Interpretation of Clinical Chemical Data with the Aid of Automatic Data Processing

Donald S. Young

I summarize conventional applications of computers in clinical laboratories and discuss the possible role of the computer in providing assistance in interpretation of laboratory data through the use of data bases. The data bases include effects of drugs on the results of laboratory tests, factors influencing reference values, and conversion factors for converting data from conventional units to SI units. Reported diagnostic applications of the computer are discussed with reference to both clinically oriented and laboratory oriented programs.

Additional Keyphrases: variation, source of • diagnostic aids • data processing • computers

Laboratory tests are used by physicians primarily to assist them in the diagnosis of a disease, to monitor the effectiveness of therapeutic regimens, and to screen for the presence of unsuspected disease. The number and variety of tests used for these purposes have steadily increased. The increase in workload in most laboratories has been accommodated only by extensive mechanization; the resulting increased efficiency in performing tests has led to another major bottleneck. As much as 30% of a technologist’s time may be used in clerical activities (7), many of which can be performed as well or better by computers.

Computers were first introduced into clinical laboratories in the mid-1960s. They were then expensive and had limited capabilities. Now their role has expanded greatly and they are in common use in clinical laboratories throughout the world.

Computers have been used in clinical laboratories to perform certain clerical, data acquisition and processing, and management or business functions. In university centers, computers may also be extensively used in research. A role that has not yet been exploited to any extent is that of data utilization or interpretation, potentially one of the most useful roles for a computer in a hospital setting.

Clerical functions now performed routinely by computers in the clinical laboratory include preparation of work lists, loading lists for mechanized equipment, directories for matching specimens with patient names, logs of specimens received, daily reports of results, and cumulative summaries or other summaries of work, as required.

Data may be acquired directly on-line from analytical instruments or indirectly in an off-line mode after information is entered into the computer by means of punched cards, punched paper tape, or magnetic tape, or through communication terminals such as cathode-ray tubes. Instruments yielding either an analog or digital voltage output may be interfaced with a computer. When an analog output is used, it must first be digitized before processing by the typical laboratory digital computer. The output from most continuous-flow analyzers is an analog voltage but these instruments are readily interfaced with computers. Many instruments with digital displays or printed output can be coupled directly to a digital computer without prior voltage conversion. Such instruments include many of the common flame photometers, enzyme analyzers, and densitometers.

The “management” role of the computer includes billing for the tests performed and monitoring the total workload and keeping track of tests requested, to ensure that the work is completed expeditiously. It may be used in various ways to monitor the quality of work performed. Results from control specimens may be displayed graphically, or means of all, or selected, tests or the cumulative sums of daily control specimens may be listed or displayed. The computer may be used to list results outside predetermined limits. It may derive additional values, such as values for the anion gap or the creatinine/urea nitrogen ratio, with an evaluation of the probability of the results being abnormal. Results of tests from one day may be compared with those from the same tests on another day.

Transformation of Data into Information

Traditionally, clinical chemistry laboratories have reported numerical data to physicians. Few centers have attempted to provide assistance in interpretation of results, a situation that has arisen because most laboratories do not have an adequate number of appropriately trained staff to provide this service and because it is generally assumed that if a patient-care physician has ordered a test he must be capable of interpreting its results.

Results reported by a laboratory are generally quantitative. They are not necessarily informative.
without an interpretive step being interposed between their generation and receipt by a physician. In many clinical laboratories the staff has been preoccupied with increasing the precision and accuracy of results, less concerned about the application of these results in the diagnosis or treatment of patients. If such a choice must be made, a laboratory might be better used by trading some quality of data in exchange for more professional time that can be used for interpreting results. I do not condone abandoning the concept of producing the best possible quality of data within the operational limitations of a clinical laboratory, but I do believe that the laboratory must become involved in the transformation of laboratory data into information that is usable by a physician in the treatment of his patients. Although most laboratories do not have an adequate staff to provide this service, they may still expand their interpretive role through the use of a computer. Interpretive computer programs may be developed from the knowledge of experts in a specialized area and used as background for interpreting data.

The availability of some computers in hospitals in the early 1960s stimulated considerable study of their possible application in diagnosis. Much of this early work was exploratory and not necessarily designed for practical application. Nevertheless, disillusionment with the possible role of the computer as a physician's aid followed the early pioneer applications—probably because of the high cost of hardware and programming, but possibly also because of a failure to involve all individuals in the data production and utilization chain. Recently, the availability of cheaper hardware and simplified programming languages has stimulated a further examination of the possible interpretive roles of the computer.

Interpretive Applications

Two levels of interpretive applications have been developed. In the first, the computer is used to select and present data in a format that makes it easier for a human to make a decision. This approach frequently uses data bases from which a limited number of choices can be presented to a scientist or physician, who then is able to decide which he thinks is the most appropriate in the particular case. The second application involves actual decision making by the computer. A decision tree may be used with branching logic so that a single pathway is followed through to a conclusion. In a more elaborate process, probabilities are weighed by the computer, most often by using Bayes' theorem so that the most probable of several options is presented.

Most of the decision-making processes are complicated and require considerable readily accessible storage space in the computer. This is especially true when large data bases must be accessed. However, decision-making capability has been programmed into smaller computers, such as the PDP-8, but in these cases the decision making is relatively straightforward and simple. An example of such an application is the blood-typing program used with the ORNL miniature centrifugal analyzer (2). Interfaced with this instrument, the computer is able, from evaluation of the absorbance readings that result when whole blood is mixed with various antisera, to assign the correct group and Rh factor to the blood specimen. The program can also be modified to operate in a reverse typing mode.

Interpretive functions have been built into small dedicated computers for other functions, e.g., verification of the linearity of a calibration curve or the reaction rate of an enzyme determined kinetically. With a laboratory computer it is possible to match data obtained on one individual on one occasion with those obtained previously. This shows whether results have changed by an amount greater than can be accounted for by normal physiological variation over the specified time interval. In our laboratory, we incorporate this program into our daily procedure for quality assurance of data. It is possible to identify specimens that should be reanalyzed, or results that should be followed up by one of the laboratory staff with a patient-care physician. An incidental benefit is that the laboratory staff has become much more involved in assisting clinicians with the interpretation of laboratory data.

Computers may be used in assuring quality of data. Thus correlation between results may be readily determined through programs that calculate the anion gap or serum osmolality. Solberg (3) developed a program to correlate values for base excess with those for pH, $p$CO$_2$, and standard bicarbonate on the same blood. Rodbard and Hutt (4) devised an iterative, least-squares method for logistic curve fitting for radioimmunoassays, to improve the quality of results. We have now applied the same procedure to the EMIT (Syva Corp.) system for measurement of the concentration of antiepileptic drugs (Rodbard and McLean, personal communication). Most clinical laboratory computer systems include programs for monitoring the quality control of routine test procedures, with mechanisms for alerting the laboratory director to unusual results.

Data-Base Concept

Some time ago we became aware of a few instances of misinterpretation of laboratory data because of interference of drugs with analytical procedures or lack of understanding by physicians of all the actions of the drugs that they were using. To lessen the possibility of misinterpretation we developed a file of the effects of drugs on laboratory tests, which could be accessed through a time-shared computer in response to specific questions such as the effect of a particular drug on laboratory tests or which drugs might affect a particular test result. Two editions of this file have now been published (5, 6) and it has been of great value to us and to laboratory staff in other centers in assisting the correct interpretation of test results.

A second data base that we are in process of developing contains all the factors known to influence reference values, so that it is possible to determine if a value that has been obtained is likely to indicate health or illness in a given individual (7). Although many pa-
papers have been written concerning what we now call reference values, few have considered all the factors—ranging from age, sex, body build, or smoking habits to the influence of the analytical procedure—that affect this information, and so most of it must be derived de novo or by tedious literature searches, or both.

A third data base that we have developed provides automatic translation of test results in traditional reporting units into SI units. Although the SI has not yet been accepted for routine use in this country, there is a growing awareness that it is necessary to be familiar with the system if one is to understand the foreign literature and that it has some real advantages for standardizing the reporting of data. The data base is very simple, consisting of a set of conversion factors specific for each test (8). By use of a touch-button telephone we have devised a system whereby a computer may be used to provide an audio response to each entry. Initially an abbreviated test-name is entered, then the numerical results, and finally the units in which they were expressed. After each part of the entry sequence the computer provides an audible English-language response of the information that it has received. After the final entry, the computer responds with the appropriate value in SI units (9).

Automatic Use of Data Bases

The above examples require the interrogation of the computer by a human to obtain the necessary data for interpretation of results, yet all this could be implemented to run automatically. We have used the file on the effects of drugs on laboratory tests (6) to identify possible drug-induced changes in laboratory data in three wards of a university hospital (10). Over 10,000 patient days were followed. In all instances in which an abnormal test result occurred this was matched with the drugs administered to the patient. A report was printed when any of the administered drugs had been recorded in the file as producing the observed effect. The physician users of the system believed that the computer explanation was correct in about 21% of all the occasions that a report was printed. Many of the explanations that were incorrect cited effects of overdoses of drugs or toxic effects of drugs, none of which were likely to occur in hospital practice. Most of the changes in laboratory data could be attributed to changes in the clinical state that could not be programmed into the interpretive system.

Nevertheless the automatic generation of a report listing a possible drug/test interaction served as a very useful alerting mechanism to the patient-care physicians. Indeed, in several instances it provided an explanation that was probably correct, one that had not been considered by the physician. The system sometimes prompted physicians to alter therapy because of possible modifications of results caused by the administered drugs.

Even in this first pilot application it is apparent that the computer can provide valuable assistance to physicians in patient care. The percentage yield of useful information for the "drug file" could undoubtedly be increased by eliminating the inappropriate toxic effects that are unlikely to occur within a hospital, and by including information related to the patient's clinical status. We intend to continue exploring the automatic interpretation of drug effects by using a simplified file and also introducing it into community hospitals.

Applications of Computers to Diagnosis from Laboratory Data

Two orientations have been used in the applications of computers to interpretation of laboratory data. One is the approach of the clinician. In this, laboratory data are included together with various symptoms and signs and, on occasion, the case history. The second approach is that of the laboratorian who tends only to use laboratory data to attempt to derive diagnoses. The clinical orientation of the practicing physician has definite advantages over that of the laboratory scientist in that all the problems about which the patient complained, as well as the signs on physical examination—from which a physician is usually able to make a diagnosis—may be included in the computer diagnostic system. Few diagnoses are made on the basis of laboratory data alone, yet these may be the only facts available for use in diagnostic programs with a laboratory orientation. Consequently, few laboratory diagnostic programs have had acceptance in clinical practice although they may have an appropriate role in providing differential diagnoses. Likewise, they may have a useful application as a teaching tool for clinical laboratory staff.

Laboratory Diagnostic Programs

One of the earliest laboratory diagnostic programs introduced into practice was that devised by Pribor et al. (11) for the interpretation of serum electrophoretic patterns. Essentially the same program is used for the interpretation of both serum protein and lactate dehydrogenase isoenzyme patterns. Electrophoretic patterns from serum of patients with diseases often associated with abnormal patterns were compared with a pattern developed from many healthy individuals. Using only three possible choices for each protein (high, low, or normal) a directory of patterns characteristic for each disease was developed and stored. A few nonquantitative items were also entered into the system in response to queries by the computer. These included the presence of abnormal spikes or β-γ bridging. In practice, when the pattern from a patient's serum was presented to the computer it would search through its directory of patterns until some stored pattern that matched was found. Possible diagnoses were then printed on a report, which was sent to the patient-care physician. Both the logic and the program are simple, but it is impossible to indicate whether the abnormalities are mild or marked. Nevertheless, the program does to some extent mimic the human interpretive process and enable nonphysicians to provide appropriate interpretations of electrophoretic patterns.

We have begun work on a more sophisticated ap-
proach to the interpretation of protein electrophoretic patterns (Robertson and Young, unpublished). From our files we have determined the diagnoses of patients on whom serum protein electrophoretic separations have been performed. The first electrophoretic patterns obtained on individuals with a single diagnosis have been used to develop a library of characteristic patterns for each disease. Patterns obtained on the normal volunteers admitted to our Center were used to develop control patterns. Then we used a discriminant function program to maximize the difference between disease states—i.e., nonproportional weightings were ascribed to each of the five major proteins—and compared patterns from patients with unknown diseases with those in the library of patterns. As yet, we have studied a relatively small number of patients, but the system appears to have considerable promise as an aid to differential diagnosis. A logical extension of this program, when used to assist the clinician in making a diagnosis, is to indicate additional tests that could be performed to make certain which diagnosis is correct.

The concept is applicable to tests other than protein electrophoresis. The number of variables can be readily expanded. For instance, it could be used in conjunction with a continuous-flow system (e.g., Technicon SMA 12/60 or SMAC) or with any other combination of tests requested at the same time. As with all laboratory data it is essential that long-term analytical variability is kept small if slight changes in results are to be recognized.

Reece and Hobbie (12) pioneered the use of a computer to develop a diagnosis from a combination of different laboratory tests. Their program, when used in conjunction with a Technicon SMA 12/60, sorts age-, sex-, and posture-dependent abnormal results; it then matches the pattern of abnormal values with disease patterns stored in a computer. Finally, a printout is produced that lists possible diagnoses, in the order of their probability. High and low values defining a healthy population by age, sex, and posture are stored in the computer and a patient’s laboratory data are compared with the appropriate reference values. The number of standard deviations by which a patient’s values deviate from his presumed healthy state are calculated and used to develop the array to establish the presence of a particular disease. Built into the program are certain requirements that must be met if particular diseases are to be confirmed. In these authors’ hands the program has been very effective; the actual discharge diagnosis has been one of the five most probable in over 75% of the cases examined. This program has been evaluated by Button and Gambino (13), who confirmed its usefulness in the diagnosis of liver diseases, but found it poor in the differential diagnosis of pneumonia, malignant disease, and various infectious diseases. Their overall assessment was somewhat less favorable than that of the original authors. An independently developed, but similar, system has been used at the Medical College of Virginia (14), but it has not yet been evaluated in a different setting. Another program based on recognition of abnormal patterns obtained by screening profiles has been discussed by Ramirez et al. (15), but no reports of its effectiveness have been published.

Anderson et al. (16) have used the Reece–Hobbie (12) program on admission of new patients and modified it to suggest followup tests indicated by the provisional diagnoses suggested by the computer. They concede that the system has weaknesses, but believe that with additional refinements their program should lead to accelerated diagnosis and better care of patients.

A complication common to all attempts at computer diagnosis is the possibility of more than one disease being present at one time in a patient. None of the simple approaches that have been studied will be effective in this situation, nor can the programs be expected to function well when a disease has been partly or completely treated. This underscores one of the problems when an exclusively laboratory-oriented approach to the interpretation of data on a patient is used.

Some of the more complicated but well-defined laboratory tests are appropriate for computerized interpretation. Both oral (17) and intravenous (18) glucose tolerance tests have been studied. Lupovitch (17) has combined the Wilkerson point method, the Fajans–Conn criteria, and those of the University Group on Diabetes into a single program. The report prepared for the physician by the computer lists the consensus interpretation. This enables the computer to perform as well as most clinicians.

Computers have been used to reduce errors in the assessment of glomerular filtration rates (19) for techniques that involve the use of both plasma and urine, or those that require only plasma, after administration of an isotopically labeled compound.

Computerized interpretation of acid–base and electrolyte data has been of interest to several investigators (e.g., 20–22). The same simple logic that is used to compute the derived blood-gas data in the more sophisticated blood-gas analyzers can be used with programmable calculators or computers. With either the calculator or computer a differential diagnosis can be reported at least to the extent of indicating whether the acidosis or alkalosis is of metabolic or renal origin. Bleich (23) has carried the concept further and, by combining clinical impressions with the laboratory acid–base and electrolyte data, has developed an interactive program to assist a physician in the actual treatment of patients. The logic and interpretive information for the program is derived from fewer than 20 literature references, yet the program is flexible enough to permit all the important clinical and laboratory data to be entered in response to specific questions. The computer presents an evaluation in which all the critical data are summarized, and possible diagnoses listed. Recommendations for treatment can be included, down to (e.g.) the appropriate amount of bicarbonate required to restore the plasma bicarbonate concentration to normal. This approach not only has possible applications in teaching; it can be used directly to assist the management of patients with metabolic problems.
The information required for interpretation is mainly from laboratory tests with relatively little clinical input. Such programs could then be run through a clinical laboratory computer, which would be a practical demonstration of the concept of laboratory medicine.

Discriminant analysis has been used with the cholecystokinin–pancreozymin pancreatic juice secretion test to differentiate pancreatic disorders from other diseases (24). Thirteen selected variables were used. After the discriminant function between normals and patients with pancreatic disease was determined on an initial 151 patients, the computer had as good a discriminatory record as a laboratory physician, producing the correct diagnosis in 90% of cases studied when applied to another 58 patients.

**Computerized Diagnosis from Clinical and Laboratory Data**

Computers have been used with some success in the differential diagnosis of liver diseases. Before computers were introduced into clinical practice, Martin et al. (25) used a simple discriminant function to differentiate liver disease into categories of either parenchymal or obstructive disease. They compared the accuracy of the statistical prediction derived only from measurement of cephalin flocculation and thymol turbidity with the clinical diagnosis of several physicians. With use of only the results of these two laboratory tests, 86% of the diagnoses were correct, when alkaline phosphatase was also measured this percentage increased to 89%, a rate about the same as that of clinicians.

Burbank (26) has studied the differentiation of medical and surgical jaundice. He developed a "symptom profile" of 144 questions that included history, physical examination, laboratory data, and histological findings in the liver. When the complete profile was tested against validated test patients who had prolonged undifferentiating liver disease it was 98% accurate in discriminating between medical and surgical jaundice. It correctly identified the specific disease causing the jaundice with 77% accuracy. If only the results of the liver-function tests included in the profile were used, differentiation between medical and surgical jaundice was 81% correct. Including the history and results of physical examination in a profile considerably increased the chances of identifying the disease causing the jaundice, but only increased the discrimination between medical and surgical causes by 5%. If results of several additional, and more recent, laboratory tests were included the incidence of correct discrimination between causes of jaundice could probably be increased. With the overall program, when history, physical examination, and laboratory findings were included, and a correct diagnosis was made, there was usually a clear-cut discrimination. When an incorrect diagnosis was made there was often little difference in discrimination between the selected diagnosis and the correct diagnosis. This further underscores the actual usefulness of the system and the further potential for development of the concept as better laboratory tests become available.

Stern et al. (27), using a program that included 37 items from the clinical history, 12 from physical examination and 23 laboratory tests, were able to distinguish between medical and surgical jaundice in 86% of cases in a liver unit, and 77% in district hospitals. They demonstrated that rapid feedback from this program to clinicians helped them manage difficult cases. Ramsoe et al. (28) applied multivariate discriminant analysis to clinical laboratory tests to distinguish between cirrhotic and healthy individuals and demonstrated that measurements of Bromsulphalein excretion and γ-globulin were as capable of differentiating between the two situations as were, collectively, all nine of the tests that they studied. This approach has been pursued further by Solberg et al. (29), who devised optimal combinations of laboratory tests to separate different liver diseases. Other programs for differential diagnosis of liver disease have been developed (30, 31) but have not yet had such thorough testing as the programs discussed previously.

Rozen et al. (32) developed a program to predict the duration of jaundice from data on the serum bilirubin concentration, aminotransferase activity, and the age of icteric patients. They believe that this approach may also be of value in the taxonomic classification of jaundice in patients.

Fraser et al. (33) extensively discussed the differential diagnosis of hypercalcemia by the use of discriminant analysis. They found that two functions, based on the results of only five tests, were sufficient to describe the biochemical variation between the groups studied. The discrimination was due principally to serum alkaline phosphatase, inorganic phosphate, chloride, bicarbonate, and urea. The calcium concentration little influenced the differential diagnosis. The two-discriminant-function analysis was almost completely effective in differentiating between primary hyperparathyroidism and other causes of hypercalcemia, although it was not always possible to differentiate between the various nonparathyroid diseases. However, the program was still 90% effective in assigning the patient the correct clinical diagnosis. Amenta and Harkins (34) have also used discriminant functions with phosphate clearance studies to improve the differential diagnosis of hyperparathyroidism. Marshall et al. (35) used a computer program to assist in the diagnosis of metabolic bone diseases. Not only does the program suggest possible diagnoses, but it has improved the quality of results from the laboratory by monitoring for inaccurate collections of urine specimens.

Fitzgerald et al. (36) used a conditional probability program incorporating Bayes' theorem for the computerized interpretation of thyroid disorders. The program includes signs, symptoms, and laboratory data, and in the authors' initial evaluation it had an error rate of less than 3%. More recently, Oddie (37) has described another program, also based on Bayes' theorem, in which only laboratory data were used for the diagnosis of thyroid disorders. The correct diagnosis was made in about 96% of cases. Neither of these programs includes
several of the recently available thyroid-function tests that could improve the diagnostic specificity of the program. However, it is conceivable that proper use of appropriate computer programs might avoid the need to perform many measurements, such as free thyroxine or thyrotropin, that are often included in the routine thyroid diagnostic work-up. Fragu et al. (38) have recently included several of the newer thyroid-function tests in a program that makes use of both clinical and laboratory data. They found that the diagnostic power of the free thyroxine index exceeded that of data on triiodothyronine in differentiating between euthyroid and hyperthyroid patients, and has the same discriminatory capability as $^{131}$I uptake, without the disadvantages of isotope administration.

Taylor et al. (39) used a computer to develop a cost-conscious approach to the performance of laboratory tests in patients with thyroid disorders. Interestingly, this approach had the same diagnostic accuracy as did the conventional approach. Stauffer et al. (40) devised an interactive program to provide optimal use of the clinical laboratory in performing thyroid-function tests. Such approaches have the potential for considerable impact on clinical laboratory operations by decreasing the number of requests for tests that would not really provide more useful information than was already available. The resulting decrease in the workload would allow time for additional tests to be performed for other purposes, while at the same time maintaining or enhancing the use of the laboratory in supporting good diagnostic and treatment practices.

Bogdanik (41) combined the value for the concentration of digoxin (or other derivatives of digitals) with the mode of administration, the individual's body weight, and his serum urea concentration to calculate appropriate therapy in individuals with renal failure. This program could logically be extended to other therapeutic drugs for which the pharmacokinetics are known.

Discussion

In this survey I have not attempted to discuss all the applications of computers to the diagnosis of disease. Many of the programs that have been developed have relied heavily on laboratory tests that must now be considered obsolete. In many instances they have been replaced by tests of greater diagnostic specificity, so that the reason for developing a sophisticated diagnostic program has been invalidated. Nevertheless, as has been demonstrated by the programs used to assess the cause of hyperparathyroidism, it is sometimes possible to make diagnoses effectively by a combination of simple conventional laboratory tests without the need for sophisticated new procedures. This might prove cheaper and as effective as is the performance of some of the more elaborate tests—e.g., urinary cyclic AMP, and parathyroid hormone or calcitonin measurement in cases of hypercalcemia. Certainly, a computer diagnostic program is able to extract, by means of discriminant function analysis, more information from a given set of laboratory data than could be expected of a physician. In this situation a laboratory computer should be used in the interpretive role to present to the physician a simple summary interpretation, together with the numerical values derived from all the tests. This interpretation could be performed automatically or on demand as if it were another laboratory test.

Data bases can be readily interrogated on-line if the information required for interpretation is entered into the system. When a laboratory computer is directly interfaced with a hospital information system through which drug therapy is ordered and progress notes are updated, then it should be possible to correctly interpret the effects of drugs on laboratory tests and to discriminate between such effects and changes in the patient's clinical state. Widespread use of data bases awaits the development of the material for the files. If appropriate files existed now, they could readily be used to assist in the interpretation of laboratory information, even without a direct interface between a laboratory and a hospital computer. Our experience indicates that it is often easier to use a print-out of a file, with an individual scanning it in response to specific questions, than to attempt an automatic interpretation. This permits the physician to obtain background information necessary to make decisions without having to sit at a computer terminal. Indeed, one of the most important applications of the computer may be as a text-editor, to present relevant information to the human in its most easily usable form.

If the information presented to a computer can be clearly delineated, a program can generally be written to handle the data. Thus if glucose tolerance (or any other) tests can be performed in a standardized manner, programs can be used to provide automatic interpretation if the logic involved is straightforward. Indeed, given any standardized situation, it is usually possible to develop an appropriate computer program to interpret the data. Thus differential diagnoses or treatment schedules can be established automatically.

Much of the work that has been done with computers for automatic interpretation of data is based on outmoded laboratory tests. In spite of this, many of the programs have been successful in correctly determining the diagnosis. It would be interesting to incorporate some of the newer laboratory tests into the existing programs, to see if the yield of information might be even greater. However, the role of the laboratory is not usually in the diagnosis of disease but in monitoring treatment—to assess therapeutic effectiveness or to search for drug toxicity. Computer programs have not been developed with a primary role for monitoring trends in results. A clinical laboratory computer could be programmed to assume this function.

Croft (42) believes that computerized diagnosis is unlikely to be successful without standardization of definitions and the development of large and reliable data bases. Additional education efforts are required if physicians are to accept the important role that computers could play in diagnosis.
de Dombal et al. (43) suggested that the most useful application of a computer in the diagnostic process may be to produce a probabilistic analysis from the large mass of data presented to it that may be difficult for clinicians to assimilate or to eliminate irrelevant data from this same mass of information. The computer should be there as an advisor or consultant and not force a physician to act upon its promptings. No program is likely to have clinical acceptance if it is not developed in conjunction with clinicians, if it is to be used by them. However, most physicians are not yet aware of the potential benefits that they may receive from using the interpretive capabilities of a computer.

References
7. Special issue.