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41

Volume 7 #6 Nov/Dec 1978

Computerized Protocols Applied to Emergency and Acute Care

This description of the development and application of computerized protocols for use in emergency and acute patient care illustrates the potential value of such a system to EMS personnel.

Introduction. Optimal management of medical emergencies must include methods for early detection. We have developed a computerized system which gathers physiological and clinical data on patients in a hospital and from these data recognizes and alerts the medical staff about potential life-threatening problems, and generates protocols which suggest appropriate patient treatment and follow-up.

The practice of acute medical care, especially emergency medicine, places heavy demands on the physician; the pressures of time and multi-organ problems are ever present. Our research has indicated some areas where time delays, errors, and inappropriate treatment occur in the care of the acutely ill patient, such as:

• *Communications:* Delay or loss in communication of diagnostic results, for a variety of reasons:

• *Data Review:* Lack of proper review of available data because of time limitation, overlooked results, interruption, and other factors.

• *Data Interpretation:* Even if data is communicated and reviewed it may not be properly interpreted because of, for example, data overload, failure to detect trends, insufficient knowledge to interpret, failure to integrate results with other information.

• *Action:* The final step in the process of monitoring and treatment is action. If any of the above steps are overlooked or are in error, the correct action is not likely to be taken: or, incorrect or inadequate action may be taken.

These problems can be minimized by utilization of computer techniques. Our approach to such a computerized solution is presented below.

Materials and Methods. Ten years ago, at LDS Hospital, development of a data acquisition system from sophisticated research oriented laboratories (e.g., heart catheterization laboratory, surgical monitoring, electrocardiographic areas) was begun. It soon became apparent that these techniques and technology could be applied to a wide spectrum of clinical medical problems. Thus expansion has been made into every intensive care unit, into the clinical laboratory and other locations. Data is currently available for the computer data base from the following areas: the emergency department, the clinical laboratory, the pharmacy, radiology, the pulmonary lab, the blood gas laboratory, multiphasic screening, ECG, the catheterization laboratory, infectious disease monitoring, medical records, surgical operating suites, and the intensive care units. Integration of all this data into a common storage point or data base is one of the major attributes of the computer system we have developed.

As the computer system was developed, we observed that one major task it could perform was that of communications; for example, communicating from the laboratory to the emergency department. To assist in this task we developed a computer network to integrate data from several computer systems into one centralized data base and communication system. There are now eight minicomputers connected with the large centralized data base; these minicomputers are physically located in the clinical laboratory, multiphasic screening, several intensive care units, pulmonary functions/blood gas laboratory, and heart catheterization laboratory, and provide analog front-end processing and high-speed communications to the centralized patients' data base. They provide rapid communications and interaction with the operator so that time-critical activities are performed rapidly with a high degree of reliability. The distributed system gives redundancy and high reliability and minimizes the load and fast response requirements of the central computer system.

Communications terminals were installed on each of the nursing divisions and in critical care areas such as the emergency department and the intensive care units. Once this was accomplished we not only had a data base that was easily reviewable and rather complete, but also an intercommunication system which made all patient data readily available to nurses, physicians, and paramedical personnel throughout the entire hospital.

It then became apparent that data acquisition, storage, retrieval and communication was important, but was not a complete utilization of the data. Therefore, about six years ago we began development of a computerized medical decision-making system. This system is called HELP (Health Evaluation through Logical Processing). By utilizing the already captured information on a patient it is possible to make decisions and for those decisions to be applied to an interpretation of data — in some cases

Supported by research grants HS02463, GM23095.

determination of a diagnosis and in other cases recommendation of treatment regimens. We developed several applications of this computerized decision-making technology to interpret results of complex tests (such as blood gas analysis), to prevent drug interaction and to review laboratory results for drug contraindications; for example, prevention of further renal function deterioration by administering certain antibiotics to people with depressed renal function.

The timely availability of patient information and the decision-making capability of the computer system allowed us to develop:

- A set of computerized rules to identify potentially life-threatening events (alerts).
- Action-oriented protocols for evaluation and treatment of these alerts.
- Computer aided treatment protocols for management of patients in critical care units when all the patient data is stored in the computer.

As part of this development we established feedback mechanisms by which physicians could be promptly notified of critical or life-threatening situations. These are broken down primarily into two areas: alarms are generated for drug-drug interactions and alerts are generated for drug-laboratory interactions. The drug alarming feedback goes to the physician through a clinical pharmacist. Alerts are primarily from hospital laboratories and go through nurse clinicians who contact and feed back critical information to the physician or nurse. To evaluate the effect the alert system had on patient care, we randomized patients into study and control groups.

If a study patient alerts, a nurse clinician verifies the alert and promptly notifies and gives the patient's physician an action-oriented protocol. The patient is then followed by the nurse clinician for 48 hours to determine if appropriate care is provided and if the alert condition is resolved. If a control patient alerts, no feedback is given to the physician other than the information obtainable from the usual sources. The control patients are followed up using the same explicit criteria used on the study patients. In this way differences caused by the alert system are measured.

Results. A scenario of an alert patient will help illustrate the system's operation. A 62-year-old female was admitted to the emergency department confused, vomiting, and unsteady on her feet. The admitting SMA 6 generated a hyponatremia alert for a low sodium level of 110. The lab test was drawn at 18:35 hours, and posted by the computer at 19:20 hours. The nurse clinician observed the alert on her computer terminal at 19:30 and went to the emergency department to assess the physicians' awareness of the problem. The admitting diagnosis on the chart stated, "Left temporal cerebral vascular accident," and no laboratory work was charted.

It was felt by the nurse clinician that the physicians were unaware of the hyponatremia and that they had possibly mistaken the patient's symptoms for signs of a stroke. The physicians were notified at 19:45 and expressed their surprise at the low sodium. The patient's physicians' assessment was changed from cerebrovascular accident to hyponatremia seizure. Because of the severity of the symptoms which developed, including a seizure, the patient was transferred to the medical-surgical intensive care unit. Appropriate treatment with intravenous saline was begun 2.75 hours after the posting time of the alert. The laboratory values went out of the alert limits in 10.25 hours and were within normal hospital limits in 33.25 hours. The patient stayed in the intensive care unit four days and was discharged a few days later with a normal serum sodium.

More than 50 computerized rules are evaluated each time appropriate data is available. Each time a patient alert condition is detected, prompt, careful follow-up and documentation of the event are made by a nurse clinician. If it is a study patient the physician or nurse is promptly notified and a computer-generated protocol placed in the patient chart. Time intervals for various actions by the physician and the patient are noted, such as first action to the condition, time in the life-threatening alert condition, and appropriateness of the action taken by the physician.

Over the last 10 months we have reviewed alerts on over 3,000 patients, of whom about half were study and half control patients. We found that by randomizing our patients into study and control groups by patient number, we could eliminate time dependent variables such as seasonal variations, etc.

Metabolic acidosis serves as a good example of the differences one could expect from this type system; we found that in the study group (208 patients) it took an average of 3.6 hours for the first action to be taken, while in the control group (181 patients) it took 6.7 hours. This time difference is highly significant statistically. We also found that *no* action was taken by the physician in 13 of 140 cases (9.3%) in the study group, and in 28 of 91 patients (30.8%) in the control group, also very significant statistically. Therefore, the conclusion was that there was a very significant difference in how promptly and how often action was taken in the treatment of this particular life-threatening problem. We evaluated how long the patient stayed in the alerting condition (i.e., how long the patient was in metabolic acidosis). We found that the mean time for patients in the study group was 23.7 hours, while it was 34.3 hours for the control group, also a significant difference. Similar to our findings when evaluating the first action taken, we found that there were significantly more patients who never came out of the alert range in the control group than in the study group.

Another interesting observation was that prompt protocol-suggested care of the patient with metabolic acidosis, either study or control, had a marked effect on how quickly the patient recovered. This gave us confidence that the simple therapy protocols we had generated were having an effect on the quality of patient care.

During the time the study was conducted, physicians were seeing patients in both study and control groups. Therefore, there was a training effect operational -what physicians learned on a study patient could be applied to the next control patient who had the same condition. Even with the contamination of the training effect, there was still statistically significant differences between the two groups. Therefore, we are confident that there is a major difference in the treatment of the patients affected by these computerized protocols.

Conclusion. The study results seem to show that the computer nurse clinician alert system can be of great value in eliminating some of the problems which develop in the management of acutely ill patients.

- The system can *speed* the *communication* process by organizing the data and presenting it on demand at computer terminals on the nursing division, thereby making possible personal follow-up by nurse clinicians even when the physician is not available.
- The system *reviews* all available patient data with a complete set of criteria for life-threatening events and does it tirelessly and continuously.
- The computer system *interprets* the data for all possible alert conditions by integrating new data with other patient information to identify interaction or trends, and alerts only when conditions warrant.
- More prompt and appropriate *actions* can be taken by physicians, nurses, or paramedical personnel who receive the alerts.

The study points out the value, especially for emergency and acutely ill patients, of a computerized clinical decision-making system. We have not quantitated each of the problems listed earlier but have shown that an added suggestion given promptly can make a difference in medical staff behavior and patient response. The situation of care for an acutely ill patient places time and intellectual demands on physicians which at times are unreasonable; with the information overload that can occur, computerization of data acquisition, communications and interpretations with warning alerts appears to be of great value.

Cost-benefit studies with this type of feedback have not been done.

We have strong evidence that the method can make a difference; the excellent physician support received indicates that physicians have appreciated the information and patient treatment suggestions.

Future plans call for more sophisticated treatment-oriented protocols which are patient specific. The protocols that have been developed to this point are very simple in content; yet, even with these simple protocols a positive effect

continued on page 180

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COMPUTERIZED PROTOCOLS *from page 93*

on patient care has been shown. As the cost of computers decreases and there is increased utilization of computers in patient care, we anticipate that these research activities will become a routine part of patient care. Current limitations are primarily in

- The development of medical protocols that are agreeable to the majority of physicians;
- The development of simplified and efficient man/machine interfaces so that, especially in the emergency and acute care situations, data can be entered promptly and accurately by health care providers;
- The development of easy coding methods to permit rapid and convenient entry of other input information by physicians and nurses so that all the data might be put into the system for decision-making purposes.

The computer will never replace physicians in their ability to establish interpersonal relationships, in their observational capabilities, nor in the art of extracting information and making decisions, but it can alleviate the physician's burden by speeding communications, eliminating lost data, assisting in decision-making and suggesting optimum therapies. •