INTEGRATED COMPUTER NETWORK FOR ACUTE PATIENT CARE

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ABSTRACT

Care of the acutely ill hospitalized patient places unusual demands on the practicing physician. Large amounts of physiologic, laboratory and other patient related data must be quickly and efficiently obtained and acted upon. The therapy for these patients is complex and time dependent and must be accurately documented. To help meet these demands an integrated computer network has been established to speed data communications, provide integrated data reporting and assist in medical decision-making. Experience with this computer network and its impact on patient care are discussed.

INTRODUCTION

Care of the acutely ill hospitalized patient places requirements on the practice of medicine which are demanding of both time and intellect. Some of the complexities caused by these acute events are: 1) the patient's physician is not always present when decisions are required, 2) data required for decision-making is complex, voluminous, and requires considerable time to acquire, process and report, 3) there are "teams" of physicians involved in the care of the acutely ill complicating communications. At times data can be lost, misplaced or ignored. 4) care of the acutely ill requires integration of all patient data to synthesize a rational treatment plan, 5) experience has shown that in some situations patient treatment can be delayed, even when evidence of impending crisis was available hours to days before an action was taken.

For these reasons and the belief that computers could aid in the care of the acutely ill patient, we have established an integrated computer network to assist in the care of these patients (1). The system know as HELP is operational at LDS Hospital in Salt Lake City. It serves this 520 bed tertiary care center which includes 64 intensive care beds.

SYSTEM

The HELP system acquires data from a wide variety of hospital areas: 1)admitting-discharge -transfer information is obtained from the admitting office and through nursing divisions. Admitting diagnoses are also entered into the system during patient admission, 2) order entry information is obtained from nursing divisions and service departments such as radiology, 3) laboratory data are obtained from a computerized clinical laboratory system interfaced to the network and from other laboratories such as the blood gas laboratory via direct interface to the HELP system, 4) Radiology data with computer assisted interpretations are obtained directly from radiologists(2), 5) pharmacy prescriptions and drug allergies are entered by clinical pharmacists on the nursing divisions, 6) infectious disease data are obtained from a computerized clinical microbiology laboratory as well as from a specialized infectious disease monitoring group, 7) physiological data from intensive care patients are automatically obtained from bedside monitors. Data on drugs given, fluid balance, and patient observations are entered by compter technicians and nurses. 8) respiratory therapy data are entered by therapists as procedures are performed 9) surgical procedures performed are promptly encoded into the system by the surgery department.

All of the above data entry is made possible by a network of microcomputers connected to the central HELP system running on a TANDEM computer. The system is basically a star network with the TANDEM computer at the center. The TANDEM computer is a highly reliable system with little downtime because of its architecture and supporting software. Currently the central TANDEM system is consists of 6 processors with over 1,500 million bytes of disc storage. There are 18 microcomputers connected to the system and more than 250 terminals and 70 serial printers and plotters connected to the system. The system also interfaces to the hospital billing system. Charges are automatically captured whenever a procedure is completed, an item is delivered or if a drug or IV is given in an ICU.

It became apparent as the system was being developed that two resources were always in short supply: 1) sufficient terminals to allow convenient and prompt data entry and review and 2) response time was compromised during busy times of the day. To help resolve both of these problems we chose to establish a network of microcomputers (Figure 1) and distribute the

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data base. The concept was that we needed the data base in a central location to optimize the data integration function so crucial to the decision-making functions of the system. However, we found that for the intensive care patients there was about a 50 to 1 ratio between data read (reviewed) from the patient record compared with that written into the computer record. Therefore we have established distributed processing and distributed data bases. By doing this we have been able to: 1) increase the number of terminals because they are attached to the microcomputers and 2) improved the response time because the majority of the data is available "locally" on the microcomputer disc storage (Figure 1). Our new intensive care units, which are our development model, have a computer terminal (work station) at each bedside and several other terminals strategically placed throughout the unit -- clerk desks, nurses central station, physicians work area, physicians offices etc.

As can be seen from the above discussion we are rapidly moving to a more distributed processing and data base distribution.

APPLICATIONS

Application of the integrated and distributed compter network has yielded exciting results. Two examples will illustrate the power of the integrated network with decision-making capabilities.

ICU ROUNDS REPORT

Figure 2 illustrates a computer generated rounds report from a patient in an intensive care unit (ICU). The report formats data from a wide variety of sources into a body systems format which makes physician assessment more structured and convenient. Although all of the data are available to physicians in conventional ICUs, the speed and convenience provided by this report are of considerable benefit. Our ICU physicians routinely use these reportd during rounds to assess and treat patients.

INFECTIOUS DISEASE MONITORING

By linking the computerized clinical microbilogy laboratory with the HELP system we have been able to develop a Computerized Infectious Disease Monitoring system (CIDM). Using data available in the integrated patient record the computer can assist the infectious disease department in finding a patient who has one of the following conditions: 1) a hospital-acquired infection, 2) an infection at a normally sterile body site, 3) an infection caused by a bacteria with an unusual antibiotic sensitivity pattern, 4) an infection for which the patient is not receiving an antibioitic to which the offending bacteria is sensitive, 5) an infection that could be treated with a less expensive antibiotic, 6) an infection that is required by law to be reported to state or national health authorities and 7) those patients receiving prophylactic antibiotics longer than is medically indicated. Figure 3 is an example of a printout from the CIDM. It shows a patient with a possible nosocomial (hospital acquired) infection suspected because of an inflitrate on

FIGURE 1. DATA NETWORK FOR DISTRIBUTED ICU/NURSING DIVISIONS

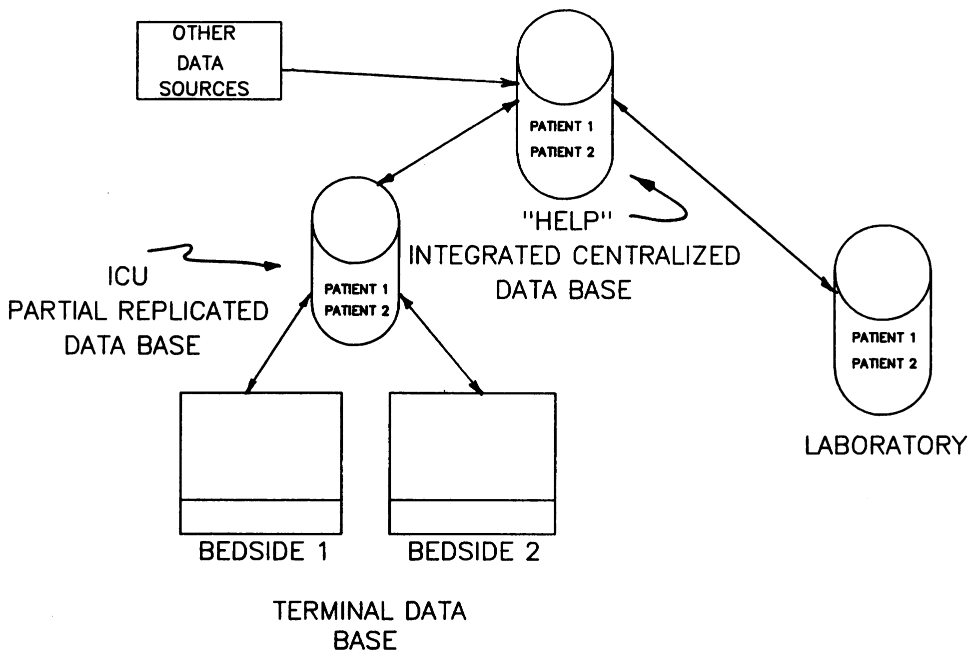

FIGURE 2.

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                       L D S   H O S P I T A L   I C U   R O U N D S   R E P O R T
                                        DATA WITHIN LAST 24 HOURS

NAME: FL                                  NO.   44665        ROOM: E411                                  DATE: AUG 13 06:05
DR. REES,                        SEX: M   AGE:  44   HEIGHT: 179   WEIGHT:  77.00   BSA:  1.96   BEE:  1717    MOF:    8
==========================================================================================================================
CARDIOVASCULAR: 1                                                              EXAM: _________________________________
TIME              CO     CI    HR   SV   SI    VP   MSP   MP SVR LWI PW   PA   PVR     RWI    _________________________________
AUG 13 06:00    6.60  3.37   110   60   31 10.0M   83   73 10   30  12   26   2.1     6.7
        AUG 13 06:00  DOPAMINE (INTROPIN)  6.00 MCG/KG/MIN
        MILD LV DYSFUNCTION
                        SP     DP     MP    HR  ! LACT          CPK          CPK-MB       LDH-1        LDH-2
  LAST VALUES           94     62     73   110  !
  MAXIMUM              285    285    285  *22   ! 3.7 (15:05)     (     )      (     )      (     )      (     )
  MINIMUM               60     30     42    83  !
  HEART RATE =  95   QRS =  80   PR =        QRS AXIS =   75
        **** PHYSICIAN OVERREAD ****
  ABNORMAL ECG
      ATRIAL FIBRILLATION WITH MODERATE VENTRICULAR RESPONSE (60-100 PER MIN)
      LEAD(S) MISSING
      EARLY TRANSITION, CONSIDER NORMAL VARIANT, RVH OR TRUE POST MI
      NON-SPECIFIC ST-T ABNORMALITIES
  NO SIGNIFICANT ECG CHANGES SINCE 08/09/1984.02:05
==========================================================================================================================
RESPIRATORY: 3
AUG 13 84       pH     PCO2     HCO3     BE   HB    CO/MT    PO2    SO2    O2CT    %O2  AVO2  VO2    C.O.  A-a  Qs/Qt  PK/ PL/PP  MR/SR
13 05:36 V    7.50     34.7     27.0    5.0  14.5    1/ 1     35     65    13.2     50                                     /   /15  18/
13 05:35 A    7.53     28.8     24.1    3.5  14.5    2/ 1     57     90    18.3     50   5.05              210   30        /   /15  18/
        SAMPLE #  28, TEMP 38.4, BREATHING STATUS : ASSIST/CONTROL
        MODERATE ACUTE RESPIRATORY ALKALOSIS
        HYPERVENTILATION (PREVIOUSLY NORMAL)
        MILD HYPOXEMIA
13 03:15 A    7.53     32.1     26.8    5.5  12.7    2/ 1     64     91    16.2     45                      170              /   /15  18/
12 23:40 A    7.51     34.2     27.3    5.4  14.0    2/ 1     70     92    18.1     60                      253              /   /15  18/
12 18:21 V    7.50     35.0     27.2    5.2  13.8    1/ 1     38     71    13.7     70                                     62/ 54/15  18/
12 18:20 A    7.51     31.0     24.7    3.4  13.7    2/ 1     64     92    17.7     70   4.10              322   33       62/ 54/15  18/
         RATE    VT     VE      VC     MIF      COMP     VD/VT    VCO2    EXAM:                            X-RAY:

    ON  ______ _____ _____ ______ _______ _______ _______ _______ !                                    !
    OFF ______ _____ _____                                        !                                    !
==========================================================================================================================
NEURO AND PSYCH: 0
    GLASGOW 15 (     ) VERBAL ________   EYELIDS ________   MOTOR __________   PUPILS _______   SENSORY _______

    DTR ___________   BABIN. ________   ICP ____________   PSYCH __________
==========================================================================================================================
COAGULATION: 1
    PT:   11.5    (05:40) PTT:     47 (05:40) PLATELETS:   65 (05:40)   FIBRINOGEN:     (     ) EXAM: _________________________
    FSP-CON:      (     ) FSP-PT:     (     ) 3P:         (     )                                  _________________________
==========================================================================================================================
RENAL, FLUIDS, LYTES: 0
   IN   1495 CRYST   1495  COLLOID           BLOOD        NG/PO            ! NA    146 (05:40) K     4.0 (05:40)  CL  109   (05:40)
   OUT  7495 URINE   4400  NGOUT      1030   DRAINS  520 OTHER      1545   ! CO2    26 (05:40) BUN  23   (05:40)  CRE   1.0 (05:40)
   NET -6000 WT            WT-CHG     0.00   S.G.    1.035                 ! AGAP  15.0        UOSM               UNA       CRCL
==========================================================================================================================
METABOLIC --- NUTRITION: 0
   KCAL        254   GLU  145    (05:40)   ALB     2.4 (05:40)  !  CA    7.1 (05:40)    FE     3.4 (05:00)   TIBC     206 (05:00)
   KCAL/N2           UUN         (     )   N-BAL                !  PO4   3.4 (05:40)    MG         (     )   CHOL     125 (05:40)
==========================================================================================================================
GI, LIVER, AND PANCREAS: 1                                                                                      EXAM:
   HCT      46.2 (05:40)  TOTAL BILI    4.3 (05:40)  SGOT   52 (05:40)  ALKPO4   74 (05:40)  GGT       52 (05:40) ____________
   GUAIAC        (     )  DIRECT BILI   2.5 (05:40)  SGPT   24 (05:40)  LDH    1195 (05:40)  AMYLASE   (     )   ____________
==========================================================================================================================
INFECTION: 2
   WBC 17.7 (05:40) TEMP  39.1 (02:00) DIFF  16B, 77P,  7L,   M,   E (05:40) GRAM STAIN: SPUTUM ___________ OTHER _________
CULTURES:
   BLOOD _______  SPUTUM ________  URINE _________  CSF ________  CATH ________  WOUND _________  OTHER ______________
==========================================================================================================================
SKIN AND EXTREMITIES:
   PULSES ________  RASH ________  DECUBITI ____________
==========================================================================================================================
TUBES:
   VEN ________  ART ________  SG ________  NG ________  FOLEY ________  ET ________  TRACH ________ DRAIN______

   CHEST _____________ RECTAL ______ JEJUNAL ________  DIALYSIS ________  OTHER ______________________________________
==========================================================================================================================
MEDICATIONS:

MORPHINE, INJ                          MGM   IV        5.0   DOPAMINE, INJ                        MGM   IV        390
ACETAMINOPHEN, SUPP                    MGM   RECT     4550   VERAPAMIL, INJ                       MGM   IV        5.0
DIAZEPAM (VALIUM), INJ                 MGM   IV       12.5   FUROSEMIDE, INJ                      MGM   IV         70
CEFAZOLIN (ANCEF), INJ                 MGM   IV      12000   CIMETIDINE (TAGAMET), INJ            MGM   IV       1200
AMIKACIN, INJ                          MGM   IV        975   POTASSIUM PHOSPHATE, INJ             MEQ   IV       80.0
CLINDAMYCIN (CLEOCIN), INJ             MGM   IV       1800   POTASSIUM CHLORIDE, INJ              MEQ   IV       46.0
METAPROTERENOL (ALUPENT), SOLUTION     MGM   INHAL    60.0
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FIGURE 3.

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***** PAT WITH POSSIBLE NOSOCOMIAL SPUTUM (INFILTRATE ON X-RAY) *****
***** PAT. NOT ON APPROPRIATE ANTIBIOTIC *****
***** PIPERACILLIN WOULD BE A LESS EXPENSIVE ANTIBIOTIC *****
@PAT: 4366787 S      , MICHAEL L                          46  M   4S30
 DOC: PRICE, RICHARD R.              COLLECTED: 01/01/84 11:26
 ADMITTED: 12/22/83 22:08   ADMIT DIAG: TRAUMA
 NO PREVIOUS ADMITS
 SURGERY
  --NONE LISTED--
 CURRENT ANTIBIOTICS
  01/03/84 05:50 AMPICILLIN  2000MGM, INJ   Q 6 HRS
 CULTURE RESULTS         -INTERIM REPORT-          ROUTINE CULTURE
  SOURCE: SPUTUM
  STAIN: FEW EPITHELIAL CELLS
         NUMEROUS WBCS
         MODERATE NUMBER OF GRAM NEGATIVE BACILLI
         FEW GRAM POSITIVE BACILLI
         MODERATE NUMBER OF GRAM NEGATIVE COCCI
         MOD. NUMBER OF GRAM POS. COCCI IN CHAINS
  RESULT: KLEBSIELLA PNEUMONIAE   LIGHT GROWTH
   SENSITIVE TO: Cephalosporin,Chloramphenicol,Gentamicin,
                 Cefoperazone,Trimethoprim-sulfamethoxazole,
                 Tobramycin,Amikacin,Cefamandol,Cefoxitin,
                 Moxalactam,Cefotaxime,Piperacillin
   INTERMED. TO: Tetracycline
   RESISTANT TO: Ampicillin, Carbenicillin
  RESULT: ENTEROBACTER CLOACAE    LIGHT GROWTH
   SENSITIVE TO: Cephalosporin,Chloramphenicol,Gentamicin,
                 Cefoperazone,Trimethoprim-sulfamethoxazole,
                 Tobramycin,Amikacin,Cefamandole,Moxalactam,
                 Cefotaxime,Piperacillin
   INTERMED. TO: Ampicillin, Tetracycline,Cefoxitin
   RESISTANT TO: Cephalosporin
  RESULT: STREPTOCOCCUS ALPHA HEMOLYTIC   HEAVY GROWTH
  RESULT: NEISSERIA   MODERATE GROWTH
  RESULT: YEAST   LIGHT GROWTH
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a chest X-Ray (radiology) and microbiology data. The patient is not on an appropriate antibiotic -- determined by knowing the antibiotic the patient is on (pharmacy) and knowing the sensitivity of the bacteria (microbiology). The computer also makes a suggestion that piperacillin would be a more appropriate and less expensive antibiotic. Also contained in the report is information identifying the patient, why he was admitted, what surgery he may have had, whether he had been in the hospital recently and if he had any antibiotic allergies. Integrating the microbiology data with medical from other areas and applying the knowledge of infectious disease experts has resulted in a powerful computer tool. Preliminary analysis of the results of use of the CIDM has shown it to be more efficient, more accurate, and more prompt than traditional methods of identifying hospital acquired infections. As a result of these preliminary results the CIDM is currently being used to augment the Infection Control Practitioiners at LDS Hospital.

CONCLUSIONS

Integrated computerized patient records combined with computerized medical decision-making provide physicians and nursing staffs with improved tools for patient care. The records are promptly available from multiple terminals, are legible, are organized, and are convenient to use. Integration of the data independent of its department of origin (laboratory, pharmacy etc) by body system or function is very helpful to the physician decision-maker. The application of decision-making logic to an integrated data base has great promise because of the timely and accurate detection of life threatening situations.

REFERENCES

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2. Clayton PD, Ostler DB, Gennaro JL, Beatty SS, Frederick PR. A radiology reporting system based on most likely diagnosis. Comput Biomed Res 13:258-270, 1980