PATIENT-RELATED DATA MANAGEMENT

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The following two papers represent two presentations from a special panel held at the First Annual Meeting of the European Society for Computing and Technology in Anesthesia and Intensive Care. The title of the panel was Patient Data Management Systems. These selected papers describe the aspirations and problems of implementing a working system in the real world. The authors and their colleagues are to be congratulated for having succeeded in a dauntingly formidable task. —— N.T.S.

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ABSTRACT. Patient-related data management (PDM) has become an increasingly important and time-consuming task in intensive care medicine. Currently, all data are usually collected in a poorly structured patient chart consisting of forms and pictures, with about 400 manual entries a day. To handle this amount of data, we have designed a three-level patient system: level 1, summarizing the whole patient; level 2, summarizing one organ system or one isolated problem; and level 3, variables describing morphology and function of organ systems. PDM must be adapted to different clinical situations. We observed three different scenarios: (1) Exploratory PDM, where the clinician learns about the patient and builds up an individual patient model in his or her mind. (2) Operational PDM, where in routine care clinicians are part of a feedback control system, in which they use the patient-related model. (3) Summary PDM, where a clinician summarizes all the information gathered during a period when he or she was responsible for the patient. Computing tools based on clinical thinking and adapted to different situations can ensure accurate, clear, and concise patient care communication among the members of the intensive care staff.

KEY WORDS. Records: anesthesia. Equipment: computers.

COMMON PROBLEMS

PDM is a three-level system that uses the hospital's information management system to collect, store, retrieve, and disseminate patient care information. As a three-level system with a top-down (inductive) approach, PDM exchanges patient care information within the hospital—for example, between the department of radiology and intensive care unit (ICU) or among staff within one department. An intensive care PDM system is structured to communicate an individual patient's needs and includes administrative, planning, therapeutic, and laboratory information for only that patient. This article describes a PDM system designed for one patient.

Structure of the PDM System

Figure 1 shows the structure of a typical PDM system. The patient was connected to several systems, including monitoring devices and infusion and syringe pumps. Because these system devices operated independently and at separate bedside locations in the ICU, it was difficult for the staff to oversee them and document all the information that needed to be included in the patient's chart.

Data and Information Flow

Figure 2 shows a circular pattern of information processes that includes the following: (1) Acquiring and

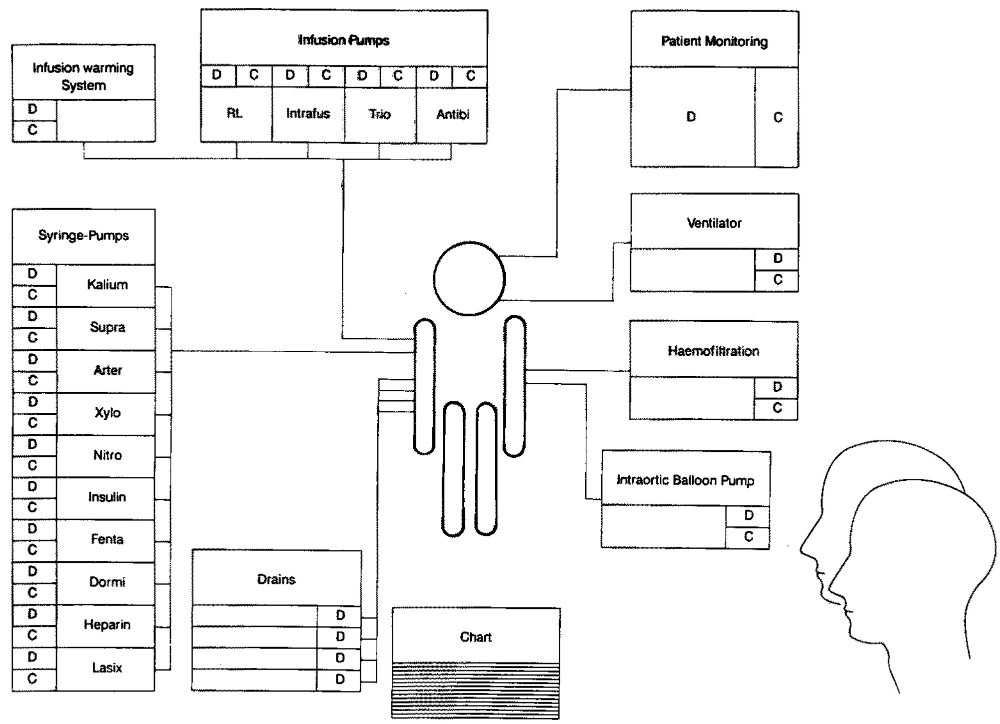

Fig 1. Schematic workplace, patient after heart surgery. D = display; C = control.

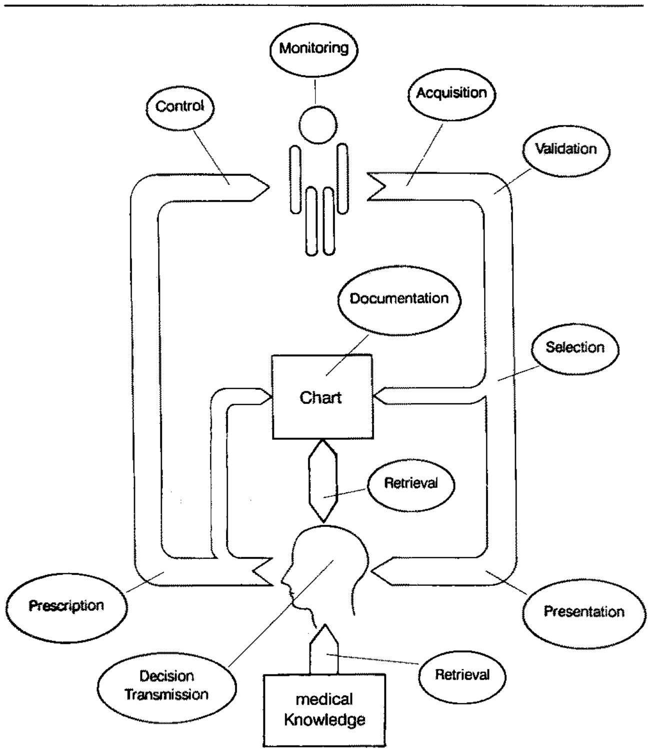

Fig 2. Treatment circle: gathering information and controlling treatment.

validating data. (2) Selecting the appropriate data for documentation and presentation. (3) Retrieving and integrating the appropriate data with medical knowledge to make treatment decisions. This retrieving function is particularly important because it is difficult to report patient care information accurately among the staff who work the three shifts of the 24-hour, 7-day ICU workweek. It is especially difficult to disseminate information during the busy weekends when the staff is short and the workload full. (4) Performing and monitoring the treatment.

Two problems occurred when monitoring and therapy instructions were prepared for the incoming shift's nursing staff: data plethora and equipment and procedures supersaturation.

The nursing staff could expect to be inundated with up to one million pieces of information each day. Only a small part of it, however, needs to be monitored, validated, and recorded in the patient's chart. Not all of the recorded information was necessary for immediate patient care decisions, and less early information was necessary the longer the patient's stay in the ICU. On day 10 it is not crucial to know the blood pressure recorded at a specific time on day 1. Our statistics indicate this surfeit of information will continue; in 1980, in our 20-bed ICU, a 24-hour chart for ruptured aneurysm of the infrarenal aorta included 27 variables with a total of

430 manual entries. In 1991, due to extensive laboratory procedures, 40 variables with 550 entries were charted.

Equipment has also increased in quantity, particularly the number of drug and infusion pumps. In 1986 our ICU averaged two pumps per bed. In 1991 there were at least three pumps, and cardiac surgery patients had 14 or more pumps. Concurrently, the number of procedures has increased. Hemofiltration is routine. Pulse oximetry is used for all ventilated patients. Also, as the number of procedures increased there was a concomitant increase in the monitoring, documenting, validating, and decision-making required of the clinician and nursing staff.

THE GOAL: A NEW PDM CONCEPT

The goal was to develop a PDM system that permitted more efficient recording, monitoring, processing, analyzing, and disseminating of patient care data. We had to meet two objectives to reach this goal: (1) reduce the amount of data received by the healthcare staff and condense the data report, and (2) adapt the reported data to accommodate an individual's patient care needs.

The clinician and nursing staff received only the information they needed. Their needs were determined by two factors: (1) Appropriate patient care information must be related to the "clinical thinking" that is routine for our ICU. The mental models used by nurses and clinicians must be translated into appropriate inputs [1, 2] (discussed in the following section). (2) Clinical situations are different and require special information management.

Approach: Clinical Model

Fifty-five-year old man with an aortobifemoral bypass after resection of an aneurysm on the second ICU day who continues to be ventilated with 40% oxygen because of a mild pulmonary insufficiency and treated with nitroglycerin for hypertension. Good kidney function. No other problems.

With this information relayed from clinician A, clinician B was introduced to the patient and began treatment—although this was not enough information on which to base treatment decisions. To make sure that even this minimum of information was relayed accurately, the ICU clinicians had to report in a familiar and unvarying manner, one applicable to all ICU patients. The clinical PDM model did this through a structured, three-level form (Fig 3).

Level 1. Information regarding either the whole patient or more than one organ system (e.g., abdominal surgery, sepsis, or multiorgan failure).

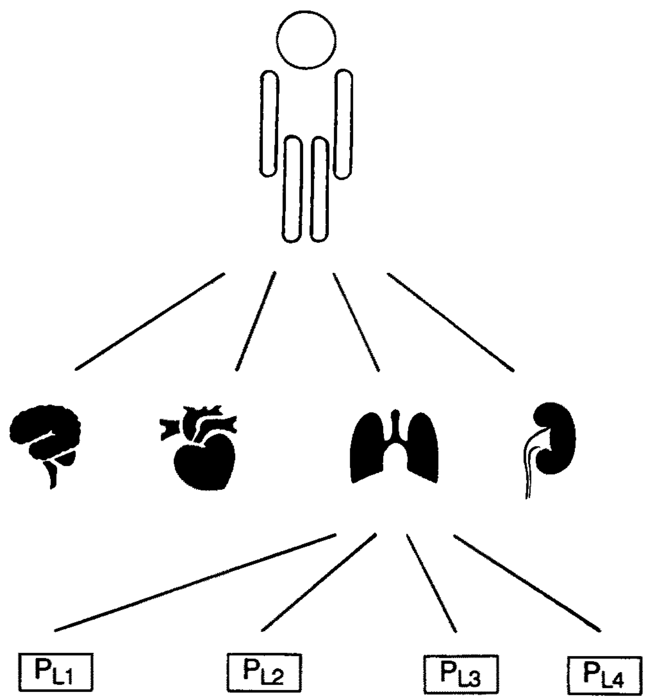

Fig 3. Levels of patient-related data management.

Level 2. Information regarding either one organ system or one isolated problem (e.g., mild pulmonary insufficiency, terminal renal failure, or complete parenteral nutrition). When we relayed information regarding organ systems in which time can make a critical difference, the most important ones were the central nervous, cardiovascular, respiratory, and water-electrolyte systems.

Level 3. The variables described the morphology and function of organ systems and their treatments. An example of level 3 information was peripheral edema, right basal lung collapse, potassium = 3.2 mEq/L, fraction of inspired oxygen = 0.65, urine output = 60 mL/hr.

A PDM clinical model required a two-directional flow of information through these three reporting levels. For example, from the top down (level 1 to level 3), kidney transplant → what kidney function → and which laboratory variable? From the bottom up (level 3 to level 1), oxygen delivery and blood oxygenation ← function of respiratory system and the function of other systems ← discharge of patient tomorrow morning.

TYPICAL USE IN THE ICU. PDM was either exploratory, operational, or summary. The following three examples explore their clinical use and the interaction of all elements of the PDM system, including the patient, clinician, nursing staff, treatment, procedures, equipment, and documentation.

Exploratory PDM. On Monday morning, a clinician who did not work either Saturday or Sunday was responsible for a patient admitted the previous Friday night. To become familiar with the patient, the clinician created a mental picture step-by-step (Fig 4).

Example 1. The clinician examined the ward list and found that the information on it correlated to level 1 of the PDM model: 45-year-old man, automobile accident, chest trauma. The questions raised by this information directed the clinician to level 2.

Example 2. At level 2 the clinician asked questions about the organ systems. During rounds the clinician asked for specific information. For example, how was the patient's respiratory system functioning?

Example 3. Level 3 included a direct examination of the patient, an analysis of the previous course of treatment, and an analysis of the current monitoring.

Using top-down (inductive) exploratory PDM, the clinician used intensive care algorithms to discover principles and fill in missing information. The clinician could, however, also have used a bottom-up (deductive) exploratory PDM, gathering details and interpreting patterns.

The two objectives to this exploratory PDM system were (1) to consider the entire catalogue of intensive care algorithms, and (2) to move through the unstructured patient chart. While achieving these objectives, the clinician kept in mind two considerations: (1) the patient who did not fit a well-known schema—for example, a child who had suffered from multiple trauma and who was in an adult ICU; and (2) the patient who appeared to be stereotyped and in whom important conditions were overlooked—for example, the traumatized patient with pancreatitis.

Computer-assisted Exploratory PDM. There was a time constraint in the ICU to create a PDM model from the past data, the current therapy, and the anticipated future course of treatment. A computer-assisted PDM system could have aided the clinician by presenting the data in a familiar manner, selecting data according to sets belonging to one problem, usually to one organ system [3, 4]. Computer checklists could also have monitored routine examinations, procedures, and laboratory tests.

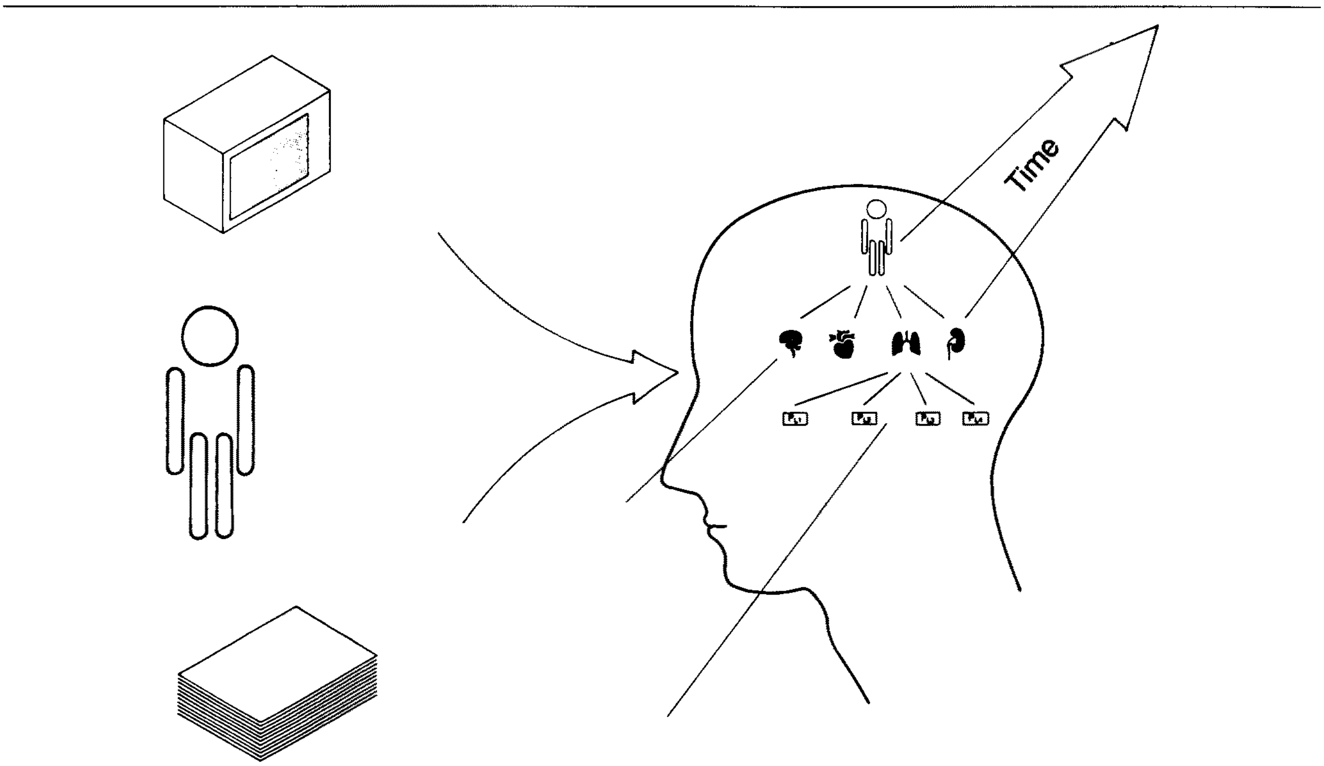

Fig 4. Exploratory patient-related data management: building up a patient model.

What a computer could not do in 1991 is recognize the patient's singularity. The clinician must develop the patient models and, as in a bottom-up exploratory PDM system, interpret the details or, as in a top-down system, propose treatment according to his or her own findings.

Operational PDM. In our ICU, the nursing staff typically monitored the patient and the equipment. Nursing was, then, a part of the ICU information gathering and disseminating control system—a system complicated by intricate, multiple single loops and many varied interferences (Fig 5). For example, when oxygen saturation decreased, the intensive care strategy was to increase inspired oxygen concentration or raise airway pressure, or both. With the latter, the patient's blood pressure decreased. These were the data that created the patient model—data that could come so rapidly from the patient or the ICU monitors that often the clinician could only react. For the clinician to react appropriately, however, validated data (i.e., data concealed in the patient's chart and scattered throughout the ICU on the monitoring equipment) were required.

Computer-assisted Operational PDM. It is possible to analyze the signals through electronic data processing and through confirmed signals used for further computing [5]. Artifacts, however, could not be avoided, which set off additional alarms—which our ICU had more than enough. Bad raw signals cannot be improved with computers either.

Computers could, however, have (1) eliminated much of the data-gathering problems that plagued the ICU clinicians and nurses; (2) assisted if the data were reliable and the algorithms clearly defined and a second-step, closed-loop, time-saving application could be designed; (3) provided a set of data supporting a weaning period or provided technical information such as ventilator settings; (4) provided automated recordkeeping, although this would have required good data that were, in general, validated and without artifact; and (5) provided a schematic presentation of the entire ICU, which would be particularly useful when alarms sounded [6].

Summary PDM. A summary PDM was initiated when the patient's primary physician or nurse summarized

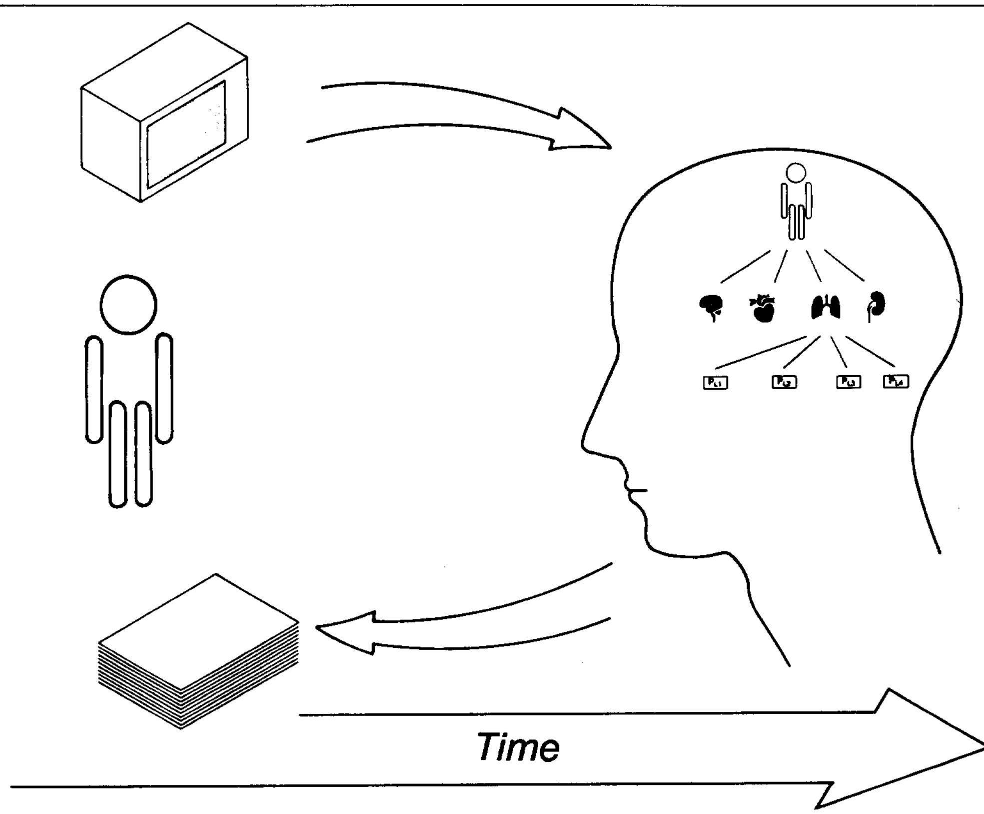

Fig 5. Operational patient-related data management: working in a closed-loop feedback system based on a patient model.

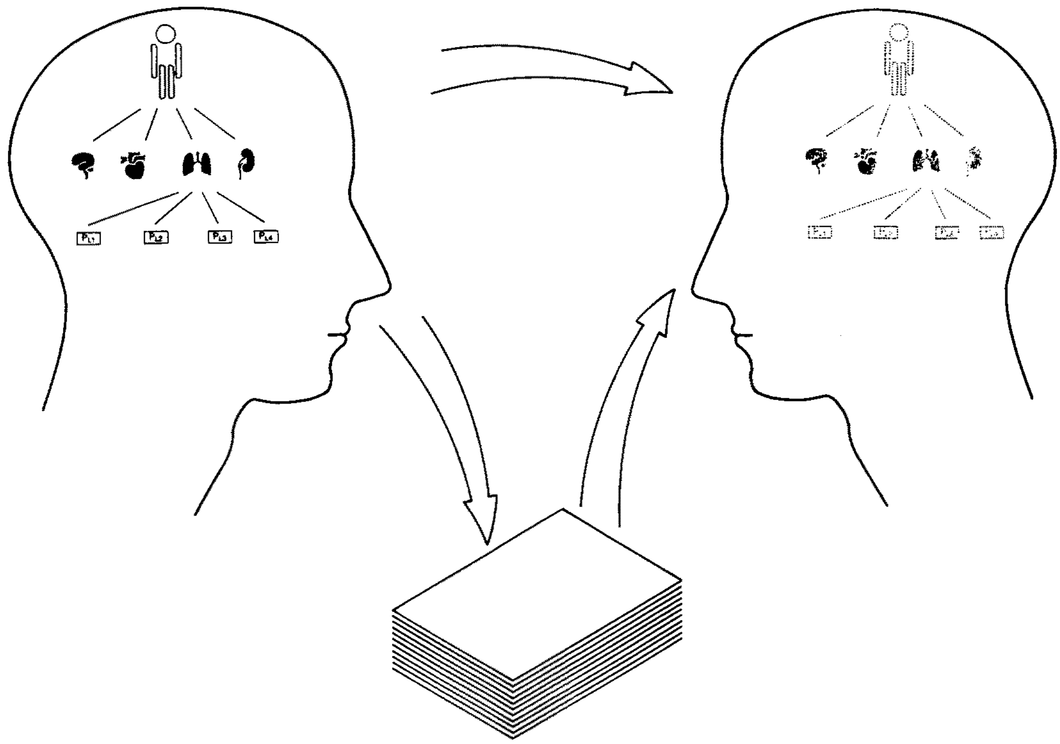

Fig 6. Concluding patient-related data management: resuming and transmitting the patient model.

patient care information for staff on an incoming shift (Fig 6). Information was relayed orally to the staff, or indirectly in a written report. In either case, there were communication problems.

In oral reports, key words triggered stereotypes. For example, the report described a typical septic patient with multiorgan failure, and details that were not a part of the stereotype were omitted. The patient, for example, may have glaucoma. Clinicians interpreted these same words differently, partly due to different lengths of experience.

Written reports took time no matter how quickly the clinicians wanted to write them. Discharge reports were particularly long, as were those for patients whose stay in the ICU was lengthy. It took time to review all the necessary information in the reports, organize the information, and condense it accurately—to reduce the report to a length that a colleague would read.

All summary reports contained (1) information that ensured continuity of treatment, (2) decisions that could be duplicated during the course of treatment—a legal requirement, (3) information to justify ICU performance to a quality assurance committee or at any audit.

Computer-assisted Summary PDM. Although computers cannot make medical decisions for ICU clinicians, clinicians can enter their medical decisions into it. The computer stores all the summary PDM resource material—all the data from observing, monitoring, validating, and treating—in an accurate, concise, and convenient form for instant retrieval the moment the material is needed for an oral or written report for the ICU staff.

CONCLUSION

PDM can be time-consuming for the medical staff. Computer support can, however, help achieve more efficient use of the clinician's time. Using information obtained from a three-level structure patient model, computers assist with the preparation of three clinical patient-related data management facilities: exploratory, operational, and summary. These tools, in turn, ensure accurate, clear, and concise patient care communication among the ICU staff.

REFERENCES

1. Klocke H, Trispel S, Rau G. Entwicklung einer Mensch-Rechner Schnittstelle für ein Anästhesie-Informationssystem unter Berücksichtigung ergonomischer Gesichtspunkte. Angewandte Informatik 1984;26:197–208
2. Rich C. Stereotypes and user modeling. In: Kobsa A, Wahlster W. eds. User models in dialogue systems. New York: Springer-Verlag, 1990:35–51
3. Shabot MM, Carlton PD, Sadoff S, Nolan-Avila L. Graphical reports and displays for complex ICU data: a new, flexible and configurable method. Comput Methods Programs Biomed 1986;22:111–116
4. Tecklenburg AC, Veit Ch. Documentation in intensive care—a case for hypermedia? Presented at the first annual meeting of the European Society for Computing and Technology in Anaesthesia and Intensive Care (ESCTAIC). Salzburg, Austria, 1990
5. Blom JA. Validation of monitored signals in a critical care setting. Presented at the first annual meeting of the European Society for Computing and Technology in Anaesthesia and Intensive Care (ESCTAIC). Salzburg, Austria, 1990
6. Chambrin MC, Chopin C, et al. RESPAID: an aid system for real-time interpretation of respiratory data in ICU. Abstract for the 10th Annual International Symposium of Computers in Critical Care, Pulmonary Medicine and Anesthesia, 1989, September 20–22