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ELECTRONIC AUTOMATION IN MEDICINE: Its Moral Implications

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The application of electronics to medicine in this century has been an outstanding contribution to medical science and education, and has enabled thereby a greater understanding not only of the function of many systems of the human body but also of the natural history of disease processes.

In this connection, the electrocardiograph and the electroencephalograph epitomize benefits of the application of biophysics in clinical medicine. In addition, other biophysical instruments have been developed to study a variety of physiological events at the bedside and in the laboratory. Therefore, it is not surprising that medical schools have chosen to use electronic instruments more and more in basic medical education, and that the understanding of physiological phenomena by medical students, for instance, has been significantly facilitated in laboratories of experimental physiology equipped with electronic devices that record simultaneously a number of different physiological events.

Although the impact of automation and use of electronic computers in industry is duly appreciated, their recent introduction in medicine introduces the question: Can moral problems arise from the widespread application of electronic computation? Therefore, at the dawn of an era of electronic computer usage in medicine, I should ask if either current or future applications of electronic data processing technologies and computers in medicine are exempt from moral consequences.

On January 14, 1955, the first Conference on Diagnostic Data Processing was held at the Medical Electronic Center, The Rockefeller Institute, in New York City. Since then the number of papers on this hitherto scanty, dealing with electronic data processing techniques in medicine has increased rapidly. Many of the publications have dealt with particular applications of computers to specific research problems; others, fewer in number.


A complete bibliography is beyond the scope of this article. The reader is referred to Proceedings of Conference on Diagnostic Data Processing sponsored by the Medical Electronic Center of the Rockefeller Institute (IRE Transactions on Medical Electronics ME-7). More recently, the Proceedings of the 1st and 2nd IBM Medical Symposium (The Medical Education Center, Endicott, N. Y.) have been published.

Electronic Computers

The efficiency of electronic computers derives from their easy manipulation of all the items of information that have been previously converted into a code of electrical signals of absolute character: i.e., the presence or absence of an electrical charge. The conversion of alphabetic or numerical information into a simple code of electrical charges has been the goal of years of multidisciplinary investigation. Most current electronic data processing instruments convert automatically into digital format any information with the form of digits or numbers. For example, a number comprising two digits such as "13" is immediately accepted by an instrument and coded into a set of charges. Likewise, a letter, for instance "A", can be converted into an intermediate code of one or two digits which in turn can be converted into a set of charges arranged, however, in such a way to characterize the letter "A" and only that letter.

Electronic data processing instruments and computers accepting information in digital form are called digital electronic data processing equipment or digital computers. Other computers manipulate information in the analog form; that is, a quantitative but not digital expression of an event. For example, the position of the needle of a car's speedometer is an analog expression of the speed of that car. The digital expression of the same speed would be given in numerical units of distance per unit of time (e.g. miles per hour).

Analog computers perform calculations with analog information in a manner similar to digital computers.

The current instruments detecting physiological events record them in analog form. Events like the electrical activity of the heart (ECG) or that of the brain (EEG) are phenomena that we have learned to recognize from their analog presentation. Analog computers that would analyze automatically the information contained in these analog records...
will be of real usefulness in medicine. Digital computers, on the other hand, will be more suitable for comprehensive quantitative analysis of large volumes of clinical and laboratory data.

CURRENT MEDICAL USES OF ELECTRONIC DATA PROCESSING TECHNIQUES AND ELECTRONIC COMPUTERS

Electronic data processing techniques and electronic computers (analog or digital) have been applied to medicine for the following purposes: 1) large scale statistical analysis of clinical and research data; 2) collection and processing of medical information concerning the natural history of disease processes; 3) testing complex physical models of biological systems; 4) aiding the establishment of clinical diagnosis; and 5) automatic control of the activity of electromechanical substitutes of physiological systems (heart-lung machines, respirators, etc.).

A MORAL CONSIDERATION

Plausible as they may seem, the tasks assigned to computers in medicine may not be provided with moral impunity. Strangely, the moral vulnerability of computers derives not only from man with his inventors and designers, and that doing so may be both effective and dangerous.

It must be understood that the danger lies in the computer's almost unlimited capacity to store information, to manipulate and originate thereby factual information at a speed incomparable to human beings. To sum up, any thought of danger or threat result from the work of computers may sound preposterous, for whatever information is given to computer must be given by man. Indeed, to borrow the words of Dr. Norbert Wiener: "Machines can and must transcend some of the limitations of their designers, and that doing so may be both effective and dangerous."

The question then arises "What can we ask the computer to do?" It may categorize for us the signs and symptoms of disease processes if we provide the computer with some indication of what a disease process is. It could also classify different diseases if we gave instruction on how to proceed to classify such diseases. Perhaps it would even establish cause-effect relationships if we previously had defined what constitutes a cause and what constitutes an effect of the cause. It might also establish the range of variation of function in health and what constituted significant departure from health.

Provided with such capabilities, the computer would then be ready to accept any medical information from a person and detect readily thereby an incipient disease. If allowed to do so, the computer could conceivably set up a whole series of therapeutic measures and to correct automatically the degree of departure from health which the computer established so accurately. The danger of such an Utopian plan lies in the speed at which the computer would perform the forenoted steps, thus reaching a point when efficient interference may become impossible. For Dr. Wiener also stated: "If we use to achieve our purposes a mechanical agency with whose operation we cannot efficiently interfere once we have started it, because the action is so fast and irrevocable that we have not the data to intervene before the action is complete, then we had better be quite sure that the purpose put into the machine is the purpose which we really desire and not merely a colorful imitation of it." In complete agreement with this idea, we may indicate that the moral danger of using this kind of automation in medicine lies in the human incapability of defining accurately the very purpose of the work of the computer itself. And were we even to assume a computer could serve best to correct physical disorders of man, can we assure it will best serve man's psyche also?

The forementioned description is, no doubt, far from becoming a reality. Indeed, it may never become a reality. Initial steps, however, have already been taken, and it is pertinent to analyze the possible morality of such steps and to discuss the moral aspects of certain applications of automation in medicine. For even at the risk of allowing unnecessary freedom to our projective thoughts "we must always exert the full strength of our imagination to examine where the full use of our new modalities may lead us."

THE DIAGNOSTIC AUTOMAT

If and when the day comes that a computer will be capable of making an accurate diagnosis on a patient presenting an array of bizarre symptoms, enormous relief will be felt by those who consider clinical diagnosis as the most important task of a physician. We shall not discuss the obstacles already encountered in programming the task of the computer to establish

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lish accurate clinical diagnoses of certain disease processes. Instead, assume for a moment that all the difficulties have been superseded and that an infallible "automatic" diagnostician already exists. Then, it would appear simple to ask the computer to identify a whole group of signs and symptoms and categorize them according to a specific disease. However fascinating, this would help to solve but few problems the modern physician is apt to encounter.

In instances of clinical emergency resulting from deranged body function, it is far more important to assess accurately the patient's degree and quality of deterioration; indeed, this may take precedence over the establishment of a clinical diagnosis of disease. Nor is the patient himself less concerned about whether he is healthy or ill, and if he is ill, what can be done to make him healthy. In fact, almost always this is the only concern of the patient, not what the name of his illness is. Many persons, of course, inquire about the diagnosis because they have acquired the habit of learning characteristics of specific disease processes, as well as their incidence, symptomatology, and treatment. At times this serves to ease the physician's obligation, permitting the patient awareness of difficulties lying ahead. All too often, however, such situations tend to lead to increased anxiety, the patient considering himself doomed to the worst aspect of his disease. It is unquestionable that most patients are not instructed on the spectrum of individual variation of diseases as we conceive them today. The patient of the future perhaps will be more conscious of this variability and he, like Tolstoi's Ivan Ilyitch, will not feel an elation when confronted by either the doctor or computer who can only say: "such and such a thing shows that you have such and such a thing in you, but if this is not confirmed according to the investigation of such and such a man, then you must suppose such and such a thing. Now if we suppose such and such a thing, then ."

In describing the following situation, Tolstoi indicates that "for Ivan Ilyitch only one question was momentous: was his case dangerous, or not? But the doctor ignored this inconvenient question. From a doctor's point of view, this question was idle and deserved no consideration; the only thing to do was to weigh probabilities."

May we ask if a computer capable of establishing a diagnosis would consider Ivan Ilyitch's question idle, also? Will the weighing of probabilities be the most important thing the computer would be capable of doing?

**MORALITY OF AUTOMATIC THERAPY**

Were a computer to diagnose with accuracy clinical syndrome, it is also likely that it could select the best treatment for that particular clinical situation, and the selection would be made correctly and with rapidity. Therapeutic experiences of countless profes-


Even more dangerous from a moral standpoint could be the therapeutic decisions of computers when these were used as guides in the management of a patient by a series of automatic control devices. Preliminary experiments with such systems have proved successful to induce and control anesthesia. It is likely that similar systems will also be used in the future in order to manage automatically those patients with severely deteriorated pathophysiological situations. Since such situations continuously change, they will require swift readjustments of the control mechanisms. Thus, the assessments and decisions of the computer would have to be both accurate and fast. It is doubtful that the physician and the auxiliary personnel could even keep note of such decisions. Indeed, at times the physician might find himself completely defenseless either to prevent or correct a decision therapeutically sound but morally wrong.

Could we expect, for example, a computer to decide to terminate the life of a patient with pathophysiological situation deteriorated beyond hope of reversibility? Would this decision, however expedient and efficient to the computer, be tested in a proper moral perspective? Of course not. A plea for critical appraisals of the moral aspects of any method of automatic control as powerful as the one envisioned here may sound not only dramatic, but even fanatic to some. It might even appear out of perspective, for it would be just as simple to initiate

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automatic correction of pathophysiological alterations immediately after they occur, as it would be to discontinue such automatic control at the precise point where a decision beyond the capabilities of the computer should be made. The plea may sound more justified, however, to those already aware of these latter situations being possible if—and only if—the stop at the crossroad of a moral decision has been anticipated by the physician programming step-by-step the evolution of the automatic control process before it had been allowed to start.

AUTOMATIC MEDICAL INFORMATION: RIGHT OF PRIVACY?

Full scale application of electronic data processing techniques in medicine would permit storing the records of all clinical situations arising in the course of a person's life. Multitudinous medical records collected according to these methods could be made available to any physician. It would doubtless be a blessing to both the patient and physician to have such complete information readily available. This kind of medical "historian" has been envisioned by Dr. Almy. He has suggested the creation of a national library of past histories of all persons living in this country. He illustrated an extreme advantage of this system. An unconscious patient is brought to the hospital emergency room. A code number would be transmitted to the central library of medical histories. In a matter of seconds, all medical information available on the patient would be transmitted from there to the physician treating that patient despite vast distances separating the physician and the library. Outside of the theoretical advantages of the aforementioned system, would the documentation and coding of the patient's medical history throughout his life be an invasion of his privacy?

Indeed, a person realizing that all kinds of intimate information concerning himself is available in seconds to innumerable persons in the world may justifiably fear that without his having any control, such information might be released not always for his own good. The issue of life insurance policies, the selection of personnel for specific jobs, perhaps even the mating of couples could be seriously affected by an automatized system of recording medical information. If our society ever reaches this level of organization to what extent will decisions be based on mathematical expressions of materialistic values while spiritual considerations will be set aside because they are not quantifiable?

AUTOMATION AND PATIENT-PHYSICIAN RELATIONSHIPS

Patients themselves have followed with extraordinary interest the progress made with the use of computers in medicine. Some are delighted over the prospect of a machine capable of infallibly tagging their ailments, assessing a prognosis, and selecting the best possible treatment. Some physicians look at such a possibility as a more tangible threat than that of socialized medicine. Full reassurance can, however, be given to both the over-optimistic patient and the overly concerned physician that such situation should never come about.

Since its initiation the use of electronic data processing techniques and computers in medicine has been carefully studied and evaluated. Those making pioneer efforts in this field are aware not only of the capabilities and limitations, but also of the dangers in the use of powerful tools of automation in medicine.

Judging the initial trends we may envision with confidence that a full-scale application of computers in medicine will lead to an improvement of the relationships between the physician and his patients. This relationship may become warmer than ever before in the history of medicine, for computers may prove extremely useful to the physician in detecting and pointing out hidden signs of illness long before they become readily apparent to the patient himself. Correlations hitherto unsuspected between certain aspects of the psychological and physiological behaviors of a patient may become apparent and permit the gearing of treatment in the right direction. By no means do we anticipate that computers will replace the physician's role in interpreting medical data. On the contrary, greater scope will be permitted by this interpretation and the physician's judgments will be more scientific than they have been at times.

Physicians have always been aware of technological achievements and have been ready to apply them to medicine when betterment of man's health can result from this. Computers and electronic data processing techniques have been one of the outstanding achievements of the last decade. They have entered the medical field at a fast pace. Physicians need not be wary of this intrusion. On the contrary, they must welcome it, for if properly used it will contribute immensely to the scientific progress of medicine. Whether we agree or disagree on some of the moral considerations we have presented is irrelevant at this point. Agreement must be reached, however, on the moral obligation of all physicians, for keeping abreast of current and future technological advances and for the progress made with the application of these achievements in medicine. May this plea reach especially those engaged in teaching activities, for in the education of today's medical students, computers and electronic data processing techniques will become tools of importance at least equal to the
methods used by past generations of medical educators.

ACKNOWLEDGMENT

Papers of a philosophical nature on a controversial subject seldom reflect the views of only one individual. This article is not an exception. The thoughts contained herein have crystallized from many conversations on this subject which I have had with my associates in the work on autonotomy of clinical and research dolls at the Texas Institute for Rehabilitation and Research. Acknowledgment is given here to the stimulating opinions and thoughts of Drs. William A. Spencer, David Cardus, and Fred M. Taylor, who have reviewed this paper critically.

ATTENTION!

Physicians

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The National Federation of Catholic Physicians' Guilds will again be an exhibitor at the A.M.A. convention at the Coliseum, New York City, June 25-30. Consult your program for space C-36.

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Please advise the day and time you will be available. The Exhibits open one day earlier this year. Be sure to visit the Federation Booth and bring others with you.

Current Literature: Titles and Abstracts

Material appearing in this column is thought to be of particular interest to the Catholic physician because of its moral, religious, or philosophical content. The medical literature constitutes the primary but not the sole source of such material. In general, abstracts are intended to reflect the substance of the original article. Parenthetical editorial comments may follow the abstract if considered desirable. Books are reviewed rather than summarized. Contributions and comments from readers are invited.


Although postmortem cesarean section is a rare occurrence, several historical personages have been born in this manner, including Scipio Africanus, Pope Gregory XIV, and Andrea Doria. In 1280 A.D., the Church took cognizance of this procedure at the Council of Cologne. In the modern era, comprising the past 250 years, there have been a total of 120 successful postmortem cesarean sections. The author reports two personal cases. While there is no adequate specific legislation concerning this operation in the United States, the physician is obligated to attempt to save life when it can be done without hazarding or harming another.


The physician must experiment if he is to improve. The right and duty to experiment are, however, absolute. Limits derive from four quarters: the ethics of the biological-medical professional community; the standards of reputable medical and health institutions; the law; the social climate and opinion of the public.

1. Ethics of the Profession

a) Animal experimentation should precede human experimentation whenever possible.
b) The value of the project must be commensurate with the risk or hazard.
c) Use of subjects should be limited to the number necessary for the purpose.
d) No present benefit or remedy should be withheld from a patient in the interest of trying something novel.
e) Researchers must seek for the natural experiment, i.e., not induce pathology if there is expectation that it might occur naturally.
f) The researcher must have demonstrated his mastery of the required skills and training necessary for the research.

2. Codified Standards

a) The Nuremberg decision stresses the points noted above under number 1, but also stresses the voluntary consent of the patient and proper precautions against any possible harm to the patient. It also affirms that no experiment should be permitted where there is a prior reason to expect death or disabling injury.
b) Pope Pius XII held experimentation on man licit as long as the consent of the patient is had and the granting and taking of human life is not placed at human hands.
c) The World Medical Association, the Public Health Service, the Judicial Council of the American Medical Association have espoused views similar to those expressed above.
d) To insure the observance of these norms, most hospitals and clinics require that proposed experimentation be approved by a board of review. Researchers should take care to observe the various norms not only to insure protection to the patient, but to obtain the best scientific results as well as to obtain legal protection.

3. Legal Aspect

There is no American statute that specifically regulates, prohibits, or governs medical experimentation per se. For practical purposes, the major issues relate to consent. Petting aside acts which are legally or morally unacceptable, the legal adage, volenti non fit injuria, holds. Care must be taken that this consent be made by a competent person with as full knowledge as possible. Researchers should not go beyond the explicit consent given.

4. Public Attitude

The public is at once favorable to experimentation and wary of it. Researchers through adherence to recommended legal-ethical standards and pro-