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Physician-Computer Interaction as a Clinical Research Technique

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The technique of physician-computer interaction (PCI) herein described utilizes a clinical data bank for a single disease entity. Physician-computer interaction requires special programming so that the interrelationships of the various clinical and laboratory parameters may be immediately displayed. With use of a data bank composed of 60 variables in each of 500 patients with acute transmural myocardial infarction, the relationships of mortality to coronary care, age, serum glutamic oxalacetic transaminase level, white blood cell count, and congestive failure are illustrated. The technique of physician-computer interaction gives the clinician or researcher an enhanced diagnostic capability, unobtainable by batch processing or standard techniques of statistical analysis. In addition, there is greatly increased opportunity to relate variables in a number of ways. This technique further provides unusual capability in clinical care (individual physician and hospital staff), teaching (self-assessment program), clinical research (examining mortality), and administration.

Recent critiques of modern clinical practice have stressed the "significant rewards" to be gained from more precise clinical information. The traditional approach to a clinical problem has usually involved the isolation and study of a particular complication, eg, the shock or congestive failure of acute myocardial infarction. Overviews such as that of Grace have attempted to "monitor" continuously every aspect of such a clinical area, irrespective of time or specific interest of the moment. This communication will describe a clinical data bank for a single disease entity and will emphasize its utility and versatility when immediate access to the data is ensured through the mode of physician-computer interaction (PCI). Acute myocardial infarction (particularly factors relating to mortality) was chosen as the "model" because of its profound social and economic importance and the desire to evaluate new modes of therapy, including efficacy of coronary care units.

Material and Methods

Five hundred patients with the clinical diagnosis of acute myocardial infarction, all seen and followed up by one of four physicians over the past 20 years, were chosen as the "data base," and 60 parameters were selected for tabulation. Rigid electrocardiographic criteria were applied, and all those without abnormal Q waves or absent R waves, along with simultaneous reciprocal ST segment changes, were excluded.

Transfer of all data from clinical chart to code sheet was performed by a single research assistant. Parameters were related to history (prior infarction, diabetes), examination (murmurs, third sound, gallop), electrocardiographic findings (block, dyshrhythmias), type of care (general, intensive, coronary), and therapy (heparin sodium, digitalis). A single 80-column card was used for each hospitalization, and up to nine such provided per patient. There were 60 variables (parameters) for each 80-column card. Initially, a cleanup program processed cards for key punch errors and missing information. The acceptable original data were then processed and created the data base MYPARC (with random access organization). A sequential search file was then established which included each patient's identification number and the locations in the MYPARC file of all data pertaining to the patient. The software for the study included programs which added to the file, deleted, or made corrections for the individual items of data. The essential programs allowed the calling up of (1) a complete patient file and (2) information concerning all patients sharing similarities (or differences) based upon patient file information.

The physician, nurse, or student (without prior computer training) selects two or three six-character variable names, eg, AGEYRS (age-years), MORTAL (mortality), FACDIA (diabetes), and types out the following computer command: SHOW PATIENTS BY FACDIA BY MORTAL BY AGEYRS. The meaning of this command is as follows:

Retrieve from the file of all patients those with the precipitating disease factor...
"diabetes" who were discharged alive, ordering the list of patients by age upon admission. Prepare a similar list for those who did not survive. The information is obtained within 80 seconds and is displayed numerically. (In this communication, such statistical analyses have been transformed from tables to graphs for visual display). The data obtained are either a complete answer to the question asked, or serve as a basis for further inquiry, whether in a clinical, research, teaching, epidemiologic, or administrative field. Any particular physician or student, with access to a terminal, may explore his own area of interest, using the glossary of 60 variable names.

Results

Examples of data obtained by physician-computer interaction are depicted in four graphs and are drawn from a pool of computer "runs." Mortality is related in time (Fig 1), age (Fig 2), laboratory parameters (Fig 3), and congestive heart failure (Fig 4).

Figure 1 shows mortality for the 500 cases of acute transmural myocardial infarction, divided into five-year periods, and spanning the past 20 years. With the opening of a coronary care unit, the data were divisible into two groups: (1) those seen initially in the coronary care unit and (2) those cared for on the general medical service. The striking changes in mortality are evident, and the coronary care group seems to duplicate the best coronary care figures. A preliminary breakdown of those two subgroups (not graphed) suggests unintentional bias, and that perhaps the older or more complicated patients were assigned to ward care. Note the significant increase in mortality in the general medical service over coronary care in the most recent time period.

Figure 2 confirms previous data concerning the very significant effect of age on mortality. It belies the often-heard theory that any younger group has a poorer overall prognosis.

The relationship of white blood cell count (WBC) and serum glutamic oxaloacetic transaminase value (SGOT) to mortality is shown in Fig 3. Enzyme levels (SGOT) were unrelated to mortality, but highest WBC was clearly related to mortality in this series. This relationship was further explored (PCI) by relating highest WBC to the other 59 parameters. Elevated WBC was found to be related to the frequency of clinical complications (not shown in Fig 3).

In Fig 4, three variables, mortality, age, and the presence or absence of congestive heart failure, are illustrated. The findings suggest a division into two subgroups. In the presence of congestive failure, mortality appears unrelated to age. In the absence of congestive failure, a significant increase is evident with each older group. Physician-computer interaction did not clarify this relationship. Concealed coronary disease or
subclinical congestive failure could have produced this picture. A more accurate early diagnosis or more sensitive programming might have defined these relationships.

Comment

Warner and Morgan\(^7\) have outlined seven characteristics necessary for the computer analysis of "high-density" medical data: (1) semiautomatic entry of data by nonprofessional personnel, (2) unequivocal definitions for each item of data, (3) amount of data optimal to insure both easy access and valid conclusions, (4) data structured and stored according to urgency of need of access, (5) low noise to signal ratio of analogue data, (6) immediate availability in graphic or narrative displays, (7) quality control of data at each entry port. In the system described, we have satisfied such valid criteria by (1) utilization of only highly trained medical record librarians and hospital keypunch personnel, (2) team training over a five-year period to ease communication barriers, and (3) disk storage with immediate access on a computer.

A PCI program, granted the team capability as described, will take 50 to 60 hours of programming, ordinarily a three-four-month effort by a senior and a junior programmer. This effort of the computer team is necessary for the establishment and validation of the original data. However, comparison studies, enlargement of the data base, or updating is inexpensive and easily accomplished.

The essential feature of our technique, as recently emphasized by Foster,\(^8\) is the opportunity for the physician ... to interact on-line with the data base, making possible the discovery of interactions which would be almost impossible to analyse through batch processing or standard techniques of statistical analysis. ... The researcher can explore his data empirically, developing hypotheses and testing them as he goes along. Data such as outlined in Fig 1 through 4 have considerably expanded our viewpoint concerning etiology, epidemiology, diagnosis, and therapy in acute myocardial infarction. The graphs presented as examples constitute a minute fraction of the data obtainable and are presented simply to illustrate the method.

medical records in an overall program. Such broad programs do not lend themselves to the immediate acquisition of data for either teaching or research, and provide little or no mechanism for the comparison of clinical material.

**Computer Capability.**—CLINICAL CARE.—Precise knowledge of the factors affecting mortality in acute myocardial infarction (for example, those related to age) may have significant bearing on therapy for both the individual physician and the hospital group. Three examples, all the result of PCI, have been detailed: (1) appreciation of the very significant increase in mortality with age (Fig 2) should result in an altered therapeutic approach in the older age group; (2) appreciation of the lack of direct correlation of SGOT level and mortality should result in less attention to this laboratory parameter and more attention to the simple and close relationship of mortality and WBC (Fig 3); (3) appreciation of the high incidence of congestive failure may result in an increase in prophylactic digitalization.

Future optimum coronary care presages frequent physician and resident access to such clinical data banks. Each physician and resident should have the opportunity to conduct periodic routine checks on his patient "population." It is important to stress that PCI may be of value in a crisis situation; it is primarily applicable, however, in studies of complex data gathered over long periods of time, and in this "mode" it has been of proven value for resident, nurse, and intern training.

**Teaching.**—The programmed data bank is available and has been utilized by student, physician, nurse, and allied medical personnel, using a 60-word glossary of variable names. The technique has been of great value in (1) the training and retraining of coronary care personnel, (2) physician self-assessment programs, and (3) comparison studies, using remote terminals with other hospital and medical school groups.

**Clinical Research.**—In any coronary care unit, how much improvement is represented by the nurse who spots the first sign of arrhythmia, the physician who prevents it, the coronary care unit committee which advocates early digitalization in the presence of congestive failure, or the allied medical personnel who have detected early shock with special sensors? Isolation of the manner in which mortality is affected by time, therapy, and complications has become a high priority task admirably undertaken by a computer. Our experience leads us to doubt the extravagant claims attributed to "coronary care." Coronary care units tend to preselect the early, young, and uncomplicated cases. The data of Fig 1 show clearly that apparent improvement in mortality in the coronary care unit was not accompanied by a drop in mortality from acute myocardial infarction in the hospital as a whole.

**Epidemiology.**—Mortality in acute myocardial infarction can vary in relation to size, location, type of hospital, socioeconomic groups, and variations in physician and allied medical personnel. Such epidemiologic factors create very different patient populations, each of which produces a different type of diagnostic and therapeutic challenge. Feinstein has emphasized how little our traditional methods of "language, logic, behavioral science, and statistics" have aided epidemiologic studies in the past. He has emphasized that the "new basic science" must be derived from "direct clinical experience with patients." It is precisely in this sense that PCI is conceived, not only relating to the individual ward or hospital data base, but comparing separate hospital, ward, medical school, and indeed foreign populations.

**Administration.**—Most coronary care units, semieperimental and expensive at the start, have been designed to accommodate only a fraction of acute myocardial infarctions within the hospital. Rational exten-

**References**