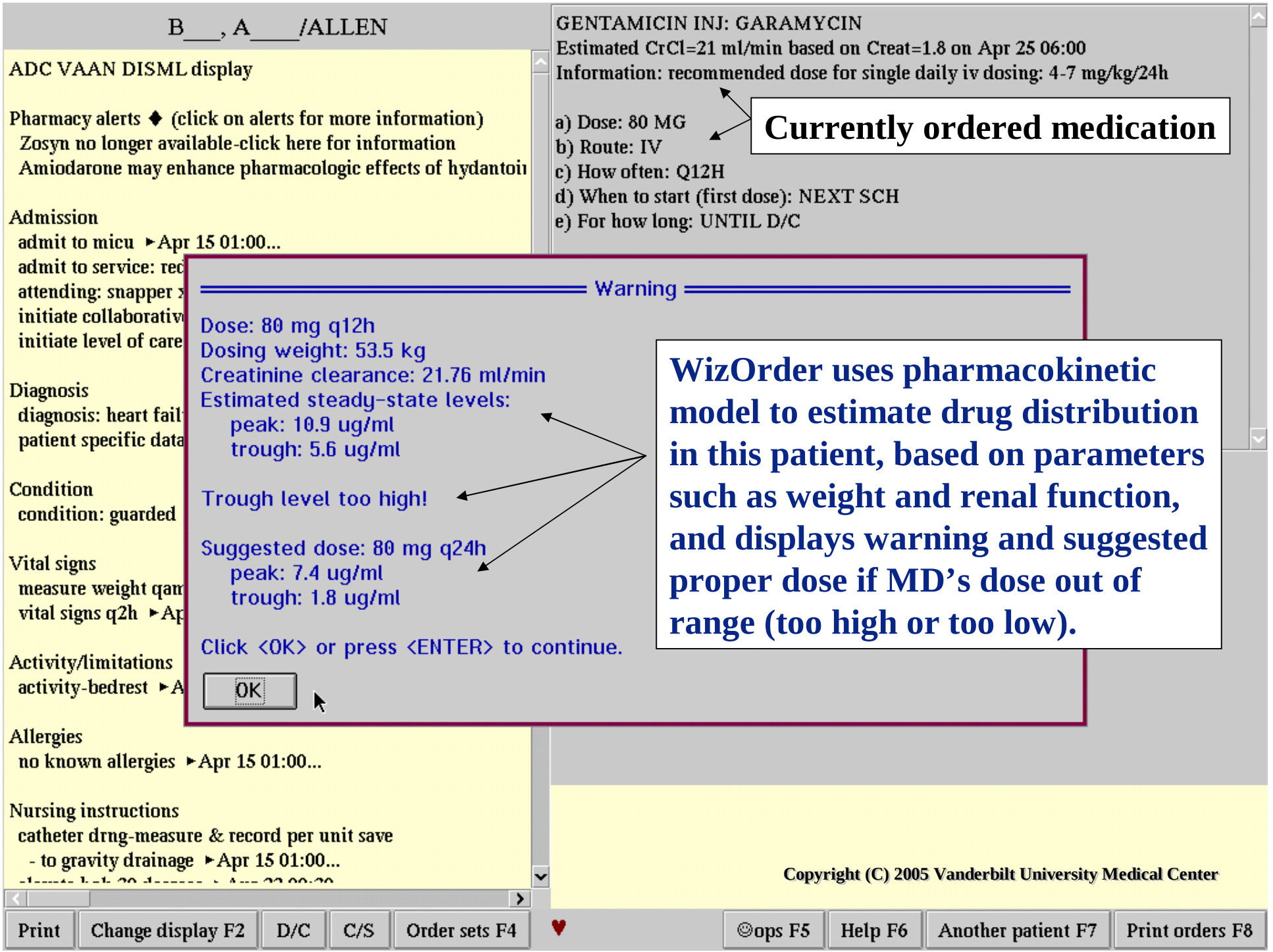
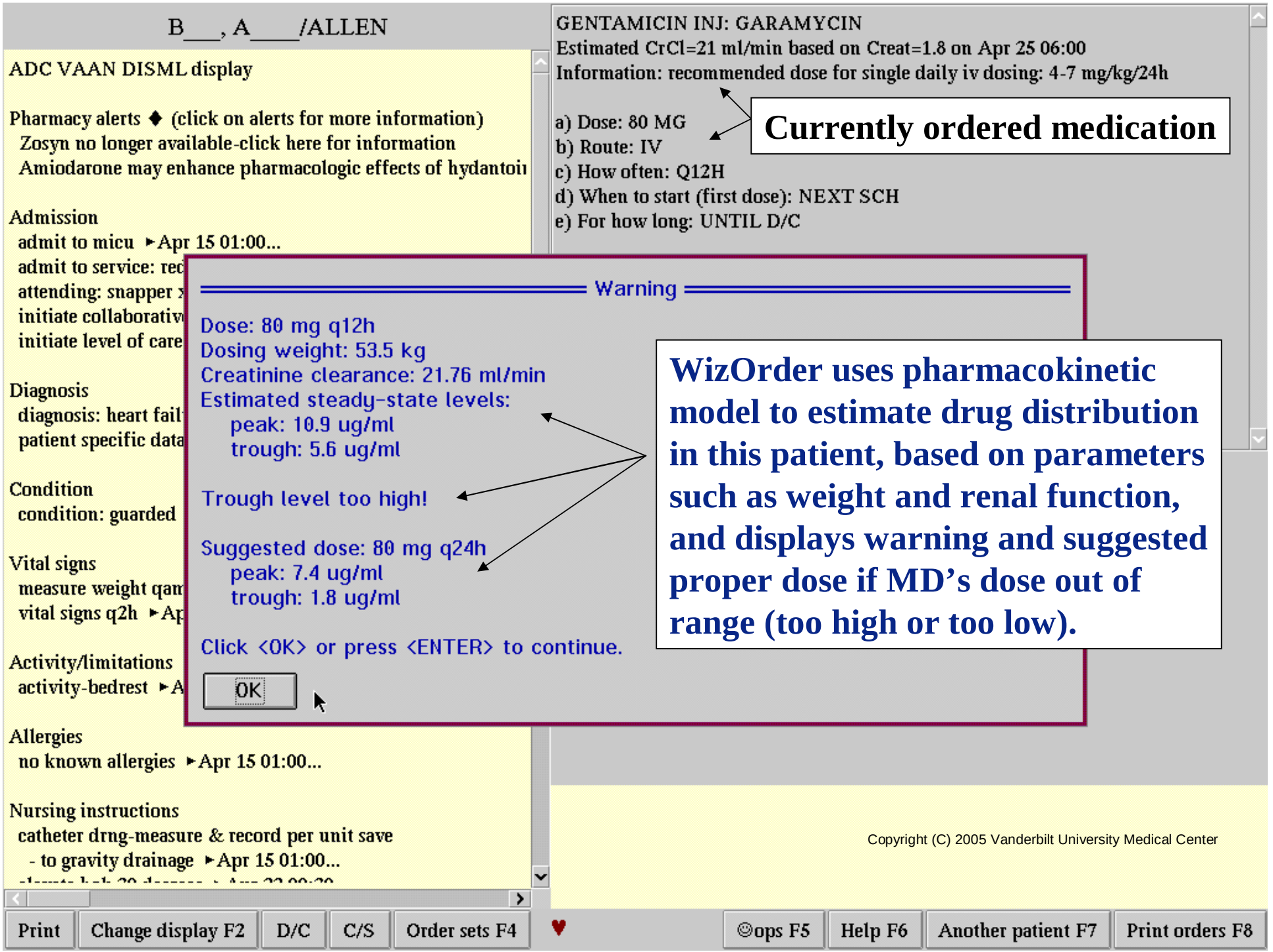
Print
Print two copies
Done
Page up
Page down
Print orders F8
Currently ordered medication
Monographs prepared by VUMC pharmacy available for medications as MDs order them


B___, A____/ALLEN
ADC VAAN DISML display
Pharmacy alerts ♦ (click on alerts for more information)
Zosyn no longer available-click here for information
Amiodarone may enhance pharmacologic effects of hydantoin
Admission
admit to micu ▸Apr 15 01:00...
admit to service: rec
attending: snapper
initiate collaborativ
initiate level of care
Diagnosis
diagnosis: heart fail
patient specific data
Condition
condition: guarded
Vital signs
measure weight qam
vital signs q2h ▸Ap
Activity/limitations
activity-bedrest ▸A
Allergies
no known allergies ▸Apr 15 01:00...
Nursing instructions
catheter drng-measure & record per unit save
- to gravity drainage ▸Apr 15 01:00...
GENTAMICIN INJ: GARAMYCIN
Estimated CrCl=21 ml/min based on Creat=1.8 on Apr 25 06:00
Information: recommended dose for single daily iv dosing: 4-7 mg/kg/24h
a) Dose: 80 MG
b) Route: IV
c) How often: Q12H
d) When to start (first dose): NEXT SCH
e) For how long: UNTIL D/C
Currently ordered medication
Warning
Dose: 80 mg q12h
Dosing weight: 53.5 kg
Creatinine clearance: 21.76 ml/min
Estimated steady-state levels:
peak: 10.9 ug/ml
trough: 5.6 ug/ml
Trough level too high!
Suggested dose: 80 mg q24h
peak: 7.4 ug/ml
trough: 1.8 ug/ml
Click <OK> or press <ENTER> to continue.
OK
WizOrder uses pharmacokinetic model to estimate drug distribution in this patient, based on parameters such as weight and renal function, and displays warning and suggested proper dose if MD's dose out of range (too high or too low).
Copyright (C) 2005 Vanderbilt University Medical Center
Print
Change display F2
D/C
C/S
Order sets F4
Oops F5
Help F6
Another patient F7
Print orders F8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initiate level of care
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diagnosis: heart fail
patient specific data
Condition
condition: guarded
Vital signs
measure weight qam
vital signs q2h ▸Ap
Activity/limitations
activity-bedrest ▸A
Allergies
no known allergies ▸Apr 15 01:00...
Nursing instructions
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OK
WizOrder uses pharmacokinetic model to estimate drug distribution in this patient, based on parameters such as weight and renal function, and displays warning and suggested proper dose if MD's dose out of range (too high or too low).
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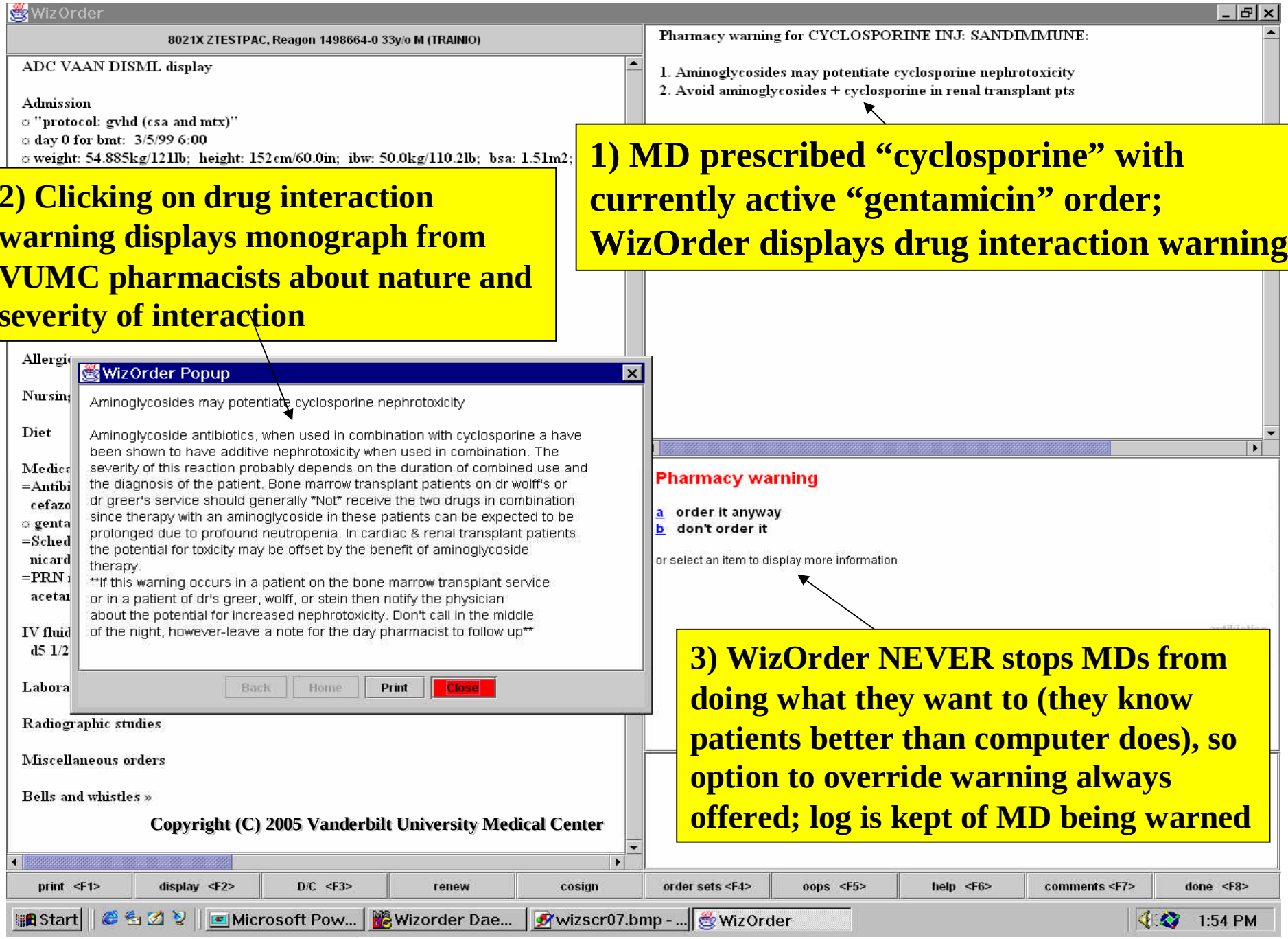
Print
Change display F2
D/C
C/S
Order sets F4
Oops F5
Help F6
Another patient F7
Print orders F8

# WizOrder: Pharmacy warning about potential drug interaction



# Sample PHM Warnings from WizOrder

*[phm .dapw 1/4 NS::889:1/4ns (no additives) can cause hemolysis-click here for info*
*[phm .dapw ABCIXIMAB CONTINUOUS INFUSION::1280:For reopro dosing info click on this message*
***[phm .dapw ACETAMINOPHEN W/CODEINE #2::-14:Multiple orders for acetaminophen. Risk of overdose.***
*[phm .dapw ACETAMINOPHEN-ETOH FREE LIQ::715:Acetaminophen in sorbitol may cause diarrhea/cramping*

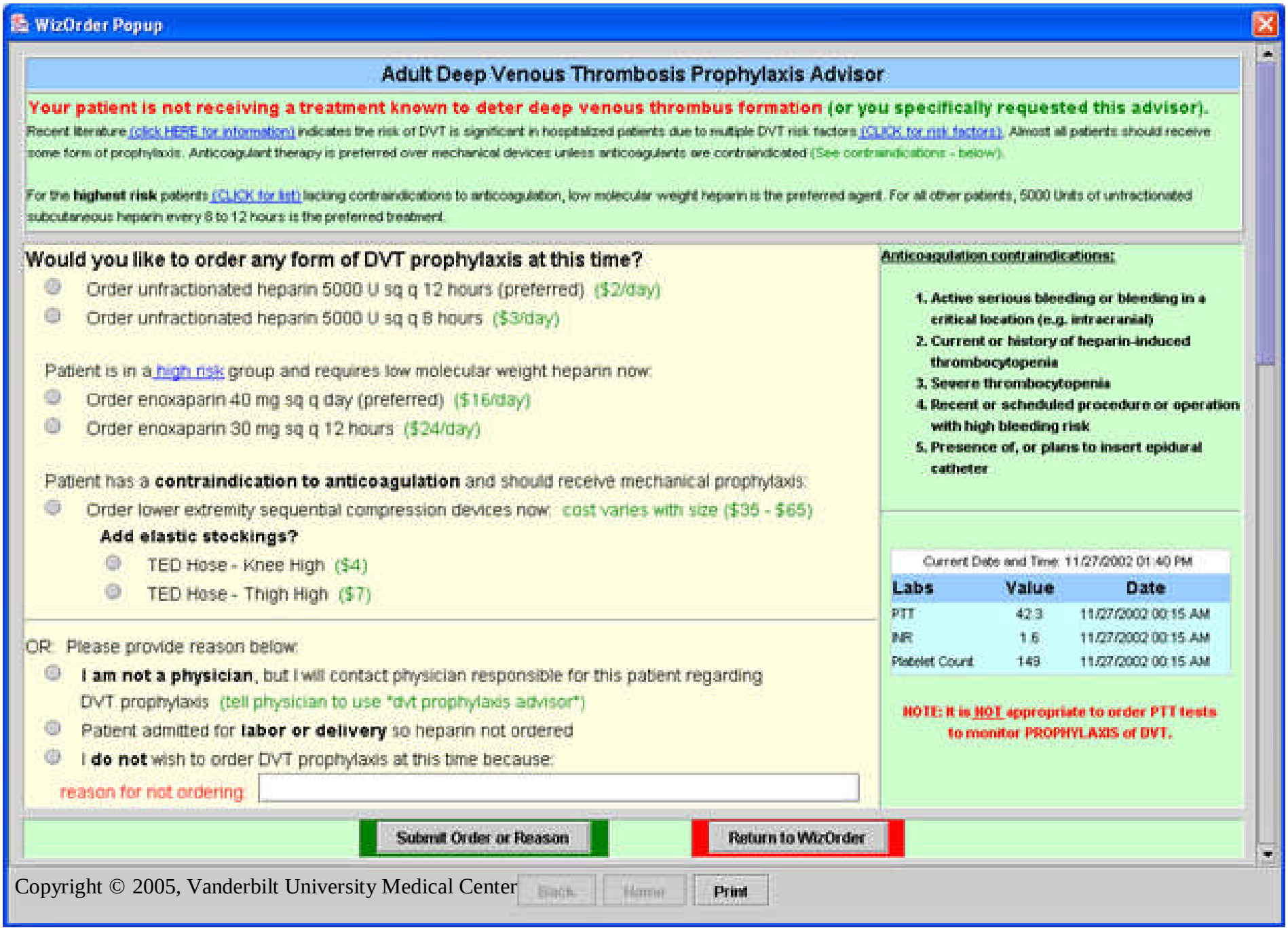
***[phm .dapw ACETAZOLAMIDE: DIAMOX:-3:Probable ALLERGY to this medication***
*[phm .dapw ACYCLOVIR 5% OINTMENT::222:No benefit w/acyclovir-ganciclovir comb*
*[phm .dapw ACYCLOVIR INJ: ZOVIRAX:229:Duplication of therapy: acyclovir & valacyclovir*

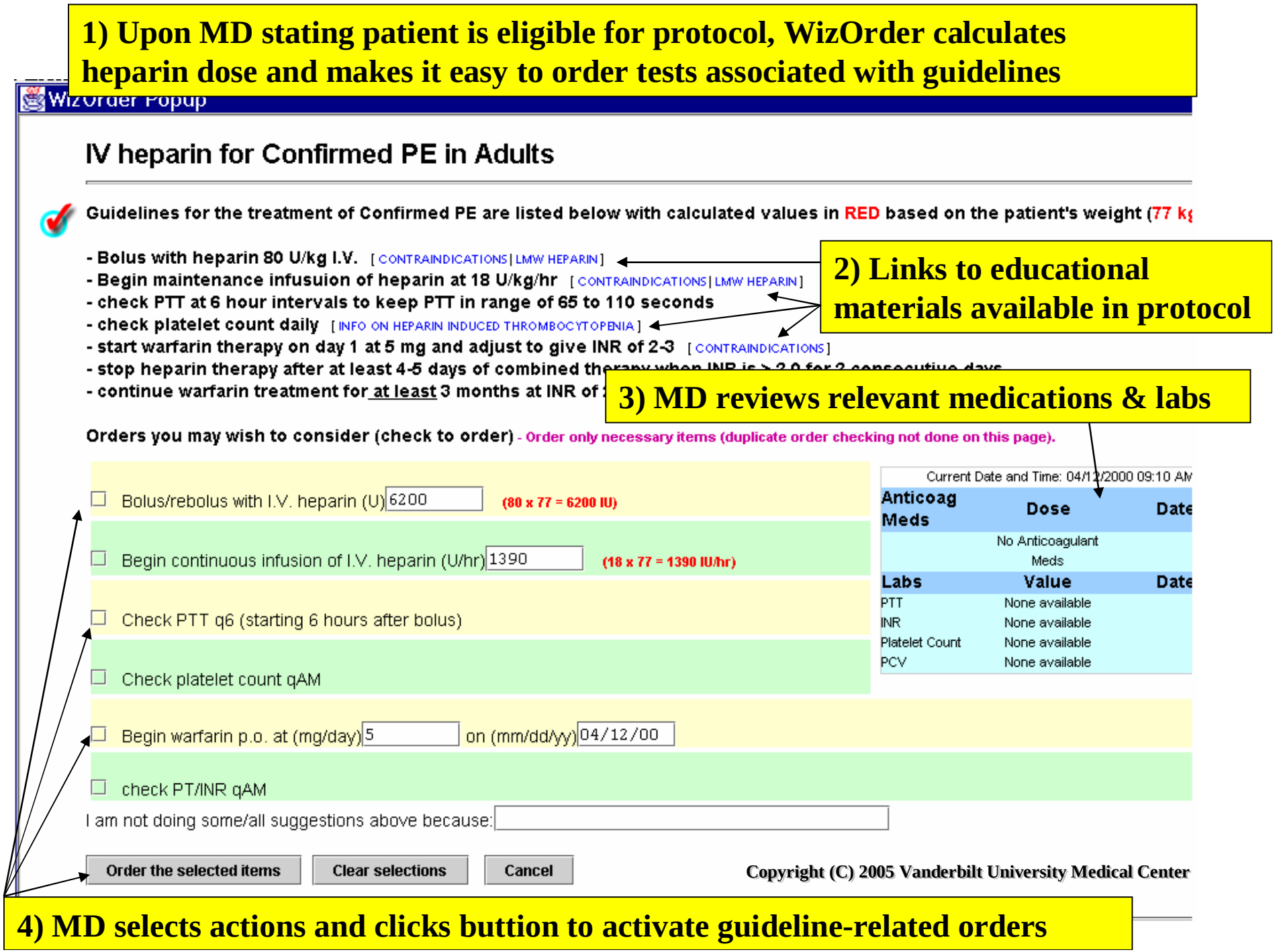
*[phm .dapw ALLOPURINOL: ZYLOPRIM:1416:Allopurinol may increase warfarin anticoagulant effect*
***[phm .dapw AMIODARONE INFUSION::633:Amiodarone may double serum digoxin concentration/effects***
*[phm .dapw AMOXICILLIN-CLAVULANATE::-3:Probable ALLERGY to this medication*
*[phm .dapw AMOXICILLIN-CLAVULANATE::154:If pt can take oral amoxacillin, why not oral h2 blocker?*

*[phm .dapw AMPHOTERICIN B INJ: FUNGIZONE:125:Fluconazole reduces efficacy of iv ampho for aspergillus*
***[phm .dapw AMPHOTERICIN B LIPID COMPLEX::1484:Fk-506 may inc. ampho b nephrotoxicity***
*[phm .dapw AMPRENAVIR: AGENERASE:1107:Drug may need to be special ordered - click here for info*

*[phm .dapw ATENOLOL: TENORMIN:1068:Beta blocker may enhance effects of hypoglycemics*
***[phm .dapw ATORVASTATIN: LIPITOR:1184:Myopathy risk increased w/niacin & statin/hmg coa red drugs***

***[phm .dapw CELECOXIB: CELEBREX:729:Celecoxib is for arthritis - click here if pt has depression***
***[phm .dapw CITALOPRAM: CELEXA:820:Citalopram is for depression-click here if pt has arthritis***


WizOrder Popup
Adult Deep Venous Thrombosis Prophylaxis Advisor
Your patient is not receiving a treatment known to deter deep venous thrombus formation (or you specifically requested this advisor).
Recent literature (click HERE for information) indicates the risk of DVT is significant in hospitalized patients due to multiple DVT risk factors (CLICK for risk factors). Almost all patients should receive some form of prophylaxis. Anticoagulant therapy is preferred over mechanical devices unless anticoagulants are contraindicated (See contraindications - below).
For the highest risk patients (CLICK for list) lacking contraindications to anticoagulation, low molecular weight heparin is the preferred agent. For all other patients, 5000 Units of unfractionated subcutaneous heparin every 8 to 12 hours is the preferred treatment.
Would you like to order any form of DVT prophylaxis at this time?
Order unfractionated heparin 5000 U sq q 12 hours (preferred) ($2/day)
Order unfractionated heparin 5000 U sq q 8 hours ($3/day)
Patient is in a high risk group and requires low molecular weight heparin now:
Order enoxaparin 40 mg sq q day (preferred) ($16/day)
Order enoxaparin 30 mg sq q 12 hours ($24/day)
Patient has a contraindication to anticoagulation and should receive mechanical prophylaxis:
Order lower extremity sequential compression devices now: cost varies with size ($35 - $65)
Add elastic stockings?
TED Hose - Knee High ($4)
TED Hose - Thigh High ($7)
OR: Please provide reason below:
I am not a physician, but I will contact physician responsible for this patient regarding DVT prophylaxis (tell physician to use "dvt prophylaxis advisor")
Patient admitted for labor or delivery so heparin not ordered
I do not wish to order DVT prophylaxis at this time because:
reason for not ordering:
Anticoagulation contraindications:
1. Active serious bleeding or bleeding in a critical location (e.g. intracranial)
2. Current or history of heparin-induced thrombocytopenia
3. Severe thrombocytopenia
4. Recent or scheduled procedure or operation with high bleeding risk
5. Presence of, or plans to insert epidural catheter
Current Date and Time: 11/27/2002 01:40 PM
Labs | Value | Date
PTT | 42.3 | 11/27/2002 00:15 AM
INR | 1.6 | 11/27/2002 00:15 AM
Platelet Count | 149 | 11/27/2002 00:15 AM
NOTE: It is NOT appropriate to order PTT tests to monitor PROPHYLAXIS of DVT.
Submit Order or Reason
Return to WizOrder
Copyright © 2005, Vanderbilt University Medical Center
Print


1) Upon MD stating patient is eligible for protocol, WizOrder calculates heparin dose and makes it easy to order tests associated with guidelines
WizOrder Popup
IV heparin for Confirmed PE in Adults
Guidelines for the treatment of Confirmed PE are listed below with calculated values in RED based on the patient's weight (77 kg
- Bolus with heparin 80 U/kg I.V. [ CONTRAINDICATIONS | LMW HEPARIN ]
- Begin maintenance infusuion of heparin at 18 U/kg/hr [ CONTRAINDICATIONS | LMW HEPARIN ]
- check PTT at 6 hour intervals to keep PTT in range of 65 to 110 seconds
- check platelet count daily [ INFO ON HEPARIN INDUCED THROMBOCYTOPENIA ]
- start warfarin therapy on day 1 at 5 mg and adjust to give INR of 2-3 [ CONTRAINDICATIONS ]
- stop heparin therapy after at least 4-5 days of combined therapy when INR is > 2.0 for 2 consecutive days
- continue warfarin treatment for at least 3 months at INR of
2) Links to educational materials available in protocol
3) MD reviews relevant medications & labs
Orders you may wish to consider (check to order) - Order only necessary items (duplicate order checking not done on this page).
Bolus/rebolus with I.V. heparin (U) 6200 (80 x 77 = 6200 IU)
Begin continuous infusion of I.V. heparin (U/hr) 1390 (18 x 77 = 1390 IU/hr)
Check PTT q6 (starting 6 hours after bolus)
Check platelet count qAM
Begin warfarin p.o. at (mg/day) 5 on (mm/dd/yy) 04/12/00
check PT/INR qAM
I am not doing some/all suggestions above because:
Order the selected items
Clear selections
Cancel
Current Date and Time: 04/12/2000 09:10 AM
Anticoag Meds | Dose | Date
No Anticoagulant Meds
Labs | Value | Date
PTT | None available
INR | None available
Platelet Count | None available
PCV | None available
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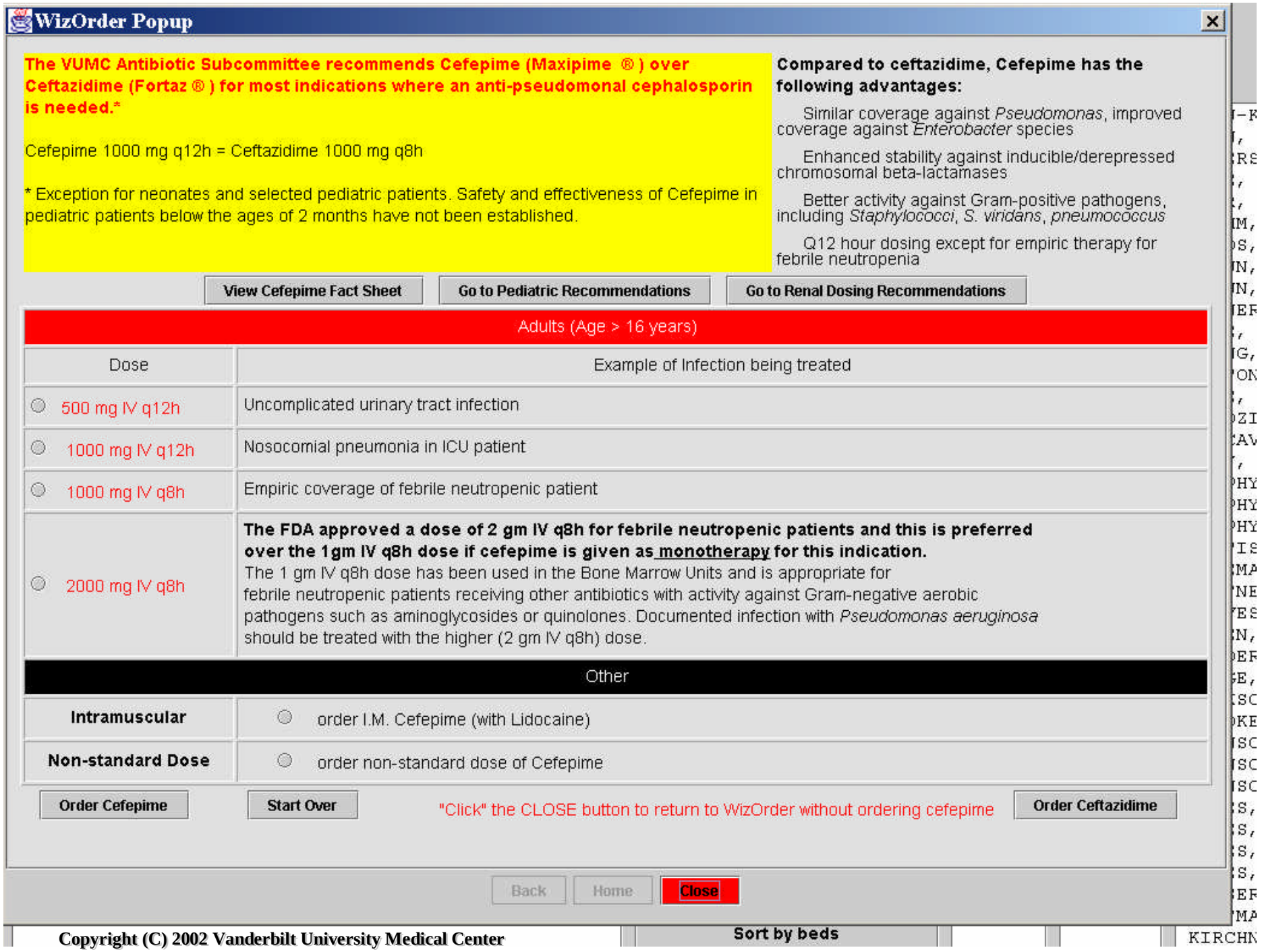
4) MD selects actions and clicks buttion to activate guideline-related orders



# Problem: Excess test ordering

**RUC = Resource Utilization Committee,**
**Eric Neilson, MD, Chair**

1. In December, 1999 RUC and DBMI used WizOrder to examine more closely patterns of test ordering.

**February 2000 Most Common Tests Ordered at VUH, All WizOrder Wards**

| | |
|---|---|
| **00648 === part thromboplastin (ptt) bld** | **** UNIT: 7n** |
| **00686 === osmolality bld** | **** UNIT: 11si** |
| **00686 === sodium bld** | **** UNIT: 11si** |
| **00715 === basic metabolic panel** | **** UNIT: 7smi** |
| **00753 === prothrombin time (pt) blood** | **** UNIT: 3n/c** |
| **00756 === basic metabolic panel** | **** UNIT: 7n** |
| **00763 === basic metabolic panel** | **** UNIT: 8s** |
| **00799 === cbc / plt ct** | **** UNIT: 3n/c** |
| **00821 === abg resp** | **** UNIT: 10n** |
| **01029 === basic metabolic panel** | **** UNIT: 11nm** |
| **01046 === basic metabolic panel** | **** UNIT: 3n/c** |
| **01084 === basic metabolic panel** | **** UNIT: 10n** |
| **01218 === cbc (wbc,rbc,hgb,pcv,ind)** | **** UNIT: 10n** |
| **01556 === abg resp** | **** UNIT: 3n/c** |

Chem7 (BUN, Creat, Lytes, Gluc = Basic Metabolic Panel) was identified as most commonly ordered test; and, in some ICU settings, daily CXRs were being done for weeks

# Problem: Excess test ordering

**2. Based on RUC discussion and deliberation:**

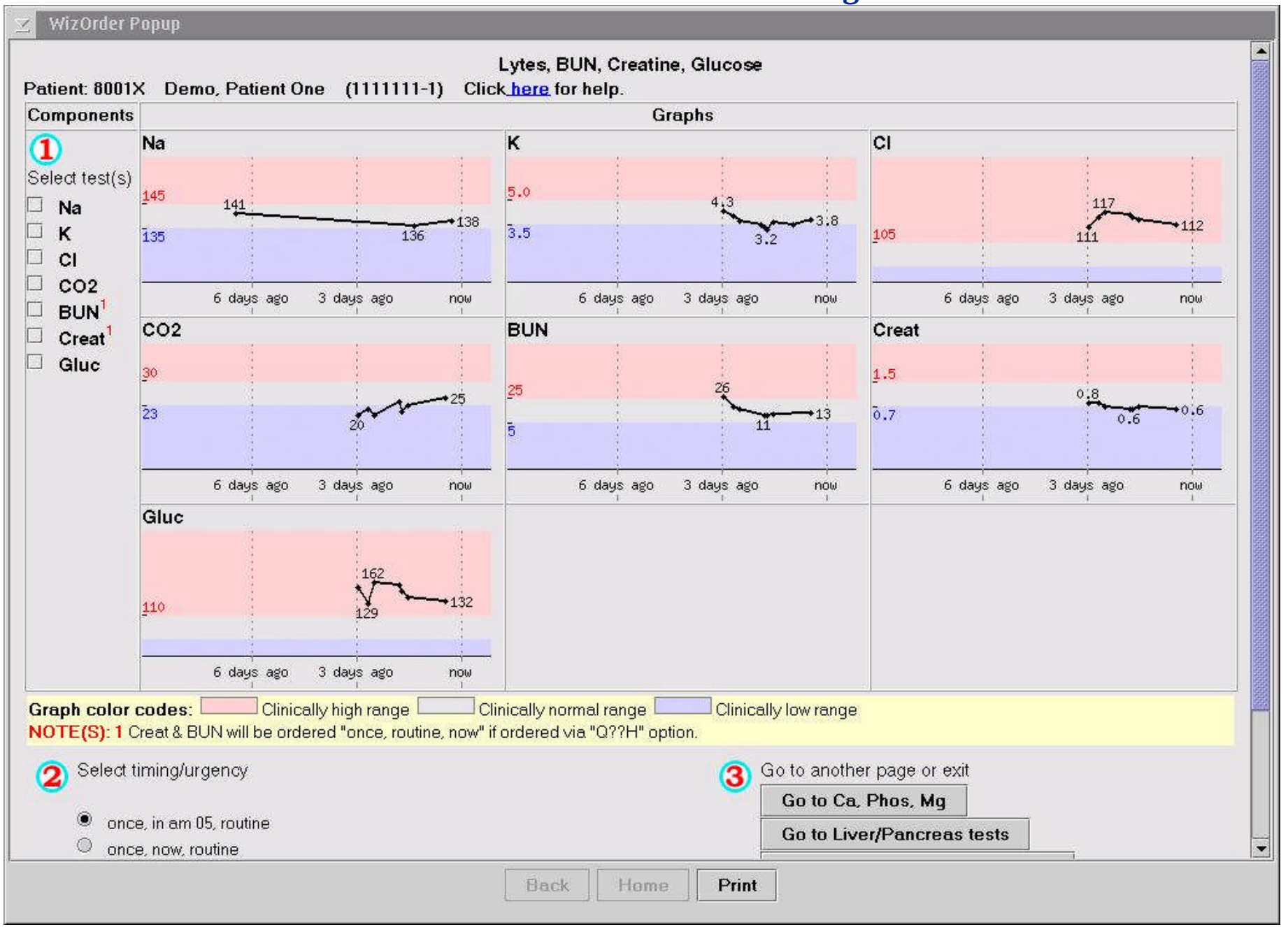
a. On Jan. 20th, 2000, WizOrder limited all radiology orders to “one time only”

b. On Feb. 1, 2000, WizOrder limited all EKG orders to 1x or 2x (q8h)

c. On Mar. 20, 2000, WizOrder limited LBCG to “only within 24 hrs”

d. Subsequently, ordering of Comprehensive Metabolic Profile restricted

# WizOrder: LBCG Ordering



# Results: Excess test ordering

1. Orders for Chem7 (BUN Creat Lytes Glucose) components and aggregate decreased 66% from baseline for previous year; actual tests performed decreased 40% from baseline.

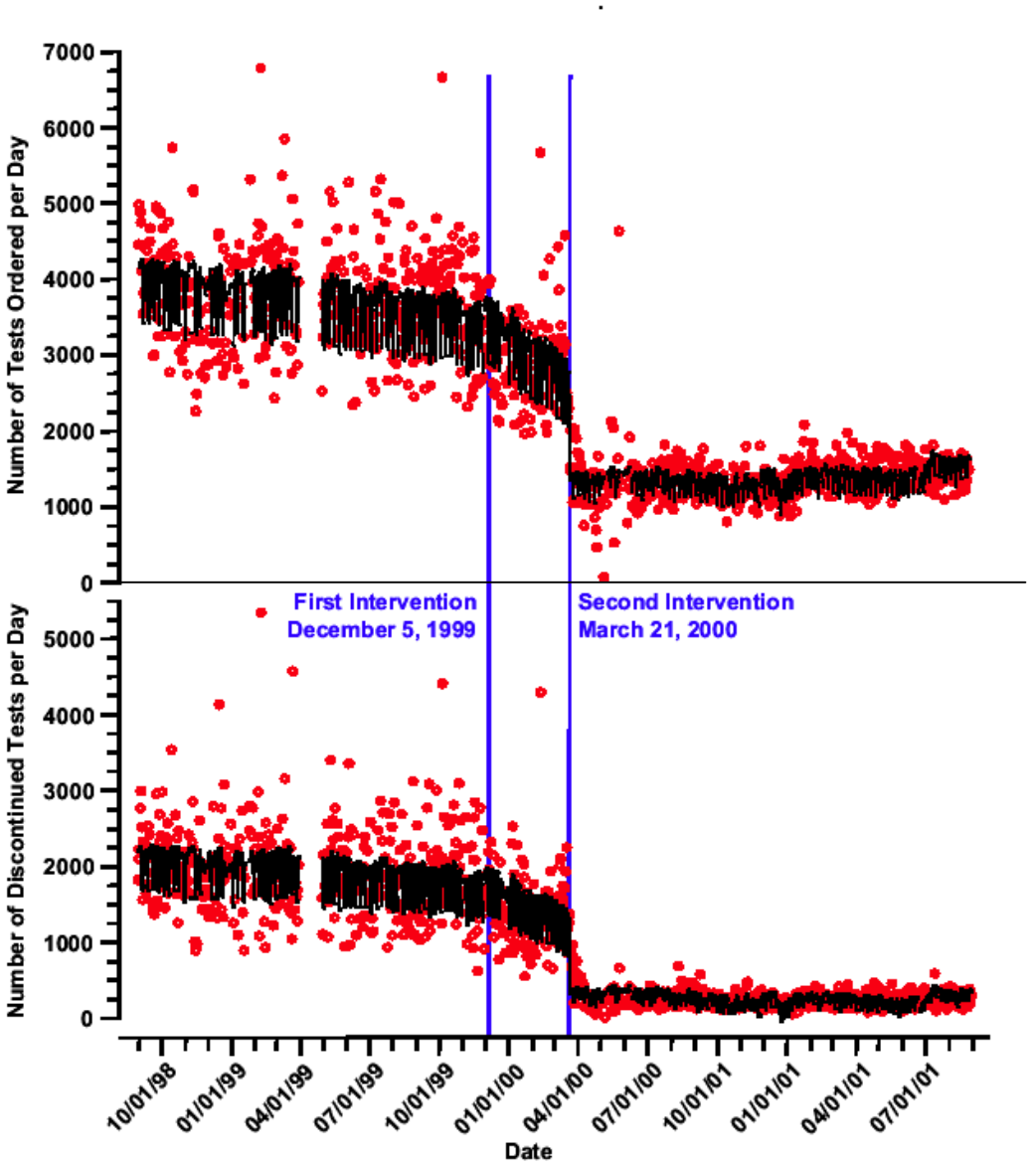
2. Orders for portable CXR's decreased 40% from baseline; studies performed decreased 35-40%.

3. Orders for EKGs decreased 10% from before.

Neilson EG, et al. The Impact of Peer Management on Test-Ordering Behavior Ann Intern Med. 2004. 41(3):196-204

Figure 3

# Results: Excess test ordering



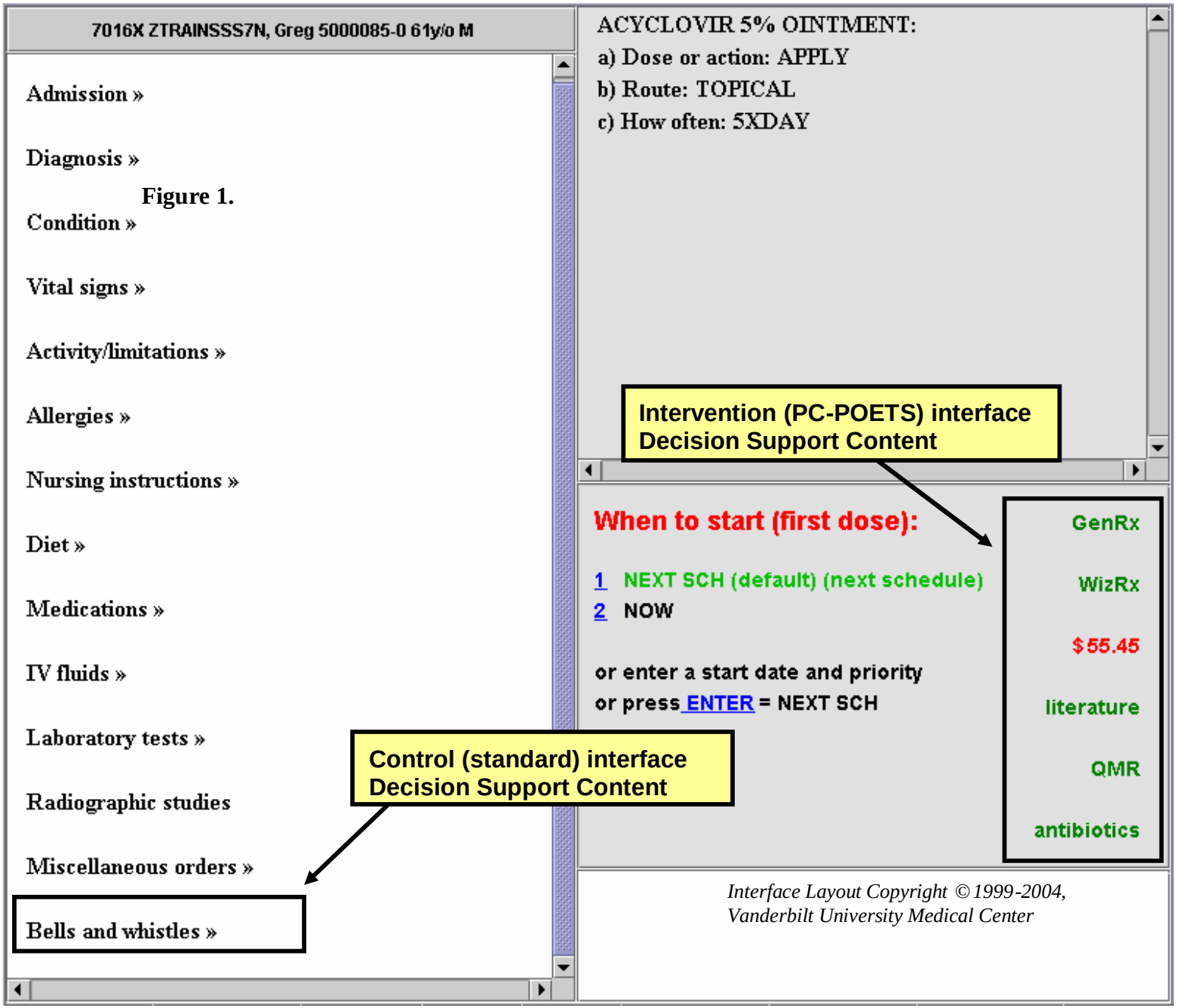



**Figure 1.**

**Table 3**. Opportunities and Response Rate Ratios during the clinical trial.

| Opportunity Code | Decision Support Opportunities | | Decision Support Responses | | Adjusted Response Rate Ratios* | |
|---|---|---|---|---|---|---|
| | Control | Intervention | Control | Intervention | Ratio | 95% CI |
| ABA | 396 | 448 | 1 | 2 | 2.90** | .059 – 140 |
| MSH | 15,116 | 20,886 | 2 | 57 | 13.4 | 3.0 – 59 |
| WRX | 45,596 | 61,311 | 3 | 43 | 9.67 | 2.2 – 43 |
| MSB | 45,421 | 61,359 | 2 | 57 | 21.2 | 4.3 – 100 |
| QMR | 15,115 | 20,908 | 1 | 51 | 32.7 | 3.3 – 320 |
| TRD | 32,234 | 42,631 | 0 | 50 | † | |
| LMR | 24,357 | 32,961 | 9 | 39 | 3.11 | 1.1 – 8.7 |
| | | | | | | |
| Overall | 178,235 | 240,504 | 18 | 278 | 9.72 | 4.7 – 20 |

*Ratio of decision support opportunity response rates for intervention subjects over control subjects; **not significant; †Could not calculate a ratio.

Reference: Rosenbloom ST et al. J Am Med Inform Assoc. 2005. 12(4):458-473

# WizOrder Development History

## Key concepts:

**System implementation represents a profound workflow change for users**

**Users' concerns must be continuously respected, listened to, and addressed.**

# Development: Social History

- **May 1994 - 3 pilot wards use joint OE system**
- **June 1994 - Early implementation problematic**
- **RM&AG work as medical ward clerks 2 weeks**
- **New iterative design with house staff input: Pizza dinners, moonlighting wages, real orders**
- **Stable design after 4 months: 9/94 to 12/94**
- **Institutional permission to use new interface, 2/95**

# Development: Social History

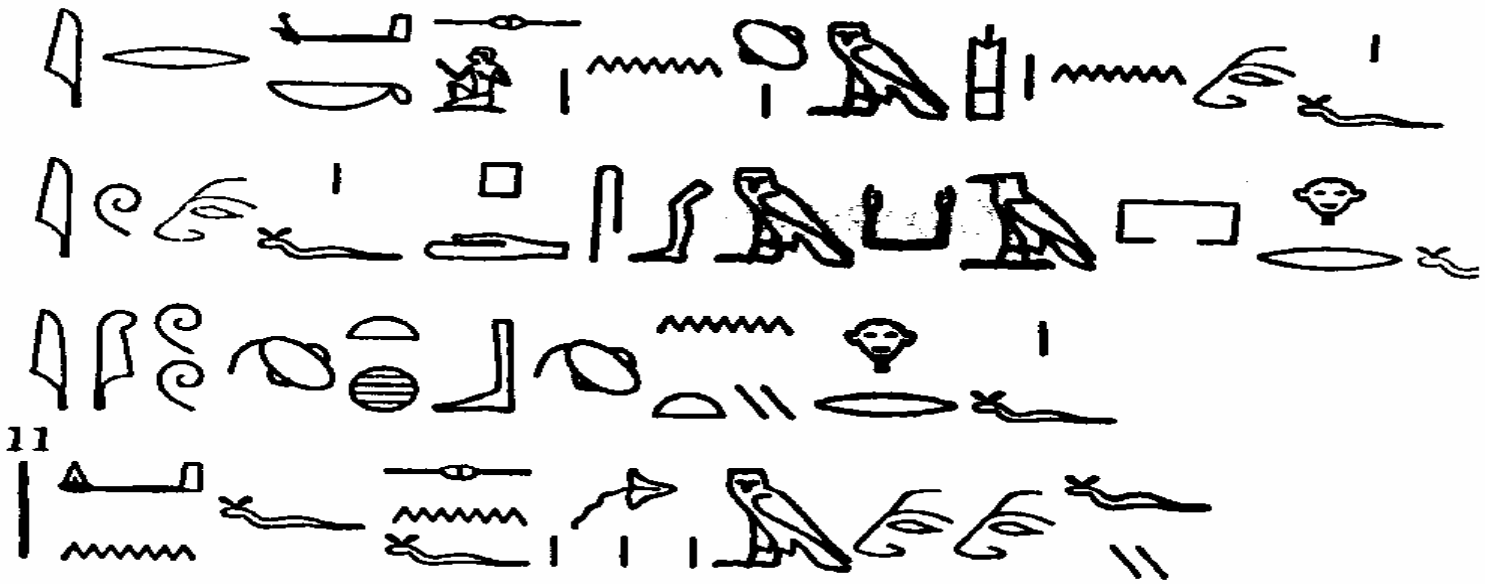
- **Training, support by User Analysts & System Support Services; DBMI, Clinical leaders & Administration participated**
- **Implemented first unit, CCU 4/95; MICU, BMT 9-10/1995;Adult Medicine & Surgery 1996; Pediatrics & OB/Gyn 1997**
- **Clinical informatics service: Care for system & users in same manner as a patient**

***MD rounds, on-call, UA/SSS, weekly clinical informatics conferences (pizza luncheons)***

# Rationale for Change:
## The Medical Record over the past 5,000 years

EXAMINATION

V 10–11



*Translation*

nest a man having a break in the column of ]

Edwin Smith Surgical Papyrus, 3000 BC, Classics of Medicine Library

# Rationale for Change:
## The Medical Record over the past 5,000 years

**Case Reports**

PATIENT 1

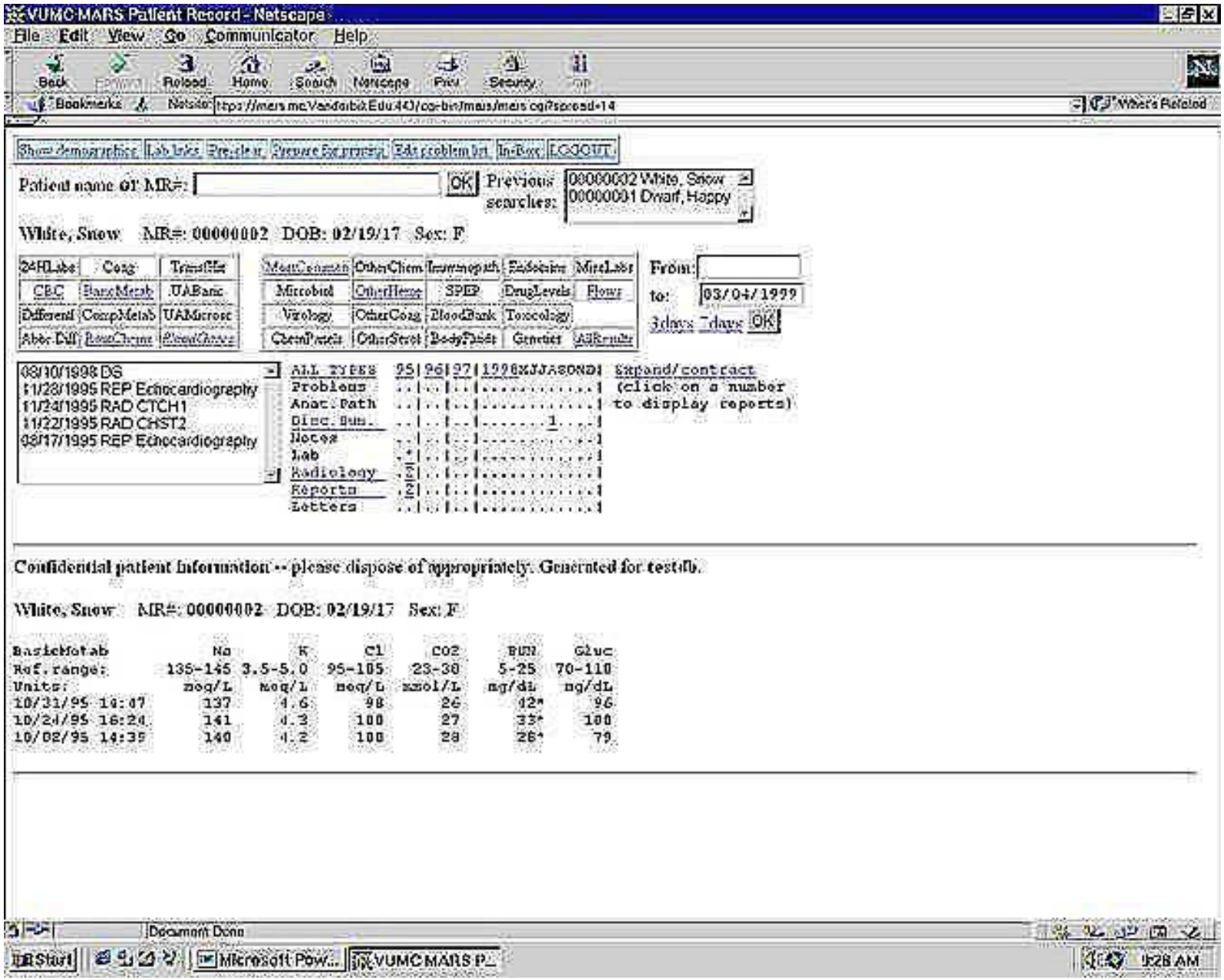
A 19-year-old woman was well until July 1985, when she had onset of fever, weight loss, facial rash, alopecia, and arthritis in her knees and ankles. The diagnosis of systemic lupus erythematosus was made on the basis of the clinical and laboratory findings (23), and she was treated with prednisolone, 150 mg/d. Although the patient's condition improved slightly, the dosage could not be reduced to below 75 mg/d. Additional therapy with azathioprine, 150 mg/d, and cyclosporine, 5 mg/kg body weight, had no beneficial effect.

In February 1986 her condition deteriorated, and she presented with fever, arthritis, malar rash, and severe dyspnea on exertion. Physical examination showed cachexia, pallor, facial rash, and tenderness in the knee joints. Despite maintenance of prednisolone she developed severe respiratory insufficiency with diffuse infiltrates in both lobes. Other symptoms included apathy, disorientation, renal failure, hemolytic anemia, and thrombocytopenia (Table 1). Despite antibiotic and antimycotic treatment her respiratory capacity worsened and she required assisted ventilation. Repeated attempts to identify an infectious agent were negative, and the transbronchial histologic examination was consistent with the diagnosis of lupus pneumonitis.

We decided to institute large-volume plasmaphereses with subsequent application of pulse cyclophosphamide. Plasma, 60 mL/kg body weight, was exchanged via hollow fiber membrane filters with immunoglobulin-free 4% albumin solution on days 1, 2, and 3. Pulse cyclophosphamide, 12 mg/kg body weight, was applied on each of days 3, 4, and 5; the first infusion was given 6 hours after the third plasmapheresis. Thereafter, oral cyclophosphamide was administered at a dosage of 2 mg/kg body weight. In addition, prednisolone, which had been withdrawn for 7 days to restore the B-cell proliferation capacity, was reinstituted on day 5 at 2 mg/kg body weight. Prednisolone was gradually tapered off and withdrawn at month 6.

The patient's condition improved rapidly. The infiltrates in both lungs subsided after 6 days and disappeared almost completely within 16 days. Blood urea nitrogen and creatinine levels became normal. There was a parallel progressive rise in hemoglobin and platelet count. Low levels of C4 and of complement-

# *The first major change in the medical record over the past 5,000 years*



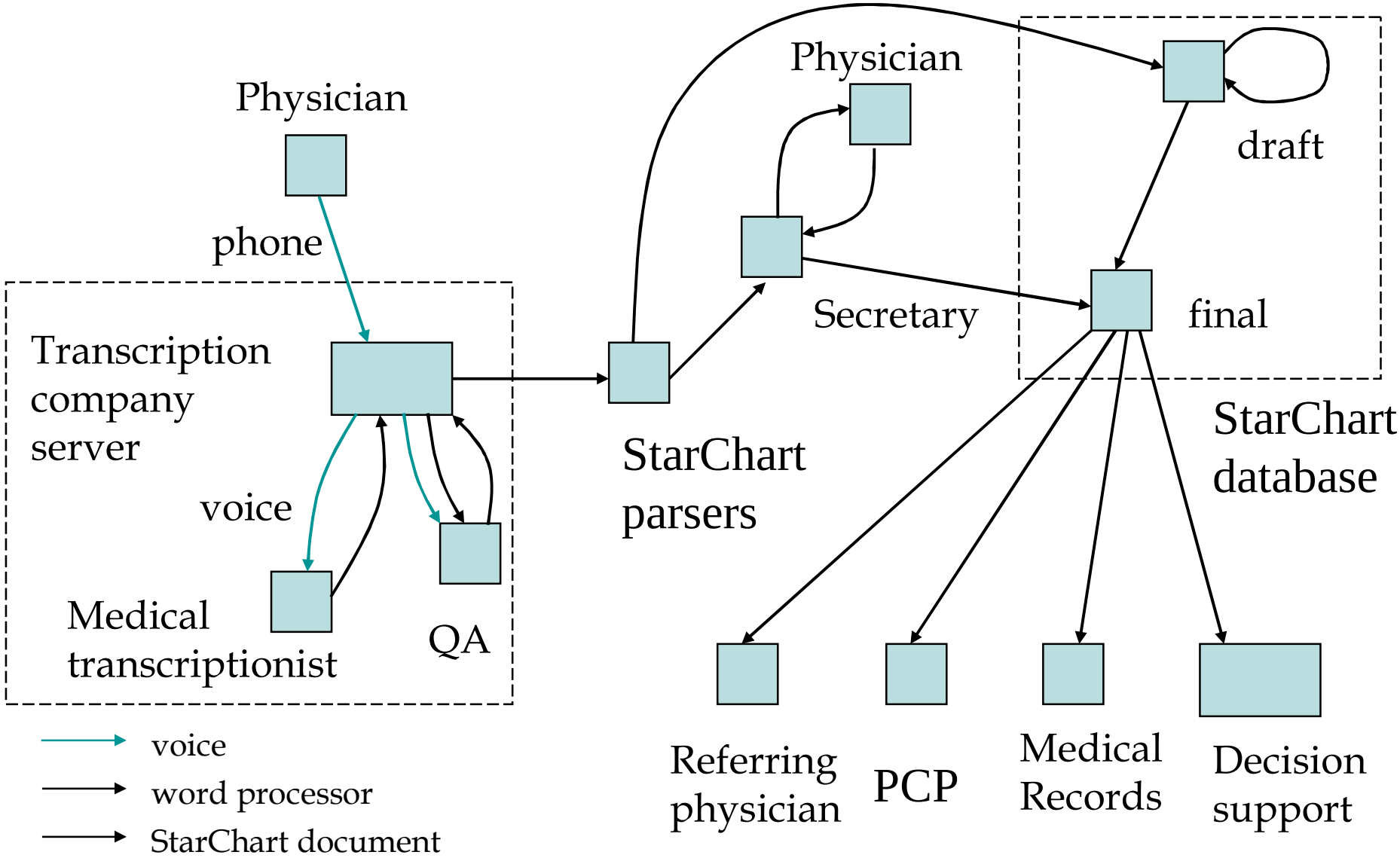
## Role of new technology: opportunity for NEW processes, not just replication of old processes using computers

1. **Single-facet HIS (electronic chart; electronic order entry) concentrates on the smaller portion of the problem.**

2. Communication among providers
(and between patient and provider) is the dominant cost
[Coiera E. When conversation is better than computation. JAMIA 2000;7:116-24] in health care.

3. Support for inter-personal communication needs to be focus for future HISs.

# A Document's Information Flow: from D. Giuse, J. Jirjis



# Conclusion

**Diseases desperate grown**
**By desperate appliance are relieved,**
**Or not at all.**

William Shakespeare, 1600; *Hamlet*, Act: IV, Scene: iii