ABC of Computing

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COMPUTERS IN HIGH DEPENDENCY UNITS

In many hospitals the most severely ill patients are cared for together in specialist areas—for example, in postsurgical, intensive care, and coronary care units—to simplify management and provide a high ratio of staff to patients. These patients usually need extensive monitoring and the necessary equipment generates a large volume of data. Computers are increasingly used in high dependency units to make these data available and useful to the staff, but unfortunately it is difficult to predict their best application. New methods need to be critically examined, and the views of the people who will have to use the system should be taken into account. It is perfectly possible to implement a computer system for the sake of doing so yet remain unaware that the real benefits may be small. The applications can be divided into off line, on line, and feedback control.

Off line applications

Off line applications are simple computer systems where epidemiological information is collected to help in directing and refining management policies. The information is entered into the computer in batches, sometimes even when the patient has left the unit, and the results of the analysis form the basis of local mortality reports. This technique allows the high dependency unit to be managed on the basis of facts rather than opinions and is an excellent form of internal audit.

One important feature of information from an high dependency unit is that it includes a wide range of different types of information, from that relating to states, such as being conscious or unconscious, to measurements such as blood pressures which are on a continuous scale.

On line applications

Data logging—The availability of fast cheap microprocessors has facilitated automatic data logging. Information from a patient—for example, blood pressure readings from an arterial transducer—may be stored by a computer and analysed to give results within seconds of any event. In the more advanced systems information may also be entered via a keyboard along with some measurements that can be done only by hand, such as eye signs. A vast amount of data can be collected, but unless the data are annotated as they are collected—for example, that the cannula was flushed—they are very difficult to evaluate when reviewed later. Furthermore, even when the record is correctly annotated, it can be difficult to understand what is happening unless additional information such as urine output and fluid and inotropic drug administration is also available. This additional information is no burden if it can be collected accurately and automatically, but if the nurse has to do it she rapidly becomes a computer feeder rather than somebody who looks after patients. One particular use of data logging is to examine the prodromal sequence of events—for example, the pattern of blood pressures before an unexpected cardiac arrest.

Alarms—A nurse by the bedside is an excellent monitor of the patient's condition, but she will never be completely vigilant. She may, for example, turn her back when getting drugs from the cupboard, and during this time the patient may have a run of ventricular tachycardia which may have stopped by the time she returns to the bedside and hence go completely unnoticed. The computer, on the other hand, can be completely vigilant, being able to sample the information many times a second. It is relatively easy to evolve complex alarm systems which require several pieces of information—for example, an alarm may be given only if the blood pressure and the pulse rate are both out of their normal ranges. This is one approach to the problem of eliminating spurious alarm signals. One problem with a computer system is the risk that staff may come to rely on the vigilance of the computer, rather than looking at the patient. The computer cannot be expected to be vigilant in monitoring signals which it does not receive. Another aspect of alarms is the need for objectivity. Suppose a form of treatment is managed on the basis of heart rate and action has to be taken at a certain threshold value. Whether the action is taken could depend on which nurse counted the pulse, because people vary in their accuracy in counting. If properly programmed the computer will have the same repeatable accuracy all the time.

Trends—The timescale of recorded events can be compressed to enable the doctor to see trends in measurements such as diurnal changes in blood pressure. An extension of this technique is to use a computer technique to predict the future value of a measurement. The heart rate reading, for example, could be logged and the trend calculated so that the staff could predict the patient's condition some hours hence. This is obviously useful in that it gives the staff warning of an event so that remedial measures can be taken to forestall disaster, but the predictions are only as good as the data on which they are based, and if during the recording period an electrocardiogram lead fell off the trend would be valueless.

Specific calculations—On line computing allows rapid calculation of information such as cardiac outputs; the computer can calculate the cardiac output from the area under the thermodilution curve recorded from an intravascular transducer and present the result in seconds. The observer merely has to type in some information on the type of catheter and the temperature of the injectate, but otherwise the calculation is simple. Detecting and identifying arrhythmias are further examples of specific calculations on logged data.

A humbler but nevertheless valuable computer application is for a preprogrammed computer to be available to help with simple calculations such as those needed for infusions, especially those which have to be run at dose per unit weight per hour, such as dopamine.

Each high dependency unit has a form or chart for recording the patient's fluid balance, pulse, blood pressure, and so on, and its design is usually determined by the variety of patients entering the unit. Computerising this chart has been tried, the attraction being to avoid cumulative mathematical errors, but there are still many problems. Firstly, a new suite of charting programs has to be designed for each unit as the requirements are so diverse. The charting system must also be able to change with the patient—for example, when a drain is removed the nurse does not want to have to continue to enter zeros under the heading "drains" each hour for the next six days. Secondly, many patients in these units have several "lines," and to get a useful impression of what is happening the doctor needs to be able to scan the results. This is much more difficult if the information is presented in several separate displays. Thirdly, the nurse still has to enter the information correctly and on time. In modern systems some forms of automatic data entry can be used—for example fluid metering devices can be directly linked to the computer.

Use of computers in a high dependency unit

There are three strategies for using computers in high dependency units and an underlying trend to move the "intelligent part of the computing" nearer to the bedside.

The oldest strategy requires a central computer which serves the whole high dependency unit via terminals which function only as input-output devices. The unit would be equipped with bedside terminals which would allow the staff to enter data and would include connections to link equipment such as transducers to the central computer. The computer, which need not be sited in the high dependency unit itself, would be able to handle several patients simultaneously.

The second approach takes advantage of the cheapness of microprocessor technology and beside each bed there would be a terminal containing several microprocessors and capable of simple operations, such as defining the peaks of the arterial waveform to identify the systolic pressure. This concept is termed the intelligent terminal. The availability of microprocessor memory chips also makes it possible to store information at the bedside so that trends can be displayed without reference to any central computer. The microprocessor bedside unit can also transfer information to a central computer, and in this function it acts as a preprocessor. One advantage of preprocessing is that only selected information is stored in the central computer, and this produces a considerable saving in the storage requirements.

The third strategy, the logical extension of the intelligent terminal, is to make the bedside unit capable of all the functions required and use the central computer only for storage and off line analysis. There may not even be a central computer. Plainly this is the last phase in the trend noted above, and has the major advantage that flexibility is maintained at all stages. A high dependency unit could be progressively equipped with bedside units, and when money is available a central computer can be purchased. One theoretical problem with this approach is that by the time a reasonable number of bedside units have been bought the technology may have moved on and the high dependency unit is left with several incompatible units at different stages of technological development.

The increasing sophistication of the bedside units has led to the development of extensive self help facilities. The nurse setting up a pressure monitoring system can be "talked through" the operation by the microprocessor in the bedside unit. Each step, zero adjustment, calibration, and so on can be "supervised" by the computer and the nurse prompted if there are any errors. This type of automated self help system is a particular attraction to high dependency unit nurse teachers as it helps in on-the-job teaching. This level of self help may suggest to the impoverished money providers that less experienced staff could be used in a high dependency unit, but again flexibility is the problem. Few computers can turn their hands to making beds or changing dressings.

Flexibility in monitoring facilities is also important in high dependency units. Some cases are setpieces, at least from the nursing point of view. For example, for a patient who has just undergone cardiac surgery the nurse can predict how many drains and transducers there will be and what type of ventilator will be used. On the other hand, many patients in a general intensive care unit—those who have undergone bowel resection, those with septicaemia, those with multiple injuries, and myaesthenic patients—may not be so predictable in their requirements. The bedside unit is designed to be "totipotent," capable of any form of monitoring.

One extension of the concept of a bedside microprocessor is feedback control of a variable. Blood pressure after coronary operations can become uncontrollable, and hypotensive agents are given to reduce the myocardial afterload and protect the integrity of vascular anastomoses. Control can be restored automatically by a feedback system which infuses sodium nitroprusside according to the blood pressure. All applications of feedback control lean heavily on reliable measurements. Very precise control of physiological variables, far beyond physiological usefulness, can be achieved by this method.

Staff attitudes

High dependency units stand or fall on the quality of their nurses, and not unnaturally staff may find that the computer intrudes on their relationship with the patient. Like most people meeting computers for the first time, nurses and doctors are sceptical and suspicious, feeling that they do not understand all the complexities. Some are reluctant to entrust even part of their patient's management to the computer. To some people no amount of explanation really allays this fear and the computer is only grudgingly accepted: this is a fact of life and must be accepted. The introduction of a computer may also cause embarrassment to more senior staff, who suddenly discover that the new staff nurse did a course in computing at school and is not as bemused as they are. In these circumstances "doing the computer" may be left in the hands of one nurse who is unfrightened, while the rest get on with the "real" nursing. When introducing a computer into a high dependency unit it is therefore essential to involve the non-expert users from the start, so that the staff feel that they all have a part in the system.

Records

Nursing and medical notes are often a problem, since staff may be unhappy to trust the computer system with the information. This is particularly a problem in the early stages when the computer is new and problems are frequent. Unfortunately, trying to manage patients and keep the normal nursing records of an ill patient can, even with the most competent staff, be a considerable strain. To add computer feeding may be the last straw.

One more limited application is to use the computer to prompt the nurse, not only to enter data, but also to carry out specific nursing procedures, such as turning the patient.

The future

The efficacy of computers in high dependency units is not yet confirmed and may be unprovable. The variety of patients, the different conditions, and the lack of objective measurements of patient well being militate against reliable ergonomic analysis. Standard measurements such as mortality rates are far too crude. A wide variety of computer systems are now being designed, some experimental, some commercial, and while many people think that computers should be used in high dependency units their precise niche has not yet been found. It is unwise to reason that because computers seem to work in setpiece circumstances they will necessarily be as useful in the general intensive care unit, which caters for a wide range of problems.

One useful idea is to define what computers do well. Computers are very fast and efficient at doing repeated tasks, storing information, and retrieving it. Storage and retrieval are examples of one relatively simple task repeated many times over. Computers are also very consistent and will, given the same information and program, always treat it in the same way and produce the same results.

On this basis, data logging is an obvious and reasonable task, and perhaps time should be expended to make some of the less invasive monitoring equipment such as automatic blood pressure recorders compatible with the bedside systems. The drudgery of routine blood pressure recording by cuff can then be left to the computer.

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