IM INTERNAL MEDICINE FOR THE SPECIALIST

Computers in the Emergency Room

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To assess the value of computers and monitoring aids in the emergency room, it is helpful to understand the information used by the emergency-care team. The care of critically ill patients admitted to the emergency room requires considerable skill and prompt, accurate treatment decisions. Physicians and nurses collect a great deal of data through frequent observations, laboratory testing, and continuous monitoring of the vital signs of these patients.

The emergency room is the site of some of the most dramatic and lifesaving care given in medicine. Complex communications and transportation systems with helicopters, ambulances, and fixed-wing aircraft have been developed to funnel traumatically injured or desperately ill patients to the emergency room. The emergency room receives a broad class of patients with varying care situations who are cared for by a team of specialized physicians.

There is seldom time to prepare for the patients who are admitted. Often little or nothing is known about the patient's medical history on admission. First aid, basic life support, and advanced life support are given immediately to sustain the patient's life. How, then, can computers be used to aid the patient in this fast-paced, time-intensive environment? The following fictitious scenarios illustrate how today's computer technology might be applied to patient care.

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CASE I

John, a 28-year-old man critically injured in an automobile accident, is admitted to the emergency room. The staff quickly attach him to microcomputer-based equipment that monitors and displays his vital signs. If any of these vital signs change drastically for the worse, the computer triggers an alarm. The patient's name is then logged into the hospital's central computer, which searches its medical-record data base for prior admissions.

If John has been in the hospital within the past 15 years, his medical history will be immediately available to the emergency-room staff. Otherwise, staff members enter information like age, sex, height, and weight. Following this, the entire electronic network at LDS Hospital—25

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computers, 480 terminals, and 40 printers—have John's data available for use. Blood samples drawn from the patient are sent to the clinical and blood-gas laboratory, where personnel have already been notified of the upcoming order by the computer network.

As soon as the samples have been analyzed, the results are fed into the laboratory's computer, which conducts an initial check of the data for accuracy. These results are logged into the hospitalwide network, which evaluates them against normal reference values, based on the information about John's age, sex, and body size. Within minutes, the data are computer-interpreted and the results, including indications of any life-threatening conditions, are printed out in the emergency room. The results are also available for review on any of the hospital's terminals or from personal computers in physicians' offices.

John's roentgenograms, taken in the emergency room, are sent for analysis by a radiologist, who, like the clinical laboratory staff, has been alerted by a terminal in the radiology department. Based on knowledge of the patient's location, sex, age, laboratory data, and ailment, the computer can prompt the radiologist with various likely interpretations of the roentgenogram, speeding the analysis. The radiologist can then quickly select one of the displayed interpretations for transmission to the emergency room.

Once doctors have determined the extent of John's serious head, chest, and abdominal injuries and provided appropriate therapy, John is transported to surgery. During transport, computerized monitors maintain surveillance of John's heart rate, rhythm, and blood pressure. Computerized intravenous infusion pumps titrate fluid and drugs into his veins. For the moment, John is stable. During transport, all of the monitoring and intravenous pump data are automatically logged into the memory of the computer-based monitors. When John arrives at the surgical suite, the anesthesiologist connects John's equipment to a hospital information system that extracts the data stored during transport and updates John's computerized medical record.

John's emergency-room physician and nurse use the computer to collect, organize, and interpret his data, including clinical notes and observations. Thus, they are never required to write on the chart. The microcomputer-based bedside monitor collects, transmits, and records John's physiological data. Other devices record ventilatory status, intravenous fluid infusion rates and volumes, and fluid output (urine and tube drainage). This information is automatically logged into the computer by a medical information bus. A computer-activated nursing plan guides John's care.

Any drug orders are also entered into the computer. The initial order triggers the following sequence of events: the order is stored in John's electronic medical record, where it becomes available for review on any terminal; a computerized drug schedule is initiated, making it simple and fast to record when the drug is given; the drug order is processed through a pharmaceutical expert-system program that determines if the order is safe, based on what the computer knows about John's allergies, other drug orders that may be incompatible, or laboratory results that may contraindicate treatment with the drug; John's record is updated to indicate that the drug has been given; and John's account is billed. The computer record then provides an audit trail that permits careful record follow-up if errors or problems are suspected.[1]

CASE II

A mother walks into the emergency room holding a lethargic 18-month-old boy. The mother carries a small can of "Silver Cleaner" from a company called Whink Products with only a quarter of the 16-ounce can left. The mother recalls the can being approximately three-quarters full. The mother saw the child drinking the liquid but was not aware of how much he drank and how much he spilled on the floor. The contents label is unreadable, and it has been approximately 30 minutes since the incident. The child had a blood pressure of 80/60 mm Hg; pulse, 120/min; respiration rate, 20 min; and temperature, 99° F. An intravenous infusion was started with 5 percent dextrose in water, and an electrocardiographic monitor was attached.

The physician types the brand name of the substance into a personal computer and finds "Silver Cleaner from Whink Products" in a short list of agents with the name "Silver Cleaner." The microcomputer searches the information on its laser disk and displays the chemical components of the product: silica, 9 percent; isopropyl alcohol, 7.5 percent; dithiobis stearl propionate, 4.4 percent; calcium carbonate, 1.80 percent; ethenolamide of coconut acid, 1.10 percent; bentonite, less than 0.86 percent; sodium thiosulfate, 0.6 percent; hydroxyethylcellulose, 0.40 percent; cellulose, less than 0.40 percent; iron oxides, less than 0.08 percent; and water balance.

The system suggests that the 7.5 percent isopropyl alcohol and 4.4 percent dithiobis stearl propionate detergent are the components that require medical management. Isopropyl alcohol is prioritized as the most critical ingredient, and the physician asks to review the available information on management of isopropyl-alcohol ingestion. The system displays a list of subject headings for review (e.g., Symptoms, Overview, Clinical Effects, Treatment, Pharmacology, Range of Toxicity, Kinetics, Warnings). The physician chooses the "Symptoms" heading, and the system displays a summary of symptoms by physiological system:

Cardiovascular: Hypotension may occur.

Respiratory: In severe intoxication, respiratory failure may occur.

Neurological: The stimulatory phase seen with ethyl alcohol is generally absent following the ingestion of isopropyl alcohol. Ingestion may result in hypothermia, lethargy, sleepiness, and coma. Deep coma and areflexia are common following severe intoxication. Incoordination and ataxia may occur if the spinal cord becomes involved.

Gastrointestinal: Patients generally have an emetic response with gastritis (more than with ethanol), but this is not always the case.

Metabolism: Hypoglycemia is reportedly uncommon following acute ingestion, but must be checked for. Insufficient data (e.g., case reports are available in the literature to conclusively document the presence or absence of hypoglycemia in children. Mild hyperglycemia has been reported in adults (King Jr et al, 1970; McCord et al, 1948).

Acid-Base: Ketosis without acidosis is common; normoglycemic ketoacidosis is rare, but may be seen (Alexander et al, 1982).

Temperature-Regulation: Hypothermia frequently accompanies coma (Adelson, 1962).

Dermatological: An infant developed coma following topical application of isopropyl alcohol for relief of fever (McFadden and Haddow, 1969), but inhalation absorption was probably a major contributor. Neonates have been burned by topical application of isopropyl alcohol (Schick and Milstein, 1981).

The physician then chooses to review the "Treatment" section, which suggests prevention of absorption by emesis, gastric lavage, activated charcoal, or cathartic. The system also suggests treatment of exposure by physiological (vital-signs) monitoring, treatment of hypotension, and monitoring of blood glucose for hypoglycemia. The system suggests that hemodialysis may be useful in patients demonstrating marked symptoms who are unresponsive to standard therapy.

The physician inserts a nasogastric tube and receives an immediate emetic response of 20 mL of clear brownish fluid. The child is given charcoal slurry and a finger-stick blood sugar test and is admitted for observation.

If a drug had been ingested, the same information would have been available from the computer and the pill or substance identified by its markings, container, or physical characteristics. The information from this electronic textbook system can be printed out and taken by the physician to rounds the next day for review of the child's case and instruction. The system provides differential reviews of causes of specific symptoms and clinical reviews of specific disease states.

DISCUSSION

To assess the value of computers and monitoring aids in the emergency room, it is helpful to understand the information used by the emergency-care team. As the cases presented here illustrate, care of the critically ill patient admitted to the emergency room requires considerable skill and prompt, accurate treatment decisions. Physicians and nurses collect a great deal of data through frequent observations, laboratory testing, and continuous monitoring of vital signs of the critically ill patient.

Physicians generally prescribe complicated therapy regimens for such patients. As a result, the physician can miss important events and trends unless the mass of accumulated data is presented in a compact, well-organized form. Economic pressures in recent years to reduce the use of therapeutic and diagnostic resources have only compounded the physician's difficulties. At the same time, the legal liability of caring for the emergency patient has grown.

The medical record is the principal instrument for ensuring continuity of care for patients. For the emergency-room patient, this is especially important, because these patients are often cared for by a team of physicians, nurses, and therapists. In addition, data are frequently transferred from person to person. For instance, the laboratory technician calls the emergency-room nurse with data that the nurse records and reports to the physician decision maker. Each step in the transmission process is subject to error. Computers can reduce the number of transfer errors and speed this communication process, plus provide an overall surveillance function by using expert system (decision-support) capabilities.

The amount of medical data available to physicians has increased dramatically.[2] Medical students spend much of their time memorizing rather than learning the interaction of physiological systems, and established physicians have no way of staying completely abreast of the ever-expanding pool of medical knowledge. Tools like those described in Case II have been designed to serve as extensions of a physician's memory.[3] Rather than have to remember the characteristics of every drug, physicians can now use the computer system to make quick reference to the drug and review the drug formulary for clinical effects and side effects. Differential causes of symptoms can be reviewed by symptom. Clinical reviews of specific diseases are available by disease. Computer algorithms can also produce nomograms and reminders to physicians as aids in prescribing drugs.

Electronic textbooks provide faster access and more complete indexes to textual information than do their paper predecessors. When the hand-held electronic calculator became a tool for engineers, the engineering faculty could suddenly give a more difficult and practical test problem to the student because the slide rule was no longer a limiting factor in mathematical calculation. Electronic textbooks may help produce a new generation of physicians who can use the computer to extend their knowledge and their understanding of the holistic physiological process rather than have to rely on rote memorization.

Some medical electronic textbooks are now available and provide a comprehensive coverage of available information. One very good example is POISINDEX® (Micromedix, Inc., Englewood, CO). Others are just starting to be developed and will take time and extensive use to become well accepted and viable. The purveyors of these systems are not software firms but, rather, medical publishers that maintain editorial boards with the expertise to ensure that the quality of information is clinically valid, up to date, and referenced.

We reviewed the acceptability of electronic textbook systems by emergency-room physicians at two institutions and saw mixed results. All physicians who used and reviewed the computerized Micromedix systems were excited about the technology and the fast response time provided by the system. They considered the material well condensed and the topics well researched. They all thought that the system would be a very good teaching tool for medical students, because the information is presented in a manner similar to the approach of the teaching methods used. The most helpful material to those surveyed was the pediatric information because of the infrequent exposure to pediatric patients in the emergency room.

The physicians surveyed were unhappy with the complexity of using the system. They suggested that considerable training may be necessary to reduce the time and frustration in finding the characteristics of a toxic substance that could have caused symptoms in a particular patient. This dissatisfaction might have been reduced once they had become more familiar with the system.

Other comments indicated that much of the clinical review and differential review material is not complete and much of the material is rudimentary for practicing emergency-room physicians who have neither the time nor the need to wade through pages of information they already know to find a small piece of information that was forgotten or new. It also appeared that in several cases the Micromedix system should have taken a further step and added calculation facilities for algorithms provided in the text.

The current cost of the Micromedix system is large for a small hospital, but a large emergency room with a heavy caseload may find it cost-effective. Some users suggested that quarterly updates were overkill and that semiannual updates would be more than sufficient, considering the small number of new poisons and the infrequent basic changes in the practice of medicine.

CONCLUSION

Both as faster communications media to and from other support areas of the hospital and as decision aids, computers are becoming useful tools in the emergency room to assist physicians in handling complex cases. The field of computerized medical expert systems is just now beginning to provide the tools that may have a major impact on enhanced emergency-room care in the future. IM

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