Chapter 26

Data Gathering, Analysis, and Display in Critical Care Medicine

The rapid expansion of medical knowledge and technology has been 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 being 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 life 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

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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

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.

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; bedside-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, bedside-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

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*	Drugs: Input/ Output	Observations	Bedside Monitor	Blood Gases	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.

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 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 ($\dot{Q}s/\dot{Q}t$). 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 ($\dot{V}O_2$) 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.

Name ______________________ **INTENSIVE CARE • DAILY TREATMENT RECORD**

Number ______________________ Date ____________

	TIME	15 30 45	15 30 45	15 30 45	15 30 45	15 30 45	15 30 45	15 30 45	15 30 45	TOTAL
BLOOD-PLASMA EXPANDERS	Blood									
	Plasma									
	Albumin									
	Macrodex									
	Rheomacrodex									
FLUIDS AND ELECTROLYTES										
ORAL	Tube feeds/drink									
MEDICATION										
RESPIRATION										
	Bag breathing B. Turning T.									
	Vol. air + vol. O_2									
	Vent. frequency									
	Expired air vol.									
	Machine pressure									
	Patient pressure									
CIRCULATION	Blood pressure: Systol: ∨ Diastol: ∧ 240									240
	220									220
	200									200
	180									180
	160									160
	140									140
	120									120
	100									100
	Pulse • 80									80
	60									60
	40									40
	C.V.P.									
	Temperature									
REMARKS										
FLUID LOSS	Bleeding									
	N-G Tube									
	Urine									

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	HGB	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	68
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

DATE	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.

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.

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. At 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/MT	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 ($\dot{Q}s/\dot{Q}t$). The cardiac output is retrieved, and O_2 consumption ($\dot{V}O_2$) 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.

```
              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/KG/MIN
          HYPOVOLEMIA AND LV DYSFUNCTION

SEP 12 22:48    8.20  3.08  141  58  22 18.0M  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
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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.

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 format 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 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 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 to 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.

LDS HOSPITAL RESPIRATORY CARE CHARTING

VENTILATOR MONITORING

09/13/84	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

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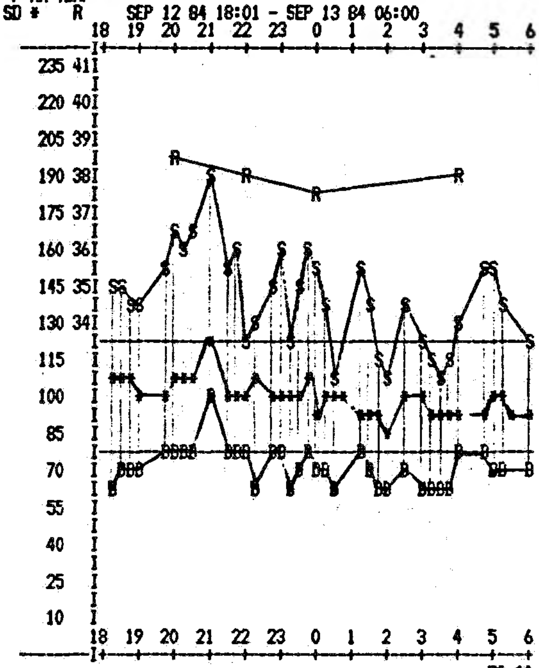
09/13/84 THPST#/DUR/ENTRY                      VENTILATOR OBSERVATIONS
13 08:40 38671/ 10/08:49   INTERFACE: TRACH TUBE;  BREATH SOUNDS: RHONCHI, THROUGHOUT INSPIRATION AND EXPIRATION, BOTH LUNGS;
         POSITION: FOWLER;  PATIENT CONDITION: ALERT;  COMMENT: SUCTIONED SMALL AMT WHITE SPUTUM, NO MORNING 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 THICK 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.

```
# 3501251  E412

AGE: 59   WT: 73.00 KG   HT: 160 CM   BSA 1.76 SQM   DR: SCHMIDT, C DUWAYNE          SEQUENCE #   46
     P HR TEMP
     SD #   R      SEP 12 84 18:01 - SEP 13 84 06:00
```



```
YESTERDAY'S WEIGHT:  75.40
TODAY'S WEIGHT:      73.00
*                                  *
******** 06:00 TO 06:00 ********
*                                  *
   MAXIMUM TEMP: 38.5

   INPUT
     IV:         800
     BLOOD:
     COLLOID:
     TOTAL:      2683    NET:  -996

   OUTPUT
     URINE:      2485
     DRAIN:        50
     TOTAL:      3679
*                                  *
********** LAB RESULTS **********
*                                  *
WBC      8.3     SEP 13 84 05:50
HCT     36.7     SEP 13 84 05:50
HGB     12.5     SEP 13 84 05:50

NA     142       SEP 13 84 05:50
K        3.6     SEP 13 84 05:50
CL     101       SEP 13 84 05:50
CO2     36       SEP 13 84 05:50
BUN     16       SEP 13 84 05:50
GLUC   167       SEP 13 84 05:50
CREAT    0.5     SEP 13 84 05:50
```

	18	19	20	21	22	23	0	1	2	3	4	5	6
WEIGHT (KG)													73.00
RESP RATE			23	23	22		23		22		22		22
URINE OUTPUT (ML)			90		90		320		100		80		420
URINE SP G					1.020								
URINE GLUCOSE					NEG								
BLOOD GLU MG/DL							195				146		
URINE ACETONE					NEG								
URINE PH					6.0								
WATERSEAL DRG 1 (ML)													50
STOOL (ML)													0

SEP 12 84 18:01 - SEP 13 84 06:00

	Dose	Route	18	19	20	21	22	23	0	1	2	3	4	5	6
PHENYTOIN (DILANTIN); INJ	250 MGM	IV							1						1
NAFCILLIN, INJ	1000 MGM	IV				1								1	
NYSTATIN, SUSPENSION	5.0 ML	ORAL												1	
NYSTATIN, CREAM	1 APPLIC	TOPIC												1	
METAPROTERENOL (ALUPENT), SOLUTION	15.0 MGM	INHAL					1				1				1
FUROSEMIDE, INJ	20 MGM	IV					1						1		
HEPARIN FLUSH	100 UNITS	IV								1					
HEPARIN, INJ	8000 UNITS	SUBQ				1									
NORMAL SALINE, INJ	3 ML	INHAL					1				1				1
D5 IN 0.45 NACL, INJ	700 ML	IV	******	******	******	******	******	******	******	******	******	******	******	******	******
POTASSIUM CHLORIDE, INJ	14.0 MEQ														

SEP 12 84 18:01 TO SEP 13 84 06:00   MCCREADY, DOUGLAS C, RN

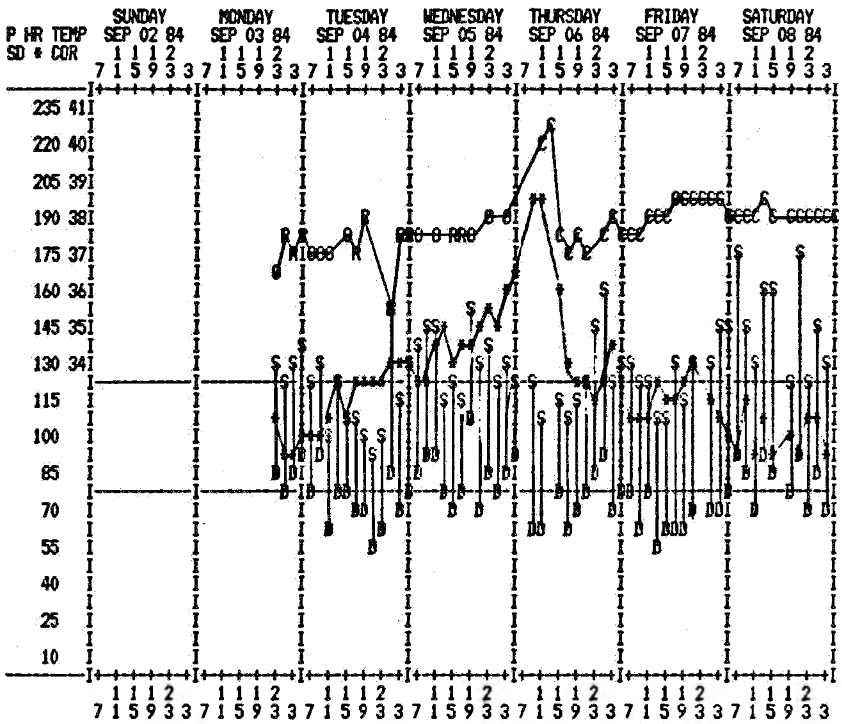
INTAKE (ML):		OUTPUT (ML):	
NON-BLOOD IV	700	INSENSIBLE LOSS	571
ORAL DRUG	5	URINE OUTPUT	1100
OTHER DRUG	9	WATERSEAL DRG. 1	50
		STOOL	0
TOTAL	714	TOTAL	1721

NET BALANCE -1007

SEP 12 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
NORMAL HI	7.45	40.0	25.0	2.5	17.0	2/ 1	85	95	22.7		5.5	300	7.30		5		
NORMAL LOW	7.35	34.0	19.0	-2.5	13.0	0/ 1	68	93	17.4		3.0	200	2.90		0		
13 05:30 A	7.49	47.9	36.4	12.5	11.1	3/ 1	67	92	14.3	40				118		/ / 8	22/

```
SAMPLE # 74, TEMP 38.3, BREATHING STATUS : ASSIST/CONTROL
MODERATE METABOLIC ALKALOSIS
HYPOVENTILATION IMPROVED
MILD HYPOXEMIA
```

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-and-output summary and the latest blood gas values are at the bottom.



			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	APPLIC	TOPIC							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	50
CHO	GM			24	106	392	689	522	546
NP ENERGY/N2	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.

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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: [illegible]                       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
         HYPOVOLEMIA 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
         HYPERVENTILATION 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   NOREPINEPHRINE (LEVOPHED), INJ    ML     IV      16
CLINDAMYCIN (CLEOCIN), INJ           MGM   IV     1800   CIMETIDINE (TAGAMET), INJ         MGM    IV     900
CEFOXITIN (MEFOXIN), INJ             MGM   IV     2000   SORBITOL 70%, SOLUTION            ML     RECT    50
GENTAMICIN, INJ                      MGM   IV    200.0   SODIUM BICARBONATE, 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 were not obtained in the previous 24 hours, the space is left blank, which is indicated by parentheses.

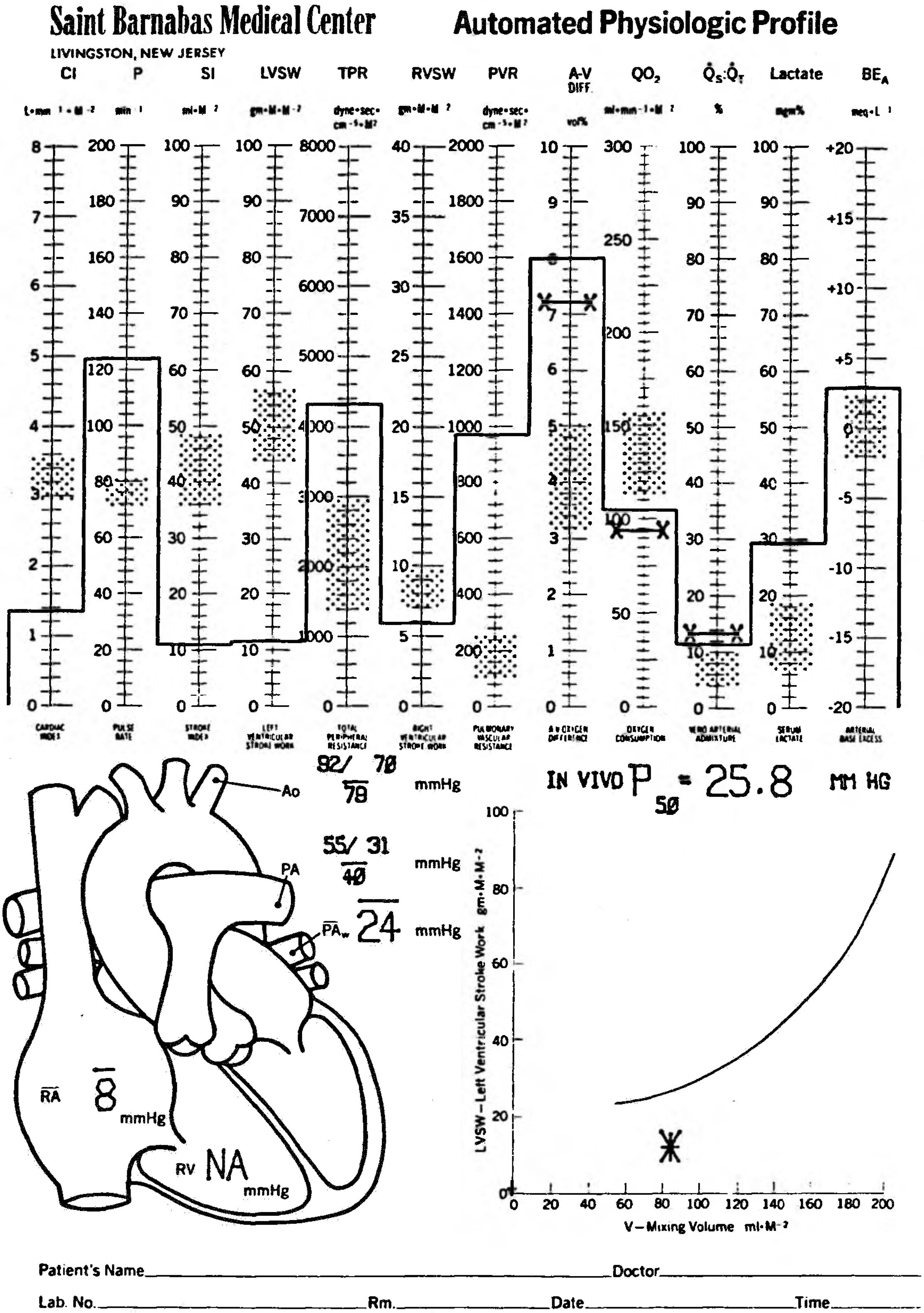

Fig. 9. Data are represented in a bar-graph format with normal ranges in the shaded areas. This report allows medical personnel to quickly focus on abnormal areas. (From Reference 3, with permission)

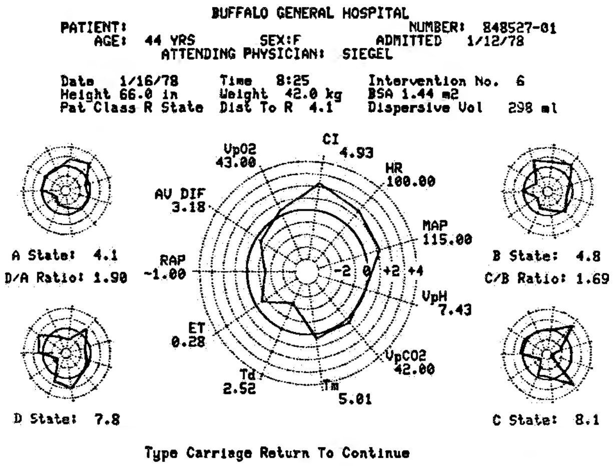

Fig. 10. The circlegram creates patterns from the physiologic data that enable health care providers, through recognition of changing patterns, to quickly classify the patient into certain physiologic states. (From Reference 7, with permission)

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.

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