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CLINICAL DATA COLLECTION WITH A PURPOSE

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The development and implementation of better systems for providing patient care is the goal of the Intermountain Regional Medical Program. In this paper we will describe an intensive care facility for patients with acute myocardial infarction which utilizes a computer as a tool for data collection, information dissemination and instruction of personnel working in such units (fig. 1).

In an intensive care ward, as in any other patient care situation, data must be collected concerning the patient care activities. This data must be organized in some way for presentation in a teaching situation since it is unrealistic to expect each person to acquire enough data from his own experience alone to justify generalizations upon which he must make future decisions about the care of other patients. In the system developed in

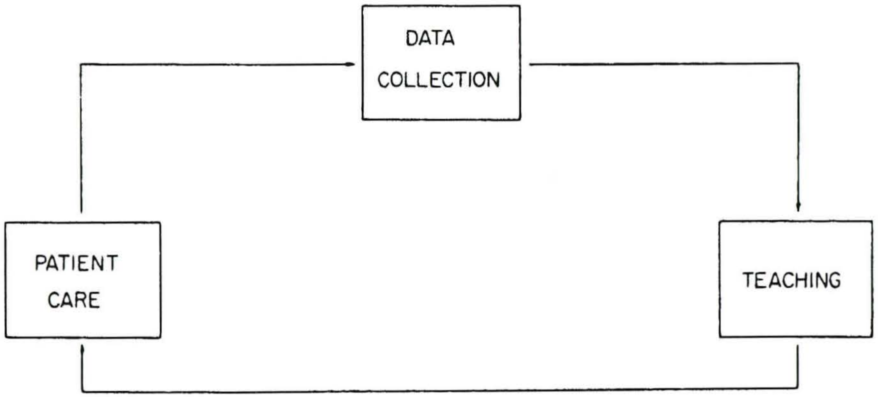

FIGURE 1

Salt Lake City it is possible not only for each participant to make use of the cumulative experience of all the personnel at all the hospitals, but also through a simulation technique to give each nurse or doctor many times the experience he or she would ordinarily acquire working in his own unit. We shall now discuss data collection, teaching and patient care in that sequence.

The present manual methods of medical data handling have been worked out by trial and error over a long period of time and have gained the confidence of most doctors and nurses. But is it unrealistic to expect that any new data collection system will be accepted unless it provides one or both of the following: (1) An easier means of entry of data than is offered by the present method, or (2) some feedback of information which is directly useful to the people entering the data. Figure 2 shows a device designed by the phone company to automatically dial a phone number when the operator drops into a slot a card with the coded number punched in it. A dictionary of codes has been devised which allows entering clinical information such as drug orders, nurses notes and other clinical information into the patient's computer record by dropping the appropriate prepunched card into the box. The decoded information is then written out by the computer on the face of the oscilloscope for confirmation by the data collector before it becomes part of the patient's record.

In the case of physiological data, read-out from pressure transducers and EKG leads is made automatically at intervals established by the computer and the nurse is only notified when a significant change in the patient status occurs.

The second type of incentive that the system can provide the data collector is the feedback of information from the system. This can be accomplished as shown in figure 3 by presenting the data in a reduced form. The input in this case was a central arterial pressure wave and displayed back is a list of 10 variables averaged over 16 heart beats including stroke volume, cardiac output, peripheral resistance, which could not be derived directly by the observer and which gives significant insight into the physiological state of the patient. Here we see one column of values representing the most current measurements and a second column used for reference. These are called the baseline values on that particular patient. The computer only saves information which represents a significant change from this baseline.

Figure 4 shows another form in which the computer can present data back to the personnel responsible for patient care. This is a plot of the time-course of two variables: mean arterial pressure and resistance, allowing the observer to quickly detect the presence of trends when they were established. However, in spite of this editing and selecting process, a difficult job still remains for the nurse or

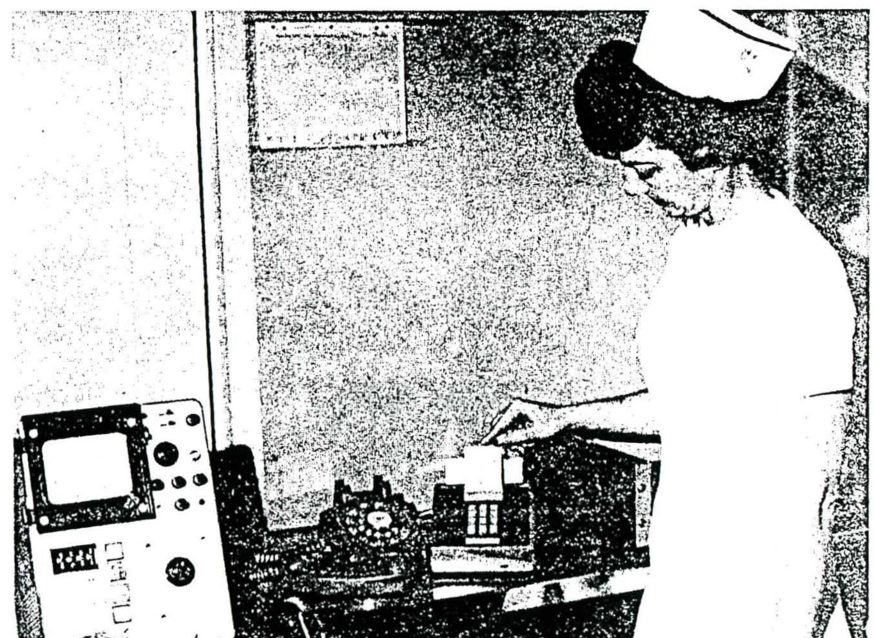

FIGURE 2

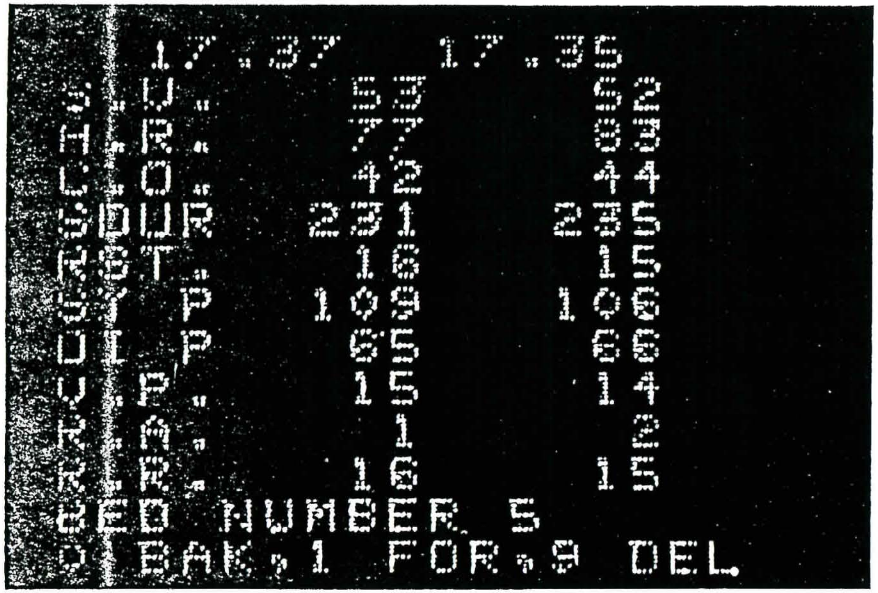

FIGURE 3

doctor in terms of the intellectual effort involved in making an interpretation of the physiological data in terms of "what should be done with this patient now." To properly assist in this process, the computer should relay back not just the physiological findings but an interpretation of the findings in terms of their probable clinical significance.

Figure 5 shows a message which appears on the scope face of the remote computer unit at the nurses' station when the nurse presses a red or yellow light turned on to alert her that a change has occurred in one of her patients. First the program displays the name of the variable furthest out of tolerance, its last value and its base value. Then the nurse, by pressing a one to choose the explain option, enters clinical information which she thinks is responsible for the deviation in the physiologic state of the patient. This data will then become the base upon which the computer on future cases will make clinical interpretations.

The nature of the data collected and its format are determined by the purpose for which it is to be used; that is, by the type of questions that are to be answered from the data. Figure 6 shows an example of a data collection scheme for a coronary care unit. This is a three-dimensional matrix called a transition matrix. The present state of a patient is represented by a particular row as indicated by the label on the vertical axis. The treatment or lack of treatment is indicated by a column as labeled along the abscissa. Corresponding to each row and column, that is, present state and treatment, there is an array of numbers in the Z axis which indicate the probability of a patient receiving that treatment when he has that arrhythmia going to any other state or arrhythmia. This matrix requires a particular data collection scheme from which this kind of data can be derived. Next we will consider the use of such a transition matrix as a teaching tool.

Any good teaching system should provide not only information but also experience in using this information as a basis for making decisions as well as some built-in evaluation of student performance and effectiveness of the teaching method. A computer-based simulation of a patient with myocardial infarction has been developed which satisfies these criteria.

Figure 7 shows a nurse sitting in front of a remote computer console participating in a training session. The face of the oscilloscope is used to display the electrocardiogram just as it

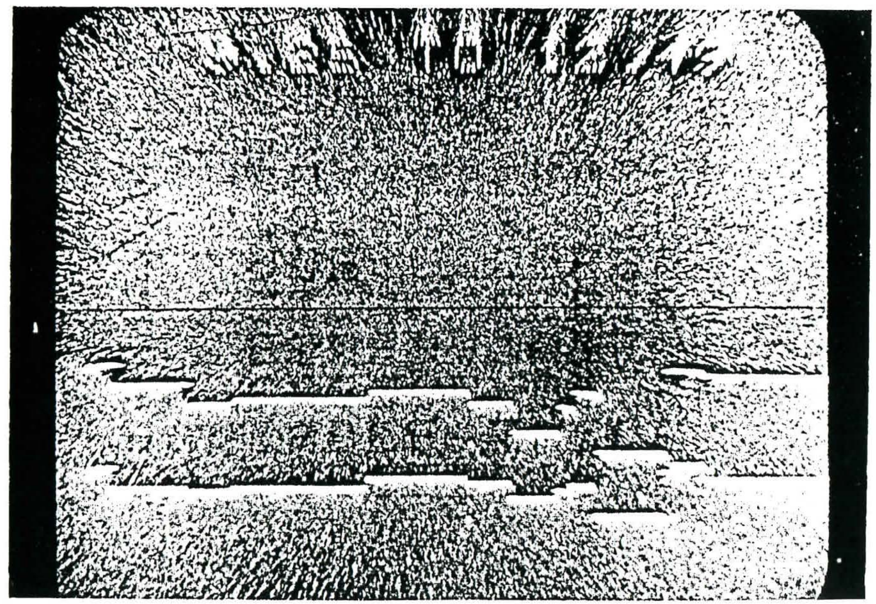

FIGURE 4

is displayed at the coronary care unit. Below the electrocardiogram on the scope options and other information are presented and the nurse or doctor may select options using a numerical keyboard below the scope. Figure 8 shows a closeup of the scope display. The nurse may choose to give a medication, perform a procedure or ask for information. For instance, if she asks for information she may check the electrodes, check the electrolytes, check the patient's blood pressure or pacemaker.

A running score is presented to the participant. This is based on the adequacy of the decision made at each decision point. If the treatment chosen is the one most likely to return the patient to a normal sinus rhythm and normal blood pressure, a number is added to the score which is dependent on how good this decision was compared to other possible choices. A negative number is added if a bad decision is made. Thus, the student has a running evaluation of his performance which may be somewhat independent of how well the patient is doing since the patient's response to a given treatment is dependent not only on the probability matrix and the decision made but also upon the random choice based on these probabilities.

Figure 9 shows the medication option. This list of medications can be expanded or modified based on current practice which, in turn, determines the availability of data to fill in the transition matrix. Thus, the system should be self-improving in the sense that it is using the most current real experience of all participants to update the simulation which, in turn, is then available for all participants to use in the teaching mode.

Based on the assumption that the limiting factor in the quality of patient care in a coronary care unit is the quality of the decisionmaking process, care should be improved by giving personnel practice in making these decisions based upon realistic data. The success of the system just described rests largely on its ability to represent reality both in terms of variety of the EKG arrhythmia patterns presented, the probablistic nature of the transitions made and the fact that these transitions are based on real observations. In any given clinical situation the therapeutic decision is based on the assumption that this case will behave like the average case in the same situation. With this simulator, however, the student is made aware that there are other pos-

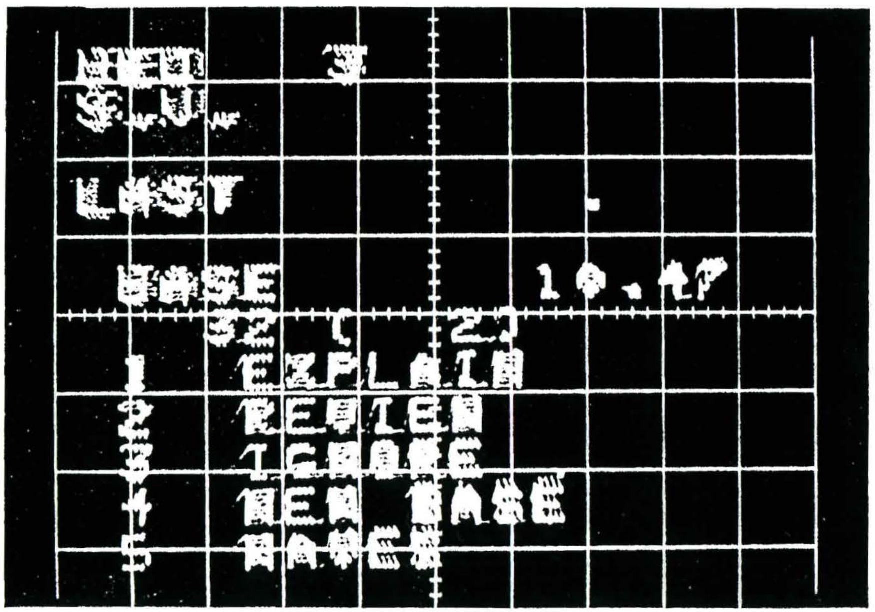

FIGURE 5

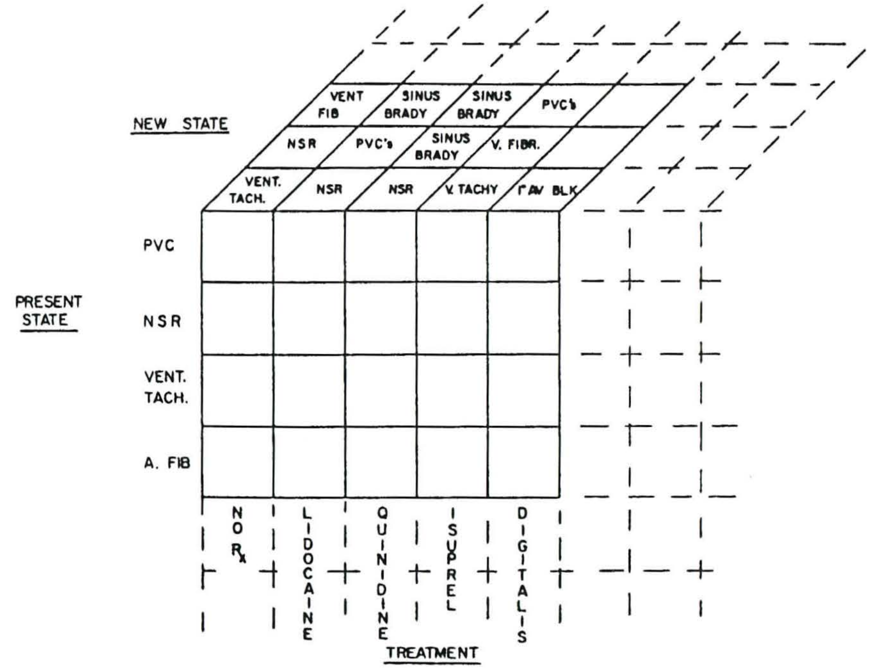

FIGURE 6

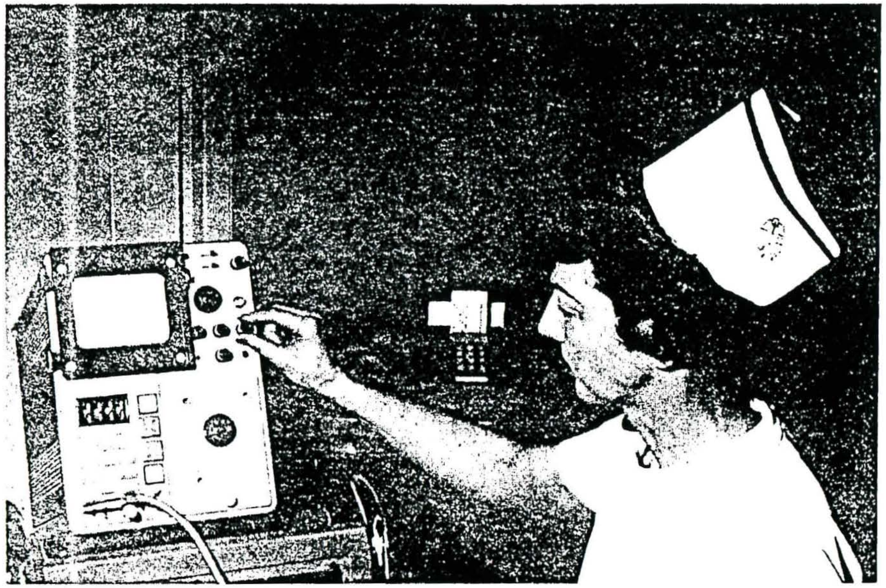

FIGURE 7

sible responses and is allowed to gain the experience in making these vital decisions without risking someone's life until he has optimized his decisionmaking capabilities.

In conclusion, it should be mentioned, of course, that as the simulation becomes a more reliable reflection of reality it can become (just as the automatic pilot) an on-line tool for informing the nurse or doctor as to what action is appropriate in a given situation. This will occur when machines become cheaper and more effective than people in carrying out this decisionmaking process.

FIGURE 8

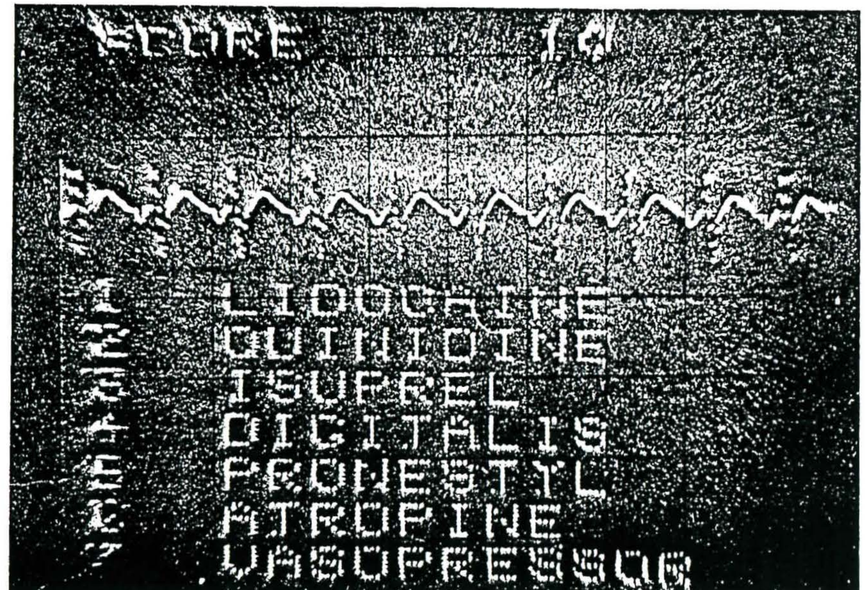

FIGURE 9