Clemmer TP, Gardner RM. Data gathering, analysis, and display in critical care medicine. *Resp Care* 1985;30:586-598.

Data Gathering, Analysis, and Display in Critical Care Medicine

Terry P Clemmer MD and Reed M Gardner PhD

The rapid expansion of medical knowledge and technology has k e n partly responsible for the development of critical care medicine over the past 20 years. For the most part, this development has been favorable, but it has also resulted in new problems. One of these problems has been the shift of attention away from the global assessment of the patient towards collecting enormous amounts of data. We often become intent on obtaining a 'number' that will allow earlier identification of a developing problem or clarification of a patient's physiologic state. In this process, we have often neglected the art of observing the patient and interpreting the expression on the patient's face and king Sensitive to the slightly different sound in the noisy intensive care unit (ICU) environment that might help us detect patient distress or the malfunction of a piece of fife support equipment. Too often we forget that the best patient monitor is a staff member at the bedside and that the most valuable skill the nurses and therapists have is their ability to interpret subtle, nonspecific changes in the patient and his environment, indicators that we are unable to put into numerical form.

Additional problems arise when important information is obscured because of the mass of data generated and recorded in modern ICUs. This has resulted in the need to communicate, organize, and integrate the large volume of data in a manner that will accentuate and focus on the information that is most pertinent to the care of the patient.

Data collection and organization is complicated by several factors. The patient with multi-organ-system failure is cared for by a team of physicians, nurses, therapists, and technicians, each contributing observations and measurements. In addition, patient data come from a variety of other sources in the hospital (Table 1) and must be transmitted to the primary care providers who make the therapeutic decisions. As a result, hundreds of items of data are transmitted daily by oral communication, chart, telephone, messenger, pneumatic tube, electronic message devices, and computer. This results in a hodgepodge of reports and notes that must be assembled, organized. and integrated prior to analysis. Mistakes are possible when information is passed along by several persons prior to being received by the ultimate decision maker.

If one examines how the large quantity of laboratory data is generated and processed, it is surprising that there are so few errors. Commonly, a nurse draws the blood for a chemistry study ordered by the physician. The clerk labels it, and a messenger takes it to the laboratory, leaving it at the desk to be logged in. Later, it is taken into the laboratory, where a technician runs the test and then phones the results to a clerk, who copies the information on a piece of scratch paper for the nurse. The nurse calls the results to the physician's office, where a secretary transcribes the data and gives them to the physician. This process may be repeated hundreds of times a day in a large hospital.

Once the data are obtained, additional processing may be required to clarify the physiologic state of the patient. For example, from blood gas data and the measured hemodynamic values, a large array of derived data is computed. In our ICU, over 140 different data items are generated daily on each patient. Because many items are measured and recorded more than once, over 500 separate items of data are transmitted per patient each day. In the midst of this mass of data, most of it unchanging, may be some very important new information. Thus, emphasis on important changes, as well as collection, integration, and analysis of the data, is required.

Dr Clemmer is Director of Critical Care Medicine, LDS Hospital, Salt Lake City, Utah, and Associate Professor of Medicine, University of Utah. Salt Lake City. Dr Gardner is Professor of Medical Biophysics and Computing, University of Utah. Salt Lake City, and Co-Director of Medical Computing, LDS Hospital.

A version of this paper was presented by Dr Clemmer on November 9, 1984, during the Conference on Monitoring of Critically ID Patients, held in Puerto Vallarta, Mexico, and sponsored by the American Association for Respiratory Therapy and its scientific journal, RESPIRATORY CARE.

Reprints: Terry P Clemmer MD, Director of Critical Care edicine, LDS Hospital, 325 8th Avenue, Salt Lake City UT 84 143.

Table 1. Sources of Data Used in the ICU

ICU
Clinical Laboratory
Pulmonary Function Laboratory (blood gases)
Pharmacy
ECG Laboratory
Radiology
Medical Records
Echocardiography Laboratory
Food Services
Catheterization Laboratory
Biophysics
Pathology
Emergency Room or Admitting Office

Recently, Bradshaw identified data that were most commonly used for decision making in an ICU,[1] He studied the decision-making process during formal ICU rounds each morning and at the bedside during the day. The information used in the process was divided into six categories: clinical laboratory data; blood gas data; pharmacy orders, including intake and output data; Wide-monitor records; physical observations; and "other" (eg, history, electrocardiogram [ECG], and radiology data). Laboratory data accounted for 32% of the information used in decision making during formal rounds, but for only 18% of the information used for decisions at the bedside (Table 2). Conversely, Wide-monitor data and blood gas information were more important to decision making at the bedside than to decision making during rounds (22% vs 12% and 20% vs 10%, respectively). It is interesting to note that the computer record consisted primarily of intake/output records and drug data (36%--see Table 2) and bedside monitoring data (32%-see Table 2), with the rest of the record being divided fairly evenly among laboratory, observational, blood gas, and other data.

The frequency of data usage and the method of integration of data in decision making are key to data organization and presentation. Most written and printed reports are quite bulky, of different size and formats, and not chronologically organized. It is difficult to file them in a chart so that related data are displayed in a manner that assists the health care provider in making decisions. Therefore, to help organize and correlate the data for display and decision making, data users recopy the data onto flow sheets (Fig. 1) or re-enter them into

Table 2. Percentages of Data Used in Decision Making. Shown by Source and by Circumstance of Decision Making. Together with Percentages of Kinds of Data Available in Computer Record

	Laboratory*	Input/ Output	Bedside Observations	Blood Gases	Drugs: Monitor	Other
In formal rounds	32	23	21	12	10	2
At bedside	18	13	22	22	20	5
% of data in computer record that comes from each source	9	36	7	32	8	8

*For example, laboratory data comprises 32% of the data used for decision making during formal rounds but only 18% of data used for decision making on other occasions at the bedside; and laboratory data comprises 9% of all the data that is available in the computer record

dedicated ICU computers. Some hospitals have fully integrated systems in which the data from all hospital services are on-line and can be processed and organized automatically for optimum display.[2]

Opinions about how to display the data are as variable as the number of users in the hospital. A simple method is to generate the reports in a chronological order so that when they are reviewed, trends can be quickly recognized. Most computerized laboratory reports use this format, as shown in Figure 2. In this case, the computer displays the old data as well as more recent values. All data are stored and available for easy retrieval. This eliminates the problem of having some data lost or unavailable for trend analysis. This format, a simple list, does not allow manipulation of the data to help clarify the physiologic state of the patient nor does it help interpret the data or link them to other related items. Figure 3 demonstrates how computer functions can be further used to assist the health care provider. In this example, the computer derives the bicarbonate (HCO_3^-) and base excess (BE) from the pH and PCO_2 to help clarify the acid-base status of the patient. In addition, it uses the measured PO_2, saturation (SO_2), and hemoglobin (HB) to calculate the O_2 content (O_2CT) and links the association between the arterial and venous samples by calculating the arterial-venous content difference (AVO_2) and the pulmonary venous admixture (Qs/Qt). In addition, the most recent cardiac output (C.O.) data are retrieved from the computer file and, if those data were obtained within 15 minutes of the blood sampling, the oxygen consumption (VO_2) is also calculated. These derived values help clarify the patient's physiologic state and allow much more sophisticated decisions to be made regarding the oxygen transport status of the patient. Also included are the inspired oxygen concentration ($\%O_2$), the positive end-expiratory pressure (PP), and the ventilatory rate (machine rate [MR] or spontaneous rate [SR]). Below these values is recorded the total number of blood gases drawn, the patient's temperature, and the breathing status (in this case. the patient is on a ventilator set in the assist/control mode). This information is necessary for the proper interpretation of acid-base and oxygen transport data Finally, a computer-generated interpretation of the acid-base status is given, along with, in this case, a warning that the severe hypoxemia should be brought to the attention of the health care providers. Previous blood values are reported for trend analysis and comparison purposes. Normal high and low values are presented as reference points at the top of the report.

Another example of integrated reporting is seen in Figure 4. Here, the computer measures cardiac output (C.O.), heart rate (HR), and vascular pressures (VP) and manipulates these values, using the patient's height and weight to calculate body surface area, which is used to normalize the data for the patient's body size. Other derived variables include cardiac index (CI), stroke functions (SV and SI), left and right ventricular work indexes (LWI and RWI), and systemic and pulmonary vascular resistance (SVR and PVR). The routine reporting of derived information helps physicians become familiar with it and enables them to become comfortable with its use in routine decision making. As in the blood gas report in Figure 3, normal high and low values are reported at the top of the report to assist those who may be unfamiliar with normal .values. In addition, to further aid interpretation, the computer retrieves data from the pharmacy section of the computer record and displays them below the hemodynamic data; this information includes all current drugs (and dosages) that might influence the cardiovascular system. As in the blood gas report, the computer generates an interpretation to help the health care providers.

Key information that can greatly aid the health care provider in data analysis and interpretation will commonly be absent unless he personally collects the data at the bedside. This global assessment includes factors like the patient's position when the data were collected, the patient's degree of cooperation, mental status, and muscle tone. and findings from the physical examination. Without this information, the proper interpretation of pulmonary mechanics-such as thoracic compliance, vital capacity, or even ventilatory rate--is difficult. Heart rate, blood pressure, and cardiac output may also significantly change between periods of distress and relaxation. This point is demonstrated in Figure 5, the respiratory care record. The measured and derived variables at the top are followed by observations-including the patient's body position, state of apprehension and/or cooperation, physical examination results, and even comments on sputum production-as an aid in data interpretation. When the person who makes the therapeutic decisions is not present when the data are collected, a means of communicating possible modifying factors, such as in this report, should be considered.

Clemmer TP, Gardner RM. Data gathering, analysis, and display in critical care medicine. *Resp Care* 1985;30:586-598.

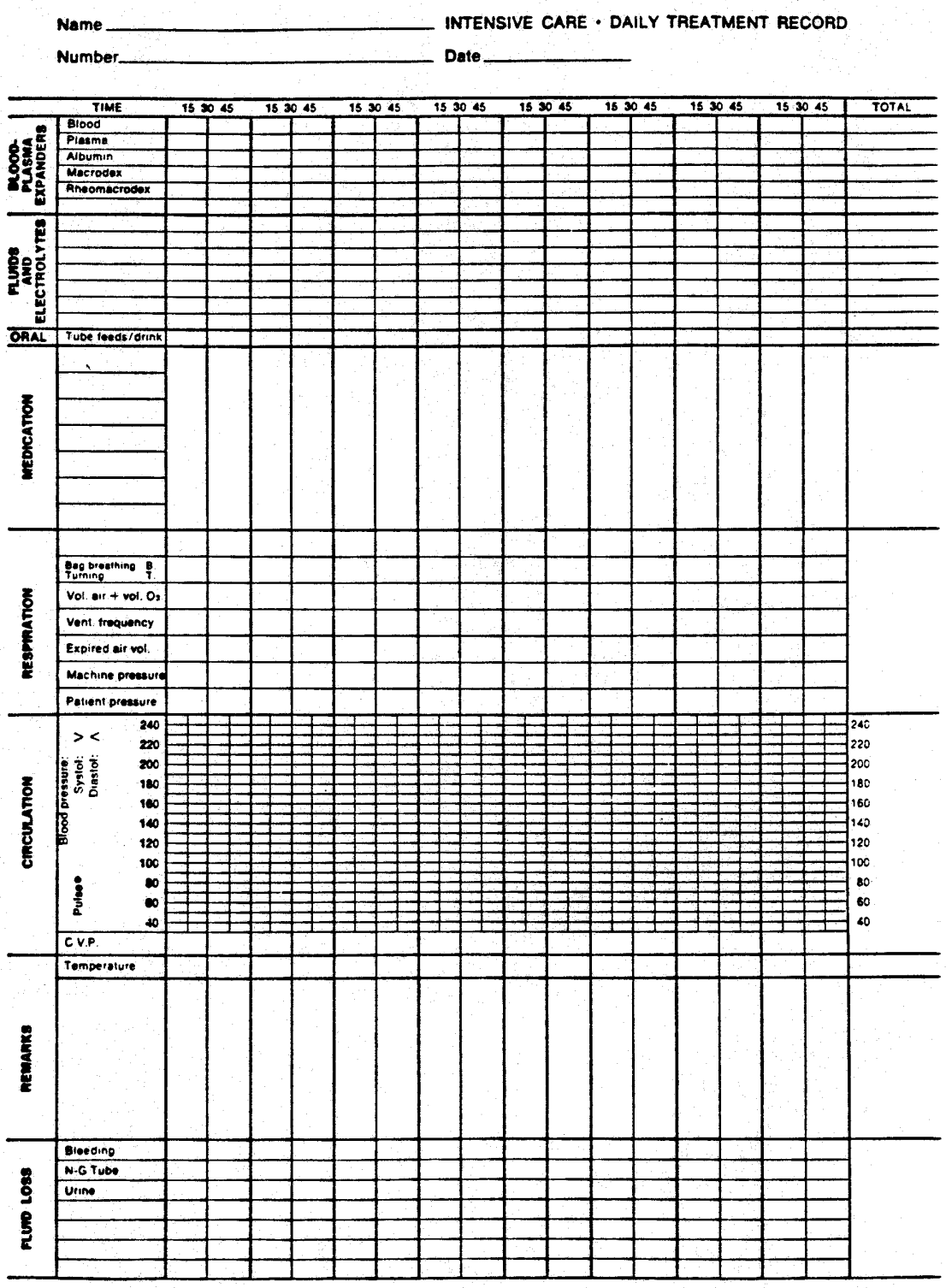


FIG. 1. A typical ICU flowsheet on which data users write in data concerning the patient's status in order to organize the data in a chronological order and allow health care providers to go to one place to find most of the current information. Laboratory values are also frequently placed on such flowsheets.

```
LAB DATA - CBC

 DATE  TIME      WBC    RBC    HOB    HCT    MCV    MCH   MCHC    PLAT
13SEP 05:10 B    6.1  4.74   14.7   43.1   90.7   30.9   34.1      46
12SEP 21:10 B    4.5  4.44   13.6   40.6   91.5   30.7   33.5      68
            COMMENT:  STAT RESULTS PHONED TO THE FLOOR
12SEP 17:26 B    3.3  4.52   13.5   41.7   92.4   29.9   32.3      88
12SEP 13:05 B    3.7  4.63   13.9   42.2   91.2   30.1   33.0     107
            COMMENT:  STAT RESULTS PHONED TO THE FLOOR
12SEP 05:15 B    5.0  4.50   14.0   40.6   90.0   31.0   34.5      29

LAB DATA - SMA-7

 DATE  TIME       NA+    K+     CL-       CO2     BUN    GLUC   CREAT
13SEP 05:10  B  143     4.5      91      18      49     425     7.2
13SEP 01:05  B  146     4.5      95      12      51     618     7.2
12SEP 21:10  B  143     4.4      94      12      48     634     6.4
             COMMENT:  SEE PRINTED LAB REPORT FOR COMMENTS
12SEP 17:26  B  148     4.8      94      12      48     580     6.6
12SEP 05:15  B  145     6.1     101      11      58     322     6.7
             COMMENT:  SEE PRINTED LAB REPORT FOR COMMENTS

LAB DATA - LACTIC ACID

DATA   TIME   VALUE
13SEP 05:10 B  19.0
12SEP 21:10 B  25.4
12SEP 17:26 B  27.6
12SEP 13:05 B  28.0
12SEP 05:15 B  25.4

LAB DATA - PTT

DATE   TIME   SECONDS
13SEP 05:10  B    47
             COMMENT:  RESULT RECHECKED
12SEP 21:10  B    69
             COMMENT:  STAT RESULTS PHONED TO THE FLOOR
12SEP 17:26  B > 130
             COMMENT:  STAT RESULTS PHONED TO THE FLOOR
12SEP 13:05  B    44
             COMMENT:  RESULTS PHONED TO THE FLOOR
12SEP 05:15  B    48
```

FIG. 2. A typical computer-generated laboratory report. The sets of laboratory values are placed in chronological order to facilitate trend analysis.

Many busy clinicians feel that the primary aim of data organization should be to save them time. They want to be able to go to one place and retrieve the data when they make bedside rounds. Thus. A format, such as a 12-hour shift flowsheet (Fig. 6) that integrates the bedside-monitor data and nursing care information (such as medications delivered, intake, output, weight, and bedside monitoring of urine and glucose), along with the latest complete blood count (CBC), blood gas values, and SMA-7, is ideal for this purpose. Here, the vital signs are given in graph form, to the right of which appears a 24-hour intake and output summary, with the patient's weights and results of bedside urine monitoring. In addition, all medications, including dosages and method of administration, are graphed according to time administered, as is the type and quantity of I.V. fluid, with the time period of I.V. fluid infusion denoted by the series of asterisks. On this sheet, 700 ml of D5/0.45% NS was infused over the entire 12-hour period. A more detailed breakdown of intake and output for the 12-hour shift is given below the medications listing.

The latest CBC and electrolyte data are given below the 24-hour intake and output summary in the upper right-hand corner. The results of blood gas analyses performed during the last shift are reported at the bottom. By presenting the most commonly used data on one sheet, this format allows the clinician to quickly review the patient's status without having to go to several places in the chart. However, more detailed data, such as other laboratory, respiratory therapy, and ECG reports, cannot all be included on such a summary sheet because of space limitation.

For long-term trend analysis, the 12-hour shift reports can be condensed into weekly summaries as shown in Figure 7. On this report, the 24-hour vital signs are reduced to a thin column. The medications are listed in the middle of the sheet by total 24-hour dosage. Below that, a summary of intake and output is given, along with the daily weights, and at the bottom, an analysis is presented of the nutrients delivered each day. This report gives ready access to long-term analysis of such items as nutritional therapy and fluid balance.

In teaching rounds, we use another method of reviewing data on patient status-data display by organ system (Fig. 8). In this report, all pertinent data relating to any given organ system are grouped together so that they may be reviewed conjointly. Thus, we see under "cardiovascular" the hemodynamic data, current blood pressure, and heart rate, along with the maximum and minimum values in the past 24 hours, the latest ECG report, the serum lactate, lactase dehydrogenase (LDH), and creatinine phosphokinase (CPK) values. A similar format is used for each organ system. AI the bottom of the report, all the invasive catheters are listed, as are the medications. There are many patient-status data, such as these from the physical examination, to which the computer does not have access. These are represented by a blank line and must be added by the clinician.

```
                              L D S   H O S P I T A L   B L O O D   G A S   R E P O R T

                          NO. 3515624 DR STEVENS, LAWRENCE E.     RM E402

SEP 13 84      pH     PCO2    HCO3    BE    HB    CO/NT   PO2   SO2   O2CT   %O2  AVO2  VO2   C.O.  A-a  Qs/Qt  PK/ PL/PP  MR/SR
               --     ----                               ---
NORMAL HI    7.45    40.0    25.0   2.5  19.0   2/ 1    85    95   25.4         5.5  300   7.30         5
NORMAL LOW   7.35    34.0    19.0  -2.5  15.0   0/ 1    68    93   19.6         3.0  200   2.90         0

12 22:51 V   7.23    38.8    15.8 -10.9  13.6   1/ 1    36    56   10.7    70                                /   /18  25/
12 22:50 A   7.26    32.6    14.3 -11.4  13.6   1/ 1    52    81   15.4    70   4.70 385   8.20  333   48      /   /18  25/
          SAMPLE #  28, TEMP 37.6, BREATHING STATUS : ASSIST/CONTROL
          MODERATE METABOLIC ACIDOSIS-INADEQUATE RESP COMPENSATION
          HYPERVENTILATION CORRECTED
          SEVERE HYPOXEMIA BREATHING OXYGEN **CONTACT MD OR RN!!!!

12 21:36 V   7.23    36.9    15.0 -11.6  13.3   1/ 1    35    58   10.8    70                                60/ 45/15  25/
12 21:35 A   7.27    29.9    13.4 -11.9  12.9   1/ 0    52    83   15.0    70   4.53 422   9.30  335   47    60/ 45/15  25/
          SAMPLE #  27, TEMP 37.6, BREATHING STATUS : ASSIST/CONTROL
          MODERATE METABOLIC ACIDOSIS-INADEQUATE RESP COMPENSATION
          HYPERVENTILATION NOT IMPROVED
          SEVERE HYPOXEMIA BREATHING OXYGEN **CONTACT MD OR RN!!!!

12 18:46 V   7.20    33.2    12.6 -14.3  12.3   1/ 1    34    55    9.5    64                                55/ 45/15  25/
12 18:45 A   7.23    28.4    11.6 -14.4  12.3   1/ 0    53    82   14.2    64   4.74            300   44    55/ 45/15  25/
          SAMPLE #  26, TEMP 37.5, BREATHING STATUS : ASSIST/CONTROL
          MODERATE METABOLIC ACIDOSIS-INADEQUATE RESP COMPENSATION
          HYPERVENTILATION (PREVIOUSLY NORMAL)
          SEVERE HYPOXEMIA BREATHING OXYGEN **CONTACT MD OR RN!!!!

KEY: CO=CARBOXY HB, MT=MET HB, O2CT=O2 CONTENT, AVO2=ART VENOUS CONTENT DIFFERENCE (CALCULATED WITH AVERAGE OF A & V HB VALUES)
 VO2=OXYGEN CONSUMPTION, C.O.=CARDIAC OUTPUT, A-a=ALVEOLAR arterial O2 DIFFERENCE, Qs/Qt=SHUNT, Pk=PEAK, PL=PLATEAU, PP=PEEP
 MR=MACHINE RATE, SR=SPONTANEOUS RATE.        *** SPECIMEN IDENTIFICATION: BLOOD (A=ARTERIAL, V=VENOUS, C=CAPILLARY, W=WEDGE);
                                              FLUIDS (P=PLEURAL, J=JOINT, B=ABDOMINAL, S= ABCESS); E=EXPIRED AIR.
```

FIG. 3. In this example of integrated reporting, the raw data (pH, PO_2, PCO_2, SO_2, Hgb, carboxyhemoglobin, and FIO_2) are processed by the computer to give HCO_3, BE, O_2 content, and A-a gradient. In addition, the venous and arterial samples are compared to each other, and the A-vO_2 content difference is calculated along with the pulmonary venous admixture (Qs/Qt). The cardiac output is retrieved, and O_2 consumption (VO_2) is calculated. The ventilator pressures and rate are also displayed, and an interpretation is generated by the computer. Previous values have been retrieved for trend analysis.

When no data were obtained in the previous 24 hours, the space is left blank, which is indicated by parentheses. This format helps to focus attention on all patient care concerns and forces medical personnel to consider all the patient's problems and potential problems each day. We have used this formal in presenting patients in teaching rounds each morning for several years and find it very useful in organizing patient care and in communicating with all health care providers responsible for that care.

Other methods of displaying ICU data have been described and used over the years to try to communicate the patient's status more rapidly and clearly. Bar graphs, such as the one shown in Figure 9, have been used to display physiologic profiles,[3] blood gas values, blood chemistry values, and the nutritional state of the patient.[4] They Serve the function of bringing related data together in a manner that allows the reviewer to quickly recognize values that are outside the normal range. However, such displays are cumbersome and not sufficiently accurate for the reviewer who wants to determine the exact value of a variable. For example, in Figure 9, the reviewer must stop and concentrate on the pulse rate scale to realize that the slash markings are for every four

```
                    C A R D I A C   O U T P U T   R E P O R T

                              NO. 3515624 DR STEVENS, LAWRENCE E.     RM E402
HT 183 CM    WT 153.30 KG     BSA  2.66 SQM
TIME              CO    CI    HR  SV  SI   VP  MSP  MP SVR LWI PW  PA  PVR   RWI
NORMAL HI       7.30  3.50   89 101  48  5.0  123 105 18  85  12  19  1.0  11.0
NORMAL LOW      2.90  2.80   49  47  38  1.0   80  70 12  48   4   9  0.5   8.0

SEP 13 03:50   8.40  3.15  144  58  22 14.0M  71  54  5  17  14  25  1.3   3.3
          SEP 13 03:00  LEVOPHED (LEVARTERENOL)  21.3 MCG/MIN
          SEP 13 00:05  DOPAMINE (INTROPIN)  15.0 MCG/MIN
          HYPOVOLEMIA AND LV DYSFUNCTION

SEP 12 22:48   8.20  3.08  141  58  22 18.OM  71  57  5  16  18  30  1.5   3.6
          SEP 12 22:40  LEVOPHED (LEVARTERENOL)  12.8 MCG/MIN
          SEP 12 22:15  DOPAMINE (INTROPIN)  13.0 MCG/KG/MIN
          SEVERE LV DYSFUNCTION

SEP 12 21:30   9.30  3.49  136  68  26 16.0M  76  54  4  21  18  30  1.3   5.0
          SEP 12 21:30  DOPAMINE (INTROPIN)  15.0 MCG/KG/MIN
          SEP 12 21:30  LEVOPHED (LEVARTERENOL)  10.0 MCG/MIN
          SEVERE LV DYSFUNCTION

SEP 12 04:00  11.10  4.35  114  97  38 13.0M 131 110  9  61  12  34  2.0  10.9
          SEP 12 00:45  DOPAMINE (INTROPIN)  20.0 MCG/KG/MIN
          LV PARAMETERS ARE WITHIN NORMAL LIMITS
```

FIG. 4. In this integrated report, the cardiac output, heart rate, and vascular pressures are processed to give indexes based on body surface area for stroke volume, stroke work, and vascular resistance. The pertinent cardiovascular drugs, with their dosages, that were being administered at the time the measurements were obtained are reported to help with interpretation.

beats and that the actual rate is 124 beats per minute. The display is bulky and requires a lot of storage space. The same data could be organized in digital form in one tenth of the space, with time trending displayed on the same report.

Among other attempts at graphic displays are circlegrams, which display the data on radial branches of a circle, with normal values describing the circle[5-7] (Fig. 10). Deviations from normal values create patterns that can be used to assist health care personnel to interpret the data via pattern recognition. Whether this method is

```
                              LDS HOSPITAL   RESPIRATORY CARE CHARTING

09/13/84                                        VENTILATOR MONITORING
        VENT MODE  VR  VT  O2%  PF TEMP   PK  PL  PP  m-VT c-VT s-VT MR  SR  TR  M-VE S-VE totVE  COMP  EAR-OX OX  CUFF P   CF
13 08:40 B-II A/C   16  800  35  50 32.0   45  30   5        616      16           9.9             24.6    96               5.1
13 05:50 B-I  A/C   16  800  35  50 37.0   50  38   5        674      25           16.8            20.4                     5.1
13 04:05 B-II A/C   16  800  36  50 37.0   55  38   5        582      21           12.2            17.6    91          20   5.1
13 01:45 B-II A/C   16  800  35  50 37.0   44  25   5        658      17           11.2            32.9                     4.6
13 00:26 B-II A/C   16  800  35  50 37.0   52  28   5        590      17           10.0            25.6                     4.6

09/13/84 THPST#/DUR/ENTRY                              VENTILATOR OBSERVATIONS
13 08:40 38671/ 10/08:49   INTERFACE: TRACH TUBE;  BREATH SOUNDS: RHONCHI, THROUGHOUT INSPIRATION AND EXPIRATION, BOTH LUNGS;
         POSITION: FOWLER;  PATIENT CONDITION: ALERT;  COMMENT: SUCTIONED SMALL AMT WHITE SPUTUM, NO MORNING ABGS
13 06:10 46547/ 10/06:16   -RESPIRATORY PARAMETERS-            HR    RR    VT     VC     VE    MIP   MEP   MVV  PK FLOW
                                                              103    22    282    307    6.2   -48
         POSITION: FOWLER;  PATIENT CONDITION: APPREHENSIVE;  POSITION: FOWLER;  PATIENT CONDITION: APPREHENSIVE;
13 05:50 46547/ 10/06:11   INTERFACE: TRACH TUBE;  EQUIPMENT NOT CHANGED;  POSITION: SUPINE;
13 04:05 46547/ 10/04:11   INTERFACE: TRACH TUBE;  BREATH SOUNDS: WHEEZING, THROUGHOUT INSPIRATION AND EXPIRATION, BOTH LUNGS,
         COARSE CRACKLES, THROUGHOUT INSPIRATION AND EXPIRATION, BOTH LUNGS;  EQUIPMENT NOT CHANGED;  POSITION: SUPINE;  COMMEN
         PROD 2CC THINK YELLOW MUCUS WITH SUCTIONING
13 01:45 46547/  7/01:52   INTERFACE: TRACH TUBE;  EQUIPMENT NOT CHANGED;  POSITION: SUPINE;
13 00:26 46547/ 10/00:35   INTERFACE: TRACH TUBE;  BREATH SOUNDS: WHEEZING, THROUGHOUT INSPIRATION AND EXPIRATION, BOTH LUNGS,
         COARSE CRACKLES, THROUGHOUT INSPIRATION AND EXPIRATION, BOTH LUNGS;  EQUIPMENT NOT CHANGED;  POSITION: SUPINE;
```

FIG. 5. The respiratory care record displays the ventilator settings, followed by the measured ventilator pressures, delivered tidal volume, and minute ventilation. The thoracic compliance is then calculated. Other data, such as ear oximetry values and endotracheal tube cuff pressure, are also given As further aids to data interpretation, such other items as the results of the chest examination, the patient's mental status, and sputum quantity and character are also provided

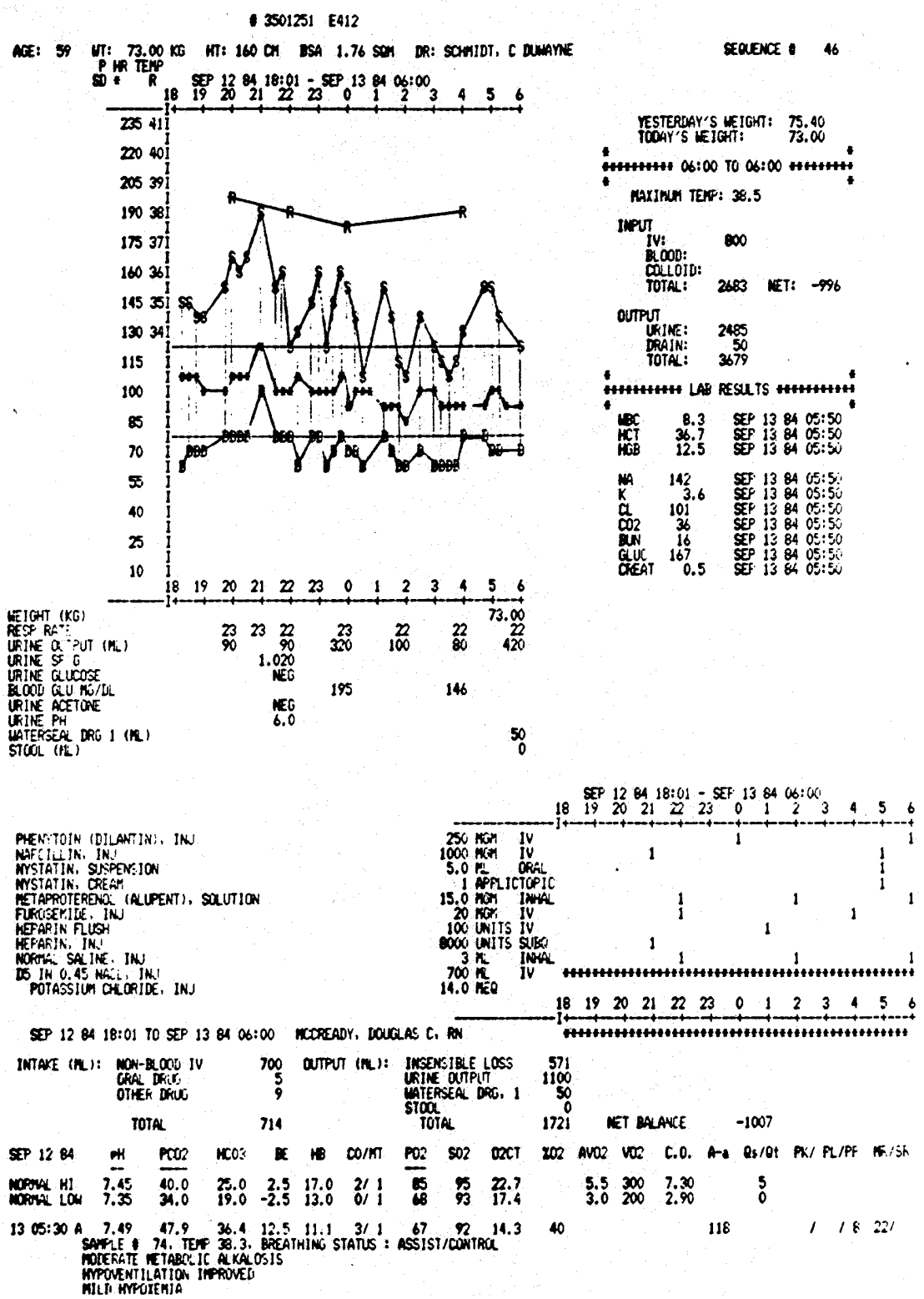
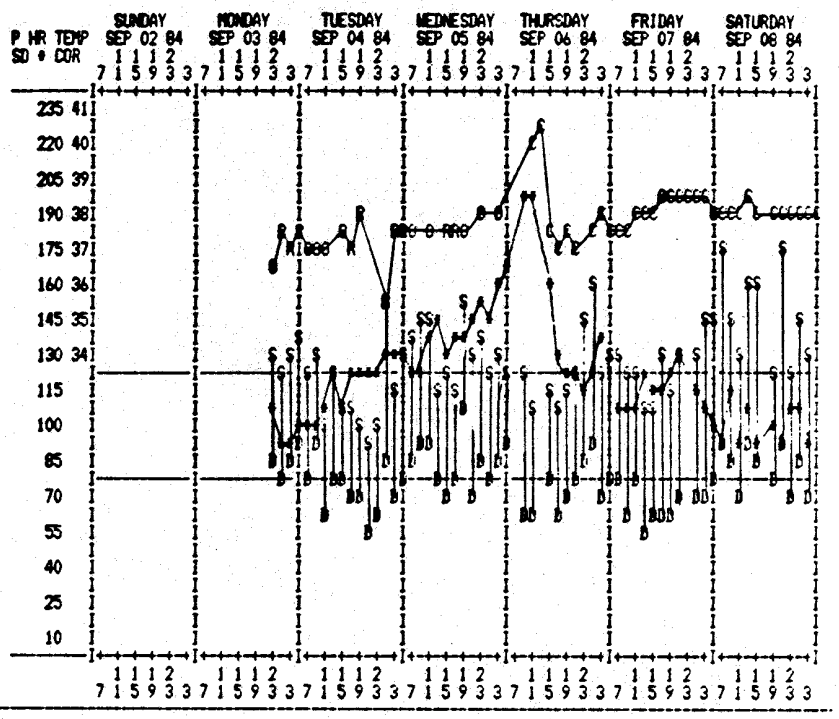


FIG. 6. Most of the information the attending physician wants for his bedside rounds is on this one 12-hour nursing report. The vital signs are given in graph form with other nursing data (weight, respiratory rate, urine output, and bedside tests) below. A 24-hour intake and output summary is given, with the latest CBC and SMA-7 below, to the right. In the middle of the sheet are all the medications administered the past 12 hours, with dosage, route, and time of administration. The I.V. fluid (D5/0.45% NS) is shown by the asterisks to have run the entire shift. A more detailed intake-output summary and the latest blood gas values are at the bottom.

Clemmer TP, Gardner RM. Data gathering, analysis, and display in critical care medicine. *Resp Care* 1985;30:586-598.



				SEP 02	SEP 03	SEP 04	SEP 05	SEP 06	SEP 07	SEP 08
MORPHINE, INJ	MGM	IV			14.0	37.0	29.0	54.0	74.0	40.0
ACETAMINOPHEN, SUPP	MGM	RECT							650	650
DIAZEPAM (VALIUM), INJ	MGM	IV				10.0	2.0	54.0	75.0	35.0
AMPICILLIN, INJ	MGM	IV					8000	18000	12000	12000
TOBRAMYCIN, INJ	MGM	IV					250	100	170	210
CLINDAMYCIN (CLEOCIN), INJ	MGM	IV						600		
CEFAZOLIN (ANCEF), INJ	MGM	IV			1000	4000	2000			
NYSTATIN, CREAM	APPLICTOPIC									2
METUBINE IODIDE, INJ	MGM	IV						128	156	216
DOPAMINE, INJ	MGM	IV						150		
MICRONEFRIN, SOLUTION	ML	INHAL				0.25	1.50			
LIDOCAINE (XYLOCAINE), INJ	MGM	IV				100				
FUROSEMIDE, INJ	MGM	IV							30	
AMINOPHYLLINE, INJ	MGM	IV					775	75		
CIMETIDINE (TAGAMET), INJ	MGM	IV					600	1500	1200	1200
MYLANTA II, LIQUID	ML	NG					120			
MYLANTA, LIQUID	ML	NG				30				
INTAKE (ML): BLOOD							500	750	585	250
COLLOID								1545		
NON-BLOOD IV					1275	2250	5822	5995	3699	4133
NG DRUG						30	120			
TOTAL					1275	2280	6442	8290	4284	4383
OUTPUT (ML): INSENSIBLE LOSS					232	757	932	1008	1087	1054
URINE OUTPUT					605	1067	1995	2370	3215	3240
WATERSEAL DRG. 1					248	595	260		10	
WATERSEAL DRG. 2					206	615	910	880	350	300
WATERSEAL DRG. 3						150	250	320	295	210
NG TUBE DRG.					200	80	560		200	130
TOTAL					1491	3264	4907	4578	5157	4934
NET BALANCE (ML):					-216	-984	1535	3712	-873	-551
WEIGHT (KG)					50.5					
NUTRITIONAL: NP ENERGY	KCAL	(IV)			81	358	1333	2341	1776	2412
TOTAL ENERGY	KCAL	(IV)			81	358	1476	2646	2042	2700
PROTEIN	GM				0	0	36	76	67	72
FAT	GM				0	0	0	0	0	5
CHO	GM				24	106	392	689	522	546
NP ENERGY/NC	KCAL/GM						222	195	177	201
N2 IN	GM				0	0	6	12	10	12
URINE UREA N	GM									13
N2 BALANCE	GM									-5

FIG. 7. A 7-day report is useful for trend analysis of such items as long-term intake-and-output volumes and nutrition therapy. This report also makes it easy to follow long-term medication delivery.

Clemmer TP, Gardner RM. Data gathering, analysis, and display in critical care medicine. *Resp Care* 1985;30:586-598.

```
                                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:                                      NO. 3515624        ROOM: E402                                        DATE: SEP 13 09:27
DR. STEVENS, LAWRENCE E.        SEX: M     AGE:  29   HEIGHT: 183   WEIGHT: 153.30   BSA:  2.66    BEE:  2884    HOF:    6
=============================================================================================================================
CARDIOVASCULAR: 1                                                                          EXAM: _____________________________________
TIME            CO    CI   HR  SV  SI   VP  MSP  MP SVR LWI PW  PA  PVR   RWI           _____________________________________
SEP  13 03:50  8.40  3.15  144  58  22 14.0M  71  54  5  17  14  25  1.3   3.3
         SEP 13 03:00  LEVOPHED (LEVARTERENOL)  21.3 MCG/MIN
         SEP 13 00:05  DOPAMINE (INTROPIN)  15.0 MCG/KG/MIN
         HYPOVCLEMIA AND LV DYSFUNCTION
                SP    DP    MP   HR  |  LACT         CPK          CPK-MB       LDH-1        LDH-2
  LAST VALUES   78    38    48  144  |
  MAXIMUM      199   118   138  167  | 19.0 (05:10)      (    )       (    )       (    )       (    )
  MINIMUM       32    17    26   25  |
  HEART RATE = 125   QRS =  70   PR = 150   QRS AXIS =   70
         **** PHYSICIAN OVERREAD ****
  NORMAL ECG
      SINUS TACHYCARDIA
      POOR R WAVE PROGRESSION
  NO SIGNIFICANT ECG CHANGES SINCE 09/10/1984.15:06
=============================================================================================================================
RESPIRATORY: 2
SEP 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 03:51 V   7.30    42.2    20.3  -5.5  13.1   1/ 1   37    55   10.2    90                                57/ 41/10  22/
13 03:50 A   7.34    34.0    18.0  -6.4  13.3   1/ 1   53    80   14.9    90   4.54             452   51    57/ 41/10  22/
         SAMPLE #  31, TEMP 38.6 BREATHING STATUS : ASSIST/CONTROL
         MILD ACID-BASE DISORDER
         HYPOVENTILATION CORRECTED
         SEVERE HYPOXEMIA BREATHING OXYGEN **CONTACT MD OR RN!!!!
13 01:00 A   7.34    28.6    15.2  -8.7  13.3   1/ 1   57    85   15.9    90                   453          55/ 45/ 8  25/
12 23:42 A   7.32    39.6    20.0  -5.3  13.0   1/ 1   49    81   14.8    90                   450            /   /15    /
12 22:51 V   7.23    38.8    15.8 -10.9  13.6   1/ 1   36    56   10.7    70                                  /   /18  25/
12 22:50 A   7.26    32.6    14.3 -11.4  13.6   1/ 1   52    81   15.4    70   4.70 385   8.20  333   48      /   /18  25/
12 21:36 V   7.23    36.9    15.0 -11.6  13.3   1/ 1   35    58   10.8    70                                60/ 45/15  25/
12 21:35 A   7.27    29.9    13.4 -11.9  12.9   1/ 0   52    83   15.0    70   4.53 422   9.30  335   47    60/ 45/15  25/
        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: 2
    PT:   15.0   (05:10) PTT:     47 (05:10) PLATELETS:   46 (05:10)   FIBRINOGEN:     (     ) EXAM: ______________________________
    FSP-CON:     (     ) FSP-PT:     (     ) 3P:        (     )                                  ______________________________
=============================================================================================================================
RENAL, FLUIDS, LYTES: 0
   IN  10422 CRYST   8557  COLLOID   715   BLOOD   550 NG/PO        | NA   143 (05:10) K     4.5 (05:10)  CL   91   (05:10)
   OUT  2529 URINE     21  NGOUT     400   DRAINS  260 OTHER   1848 | CO2   18 (05:10) BUN  49   (05:10)  CRE   7.2 (05:10)
   NET  7893 WT  153.30    WT-CHG    0.00  S.G.                     | AGAP             UOSM               UNA       CRCL
=============================================================================================================================
METABOLIC --- NUTRITION: 0
   KCAL     2166   GLU  425   (05:10)   ALB        (     )  |  CA    7.0 (05:10)    FE        (     )   TIBC        (     )
   KCAL/N2  1778   UUN        (     )   N-BAL               |  PO4       (     )    MG    1.4 (05:10)   CHOL        (     )
=============================================================================================================================
GI, LIVER, AND PANCREAS: 0                                                                                          EXAM:
   HCT     43.1 (05:10)  TOTAL BILI        (     )  SGOT      (     )  ALKPO4      (     )  GGT          (     ) _____________
   GUAIAC 1+    (06:00)  DIRECT BILI       (     )  SGPT      (     )  LDH         (     )  AMYLASE      (     ) _____________
=============================================================================================================================
INFECTION: 1
   WBC  6.1 (05:10) TEMP  38.8 (06:00) DIFF  57B, 17P, 16L,  5M,   E (05:10) 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         2.0    MOREPINEPHRINE (LEVOPHED), INJ          ML    IV          16
CLINDAMYCIN (CLEOCIN), INJ             MGM   IV        1800    CIMETIDINE (TAGAMET), INJ               MGM   IV         900
CEFOXITIN (MEFOXIN), INJ               MGM   IV        2000    SORBITO, 70%, SOLUTION                  ML    RECT        50
GENTAMICIN, INJ                        MGM   IV       200.0    SODIUM BICARBINATE, INJ                 MEQ   IV         650
DOPAMINE, INJ                          MGM   IV        1980    INSULIN REGULAR, INJ                    UNITS IV         380
```

FIG. 8. This report is organized by organ system. Grouping all related data allows a more detailed look at all aspects of the patient's status and care in an organized manner. Data that are important but to which the computer does not have access, such as the results of the physical examination, are represented by blank lines and must be filled in by health care personnel. When data was not obtained in the previous 24 hours, the space is left blank, which is indicated by parentheses.

Clemmer TP, Gardner RM. Data gathering, analysis, and display in critical care medicine. *Resp Care* 1985;30:586-598.

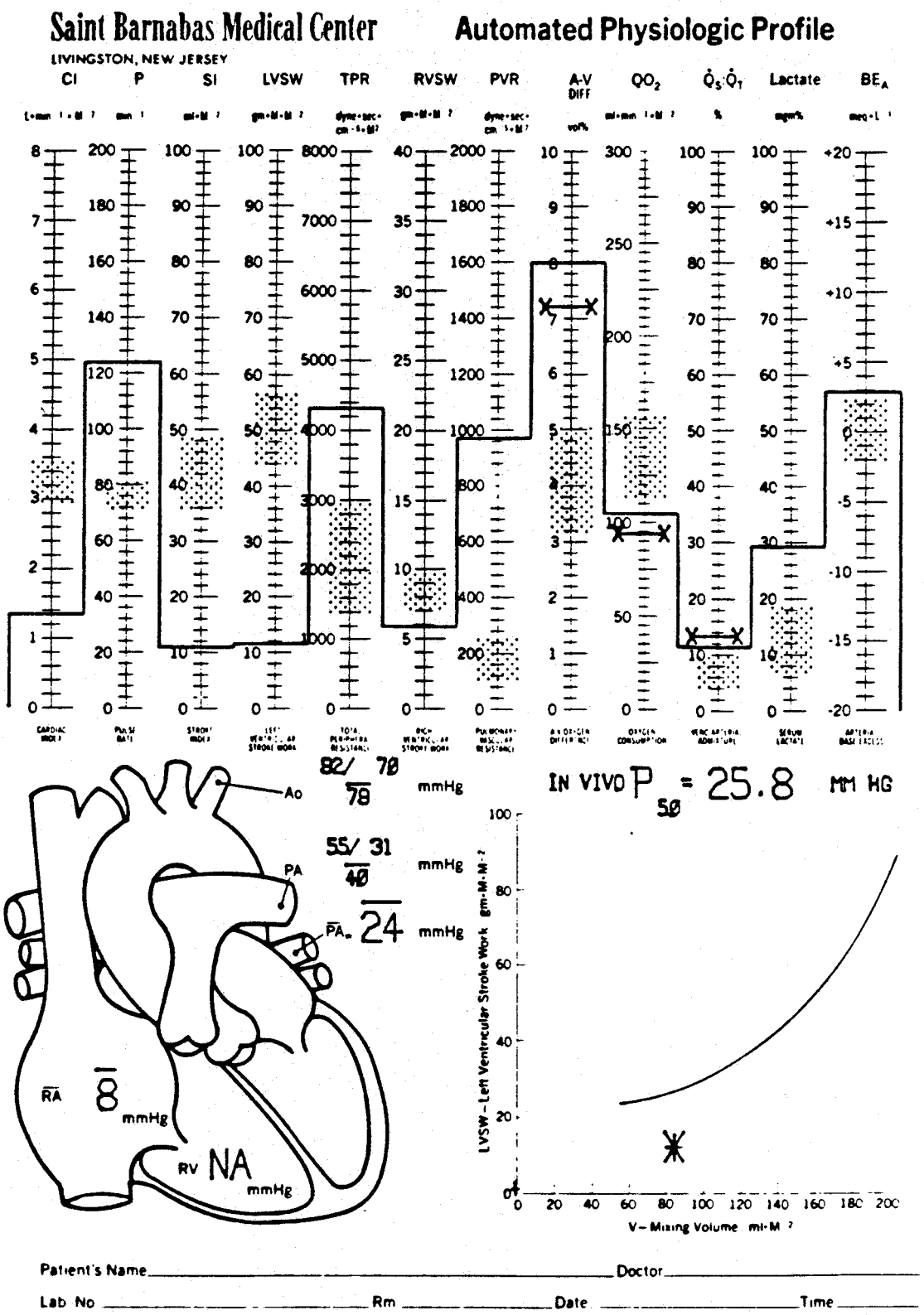


FIG. 9. Data are represented in a bar-graph format with normal ranges in the shaded areas. This report allows medical personnel to quickly focus on abnormal areas. (From Reference 3, with permission)

better than a computer-generated printed-out interpretation remains to be proven, but it is aesthetically pleasing and easy to use for quick glimpses of the patient's physiologic status. However, when one wants specific values, the circlegrams are awkward to use. Permanent copies of such displays require special equipment, data are bulky to store in this form, and long-term trending analysis is also inconvenient.

Line graphs, such as those shown in Figures 6 and 7, are very useful for the trending of data but, again, are cumbersome when exact values are desired.

ICU data can be displayed in many ways. Because of the varying needs and preferences of data users, more than one type of display may be used. The computer allows flexibility. Bar graphs, circlegrams, and line graphs can be easily and quickly displayed on the video screen. For quick bedside looks at profiles and for trend analysis, such displays are convenient. However, hard copies of such displays are slow IO print, bulky to store, and inconvenient when a more detailed look is desired. Therefore, digitally displayed data may be better for hard-copy long-term storage.

Because of the volume of data generated in critical care medicine units, computers are quickly becoming invaluable tools.[2,8] Our experience with computerized data management has been positive. The computer enhances the availability of information, automatically processes it so that derived information is accessible for use, organizes it chronologically, brings together appropriate related information, and presents the data in a form that aids and enhances the decision-making process. This not only saves the health care provider time but allows all the data to be considered when decisions are being made, thus improving the quality of decisions.

From computerized decision logic, alerts can be sent to the clinicians so that dangerous situations or trends can be focused on quickly. It also creates and organizes an easily read chart for review.

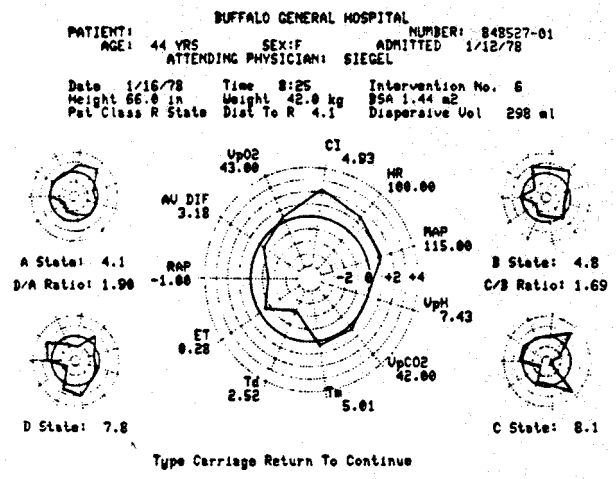


FIG. 10. The circlegram creates patterns from the physiologic data that enable health care providers, through recognition of changing patterns, to quickly classify the patient into certain physiologic states. (From Reference 7, with permission)

Unfortunately, we continue to be presented with a data overload that remains a major problem no matter how data are organized or displayed. Very few studies exist that demonstrate which variables should be monitored, how frequently they should be monitored, or how the data relate to patient care with regard to complications, cost, length of hospital stay, or final outcome.

Equipment manufacturers are expanding our ability to monitor more variables more frequently, and the computer industry delivers more numbers and in more sophisticated ways. Yet, no one has shown that this expansion of monitoring and data generation is beneficial to the patient. Major efforts will be required to help answer these questions and resolve the problems that our information-centered society is creating.

Clemmer TP, Gardner RM. Data gathering, analysis, and display in critical care medicine. *Resp Care* 1985;30:586-598.

References

1. Bradshaw KE, Gardner RM, Clemmer TP, Orme JF Jr, Thomas F, West BJ. Physician decision-making: Evaluation of data used in a computerized ICU. Int J Clin Monit Comput 1984;1:81-91.
2. Gardner RM, West BJ, Pryor TA, et al. Computer-based ICU data acquisition as an aid to clinical decision-making Crit Care Med 1982: 10:823-830.
3. Cohn JD, Engler PE. DelGuercio LRM. The automated physiologic profile. Crit Care Med 1975;3:51-58.
4. Agarwal NR, Savino JA. Feldman M. Dawson J, Gupte P, DelGuercio RM. The automated metabolic profile. Crit Care Med 1983;11:546-550.
5. Siegel JH, Cerra FB. Coleman B, et al Physiological and metabolic correlations in human sepsis. Surgery 1979;86:163-193.
6. Siegel JH, Farrell EJ, Goldwyn RM, Friedman HP. The surgical implications of physiologic patterns in myocardial infarction shock. Surgery 1972;72:126.
7. Siegel JA. Giovannini I. Coleman B. Ventilation:perfusion maldistribution secondary to the hyperdynamic cardiovascular state as the major cause of increased pulmonary shunting in human sepsis. J Trauma 1979;19:432-460.
8. Prakash O. Meji S, Zeelenberg C. van der Borden B Computer-based patient monitoring. Crit Care Med 1982;10:811-822.
9. Johnson DS, Ranzenberger J . Herbert RD, Gardner RM. Clemmer TP. A computerized alert program lor acutely ill patients. J Nurs Adm 1980;June: 16-35.

Discussion

Dr Dantzker: I am not sure I get the point. We started out yesterday excited about the kinds of things that we might want to monitor. Now you seem to be taking a totally nihilistic viewpoint with a multimillion-dollar system generating reams of data that you are not sure is very important. It is not clear to me what your message is.

Dr Clemmer: I'm not nihilistic. I'm a classical thinker. I'm into numbers as much as anyone in this room. I think it certainly has a place. It has taught us a great deal. It's sort of like *Zen and the Art of Motorcycle Maintenance*. The man who knows the motorcycle and how it works also has a better feel for it. I think knowing the anatomy and physiology teaches us a great deal and it makes us better physicians and nurses. But I don't think that we have to completely get away from the other type of thinking, illustrated by the nurse who had a talent for knowing what was wrong even though she didn't know in a scientific sense why she knew it. I think such persons are very valuable health care providers, and it is from these people that many of us try to focus on exactly why they know and feel what they do.

Dr Dantzker: My concern is that you can have too many numbers to look at. I look at your sheets and I get overwhelmed. I go into ICUs and find 72 values derived from the blood pressure and I don't know what most of them mean. I don't think anybody does. I think we all know of 1CUs that have, for years, monitored and recorded every measurable and derived physiological variable known to man, with no evidence to prove that it is helpful In the care of the patient

Dr Clemmer: One of the problems is that nobody can agree on w hat to look at and record. The problem is that in different patients different data become important. Our machines are not set up to distinguish one type of patient from another. For example, pulmonary vascular resistance in a drug-overdose patient is probably of no value whatsoever, but in ARDS it might become very valuable. When do we generate the pulmonary vascular resistance value and when don't we? How do we tell our machine to stop generating it? I think that is why physicians are in the decision-making loop. They have to get a feel for their patient and make the decision about what pieces of data they want to look at. They must learn to filter out the extraneous data.

Dr Pierson: Are you doing that in your unit? Are you trying to set up that kind of discriminant analysis?

Dr Clemmer: No. I think that would be very useful. We generate at least 140 different pieces of data on each patient every day and many of them multiple times. We have at least 1,000 pieces of data ever): day on each patient.

Dr Neff: I feel that our ICU personnel often have a problem with data overload. When this occurs, they will either start tuning out everything or, at least, stop differentiating important critical data from minor data and minutiae. Currently, our ICU personnel are spending an immense amount of time collecting, entering, and retrieving data, all of which often takes them away from the patient's bedside. When this occurs, I have seen patients die from a ventilator disconnect or an alarm malfunction. When we physicians ask for more data, we must also critically ask, "Will this request trigger a 'data-overload syndrome' for us physicians and our ICU personnel that may be lethal for our patients?
Dr Clemmer: That's right. I'll give you an example. When I'm on the clinical service, I go in early in the morning and help the technician x-ray the patients. I don't have to think, I just have to help lift the patient and put the cassette under him. The reason I do that is because I get a feel for the patient in that situation that I can't get in any other way. Even by examining the patient I don't get the same feel. There is something nice about being able just to go in and give a patient service to learn about him. That's why it is important for the doctor to talk to the nurse who has that kind of information.
Ms Nett: Because your unit is computerized, you have a unique opportunity for doing long-term follow-up with the ventilated ICU patients. You could develop a scoring system for observing severity of illness and relate it to one-year survival. What information are you collecting that might lead to prediction of survival? Are you considering correlating with one-year-survival statistics?
Dr Clemmer: We're starling to organize that sort of study. The multiorgan-system-failure score (MOF) is an initial attempt to try to prognosticate. The nice thing about the score is that it is generated completely from the computer data. We are just now thinking about that protocol and how to develop it.
Dr Gardner: We have 6,000 to 8,000 patients in our computerized data base.
Mr Ward: At our institution we have two postoperative cardiac ICUs. The first one was computerized much as yours seem to be. After about a year, they went back retrospectively to see if the computerization at least altered mortality, and it did not. I think you are looking at other things.
Dr Clemmer: Siegal et al wrote a paper with just the opposite conclusion.[1] There were a lot of other things, however, that went on in that paper, and I'm nor sure that the computer system called "CARE was really responsible for the change in outcome. Others are reporting that the computer system does make a difference. I'm a little bit like you, however, and I'm not sure that it does.

1. Siegel JH, Cerra FB, Moddy EA, et al: The effect on survival of critically ill and injured patients of an ICU teaching service organized about a computer-based physiologic CARE system. Trauma 1980;20:558-579.

Mr Ward: Patients still become disconnected and alarms still are not set.
Mr Ross: Do you have any information about time and motion studies that show the nurse actually doing more nursing care with this computer system because she has approximately 30% more time to provide this care?
Dr Clemmer: Absolutely not. The more technology brought in the less bedside care the nurses perform-and that is a major problem. Also, you attract a different kind of nurse, a nurse who feels comfortable in that information-centered environment Unfortunately, I think that we have lost some of our very best nurses who are not as comfortable in such environments but who like to lake care of very sick patients.
Mr Ross: Have you put any of this information on the permanent patient record? We have difficulty providing that kind of concept in our institution. We turn out reams of paper. Where do you put it? It could become a legal record if necessary.
Dr Clemmer: Once it's in the computer it is saved permanently. They spin it off on a permanent tape. The hard copy of our medical record is also computer generated.
Dr Fairley: I suggest that the main variables in terms of outcome are probably (1) the disease entity and its natural history and (2) relatively simple interventions that are the determinants of survival or not in each of the various disease categories. For those diseases that do not fall into that generalization, there is a high level of

complexity and an extremely low level of satisfactory outcome. I am nor sure that, in those situations, we know how much complex monitoring helps.

Dr Grossman: I would like to echo and extend Louise Nett's thoughts. You are now in a position to prospectively examine the relative value of various critical care variables with respect to disease processes and outcome. Perhaps you will validate an informal tool I have used for years, the tube index. This, of course, is the number of tubes to which an intensive care patient is connected.

Dr George: I'd like to respond to Dr Fairley's earlier comment by stating that we specifically eliminated prognosis from the context of this conference, as related to the original diagnosis, number of system involved, etc. because this conference is devoted to monitoring techniques. We really haven't talked about prognosis.

Dr Fairley: If one is not interested in outcome, then what one is doing is observing one's self, so to speak.

Dr George: The relationship of monitoring to prognosis is certainly a consideration.

Mr Mathews: I've been thinking about this for the last two days. It seems that philosophically we have come almost full circle. When we started this automation and mechanization in the ICU, the object was to free up nurses to take care of more patients and to take better care of patients. The data analysis and data gathering were a sideline to that. Now we are using data analysis as the major focus, and we are moving farther and farther from the bedside. Do we want to keep going in that direction?

Dr Clemmer: The point that I am trying to make is that technology does not bring you nearer the bedside. Anyone who says, "If you buy this machine you will free up some more time to spend with the patient" is fooling you. It's not true, and I think that you are right. I am very concerned that we should be teaching that the feel for the patient comes from working with him and being with him. The bedside care is still our most important and valid monitoring tool. Even if the nurse doesn't know how to calculate the thoracic compliance, she always knows when the patient is crashing. She can still tell when the patient is sick. This type of care is still our best monitor.

Dr Luce: If that's the way you feel, then why are you doing this? This is a reinforcement of a totally different message, in my perception.

Dr Clemmer: Yes, but there are several reasons why we do it. We learn a lot by trying to focus on why the nurse knows what she knows. We try to define what is going on. We try to find out why the patient looks bad and reverse it before it happens. We are still trying to see if there is some signal that would tell us what is going on even before the nurse picks it up. Knowing more is always valuable. If you read *Zen and the An of Motorcycle Maintenance*, you are going to find out that the rider of the motorcycle is almost able to communicate with the machine. Some people have that talent, by the way. There is no question that some people can communicate with a machine. They go over and touch it and love it, and it does what they want it to do. For other people it's a disaster every time they touch a machine. Knowing about the machine helps you out. Knowing about anatomy and physiology also help a lot. I'm not saying we should abandon classical medicine. I'm saying we should not forget the art of medicine and nursing.

Dr Luce: Your story reminds me of when the housestaff make rounds in the ICU. The interns have these clipboards on which they have collected large amounts of data. They read down their clipboards with no concept of what the data mean in terms of patient care. I don't think that it is true that the more information you get, the more you can apply.

Dr Clemmer: It is our fault if they don't know what the numbers mean. We should be teaching them how to use the scientific data properly.

Dr Luce: But I don't think that this is the way to teach them. That's what I'm saying.

Dr CIemmer: No, frequently it isn't. This helps us get a better concept of the patient. We use this information a lot, bur to really understand it is uncommon. Dr Fairley spent 45 minutes selling us what compliance really means. I learned a tremendous amount. We heard another talk about Swan-Cant catheters. You and I don't even know what these numbers mean-let alone our houseofficers. That's a real problem. We are learning more and more. Today I'm amused at my naivety concerning wedge pressures. Ten years ago I used to think I knew what those numbers really meant. I even thought that I was measuring them correctly. Today I know better. But to

know that I don't really know what they mean and that I can't unquestionably rely on the data makes me a better physician.

Dr Hudson: I'd like to ask Reed if he really believes that technology has to take you away from the bedside, and if he doesn't. then how can we prevent that from happening as we acquire more technology?

Dr Gardner: I sit here and listen in amazement to this group with their concern about too much technology. Terry is one of our most avid computer users, and if we took the computer capability away from him, he would be very upset with us. We work hard at getting the kinds of things that he and other physicians think we ought to have. Yes, computer technology can take us from the bedside, but we have worked very hard with our new ICUs to have the computer terminal at bedside so it is easy to access while we remain with the patient. We've designed our system to make computerized data collection

You, as physicians, ask for fluid balance and want a response quickly. To get fluid balance we must know the volume input from the multiple I.V's and other sources. We must also know the volume output, which includes urine, drainages from many body sites, and an estimate of insensible water loss. At present all these volumes must be manually measured. There are now new quick and accurate devices that will measure most of these volumes electronically. Thus, despite the aversion to technology being expressed here, I feel that this new technology is important to provide the data that physicians need to best manage their patients. We must record almost all patient data for medical/legal and many other reasons. We have to know what is going on with the patient. We can record information in the computer and have the computer do several other important record keeping functions. For example, our ICU nurses really appreciate not having to fill out a separate sheet of paper to bill the patient for each drug or I.V. given (Studies showed they didn't do the billing function well, either). With computer charting, once the nurse has completed the clinical charting function, the computer automatically takes care of the administrative and billing function.

The state of the art of computerized data entry is getting better and better. Computers are getting less and less expensive and much more capable.[1] Let's use them for the tasks they are good at-long-term data storage, decision making, and their ability to format the data in reports so they are more helpful to the clinical decision makers. If we don't need to collect certain data, then let's back off and not collect. However, I think we need to collect most of the data we now record. Care of the critically ill is a complex problem, and as much as we would all like to go back to the simpler patient management we practiced just a couple of decades ago, I don't think it will happen.

1. Toong HD, Gupta A. Personal computers. Sci Am Dec 1982;274:87.

Dr Clemmer: One thing that has been very useful to us-When we put the computer terminals at the bedside, the mainframe computer upstairs knows that the bed and that terminal and a certain patient's data go together. To input or output data on that specific patient is easier at h a bedside terminal. You can get to the data at another terminal, but it is more difficult. At the bedside it takes just two key strokes. At another terminal you have to go through several screens before you get there. This brings the nurse into the room to enter data. It brings the physician into the room to extract the data. So moving the monitoring to the bedside and away from the central nursing station is very useful.