for decisions about indications for cardiac catheterization and surgery after acute myocardial infarction (5), may be adapted for use in specific institutions by modifying the algorithm according to regional experience and new developments in therapy.

Physical examination in clinical decision making. Individual physical findings, both positive and negative, can be treated as specific data points and incorporated into a decision tree or computer program as a part of a data base, just as any other item of data. However, the validity of those data points depends on the accuracy of the observations, which in turn depends on the examiner having certain cognitive and clinical skills. The cognitive skills include knowledge of physiology, physical findings and the correct techniques to elicit those physical findings. The clinical skills depend on a disciplined and orderly examination in which adequate time is taken, distractions are avoided and concentration is maintained to perform the examination properly. The distinction between merely seeing or hearing and actually observing is crucial. The correct selection of instrumentation, such as a stethoscope, is important to perform accurate examinations, but skill in the correct use of the instrument and interpretation of its findings are usually much more important than any limitations imposed by the instrument itself.

The usefulness of the physical examination in clinical decision making usually depends on the competence of the examiner. The possibility that the examination may be performed inadequately or incorrectly, or that its findings may be misinterpreted, does not diminish the validity of the properly performed and interpreted examination.

The General Professional Education of the Physician (GPEP) report recommends that we spend as much time on the skills, values and attitudes of medical students as we do on their knowledge. Performing the physical examination is the key clinical skill. It cannot be learned merely by reading or from class discussion. It requires personal student-teacher interaction so that individual instruction, reinforcement, correction and coaching can be accomplished in all aspects of the cardiovascular examination, and it needs to be continued over many years while the physician's understanding of the relation between pathophysiology and physical examination matures. Priority in curriculum planning and peer recognition of the teachers of physical examination are crucial to the effective teaching of this skill.

References

1. Weinstein MC, Fineberg HV. Clinical Decision Analysis. Philadelphia: WB Saunders, 1980.
2. Garson A Jr, Gorry GA, McNamara DG, Cooley DA. The surgical decision in tetralogy of Fallot: weighing risks and benefits with decision analysis. Am J Cardiol 1980;45:108–16.
3. Epstein S. Implications of probability analysis on the strategy used for noninvasive detection of coronary artery disease. Am J Cardiol 1980;46:491–9.
4. Diamond GA, Forrester JS. Analysis of probability as an aid in the clinical diagnosis of coronary artery disease. N Engl J Med 1979; 300:1350–8.
5. Epstein SE, Palmeri ST, Patterson RE. Evaluation of patients after acute myocardial infarction. Indications for cardiac catheterization and surgical intervention. N Engl J Med 1982;307:1487–92.

Session VI: The Use and Applications of High Technology in Teaching Cardiology

Chairperson: Robert G. Tancredi, MD, FACC; **Panelists:** Abdulla M. Abdulla, MD, FACC, Campbell Moses, MD, FACP

In this session, Campbell Moses, MD and Abdulla M. Abdulla, MD discussed their experiences in developing computer-based educational programs for medical audiences. Clearly, this area has grown rapidly over the past decade and has been enhanced through introduction of microcomputers and random access laser videodisc players. Both presentations relied heavily on demonstrations of computer-based teaching programs and patient simulations for the conference participants.

Videodisc technology in medical education. Dr. Campbell Moses has been involved in the development of computer-assisted medical teaching programs since 1967.

JACC Vol. 8, No. 2
August 1986:469–84

He began his presentation with a discussion of videodisc technology. By way of definition, there are four different levels of videodisc systems. Level I refers to the system that can be used to play videodisc movies or other such programs. These systems allow no interaction with the presentation. Level II is similar, but has some programming capability, thereby permitting some interaction with the disc itself. A level III system is considerably more advanced, and allows selection of specific information from the disc by way of a computer and floppy disc. Operator interaction with the material on the disc can be accomplished by activating a floppy disc or a key pad, by use of a touch screen or, in more advanced systems, by voice activation. Finally, level IV refers to the development of artificial intelligence systems where interaction between the viewer and the videodisc is not only controlled by the floppy disc program, but the input is actually evaluated and incorporated into the computer's "intelligence." These systems are in the very early developmental stages.

Videodisc technology represents one of the most significant advances in communications and technology in this era. It stands at the center of three of the most powerful communications media: books, television and computers. A programmed videodisc consists of a series of discrete still images recorded in sequence. Motion is perceived by projecting these images onto a television screen at a rate of 30/second. However, each individual image can be addressed uniquely, and one side of a videodisc has the capacity for storing up to 54,000 such images.

Medical libraries have been using videodisc programs as teaching aids and as reference systems. These systems can be used by individuals or, through use of a video projector, can be used to address groups of people. Dual audio channels make it possible to use the same video material to train two different audiences. For example, in one training session, doctors and nurses can view the same video material, but receive different narrations directed at their specific needs. The use of a touch screen provides some sense of involvement with the program and also allows the operator to proceed at his own pace.

The following "commandments" are directed at those individuals who wish to become involved in producing teaching programs through the videodisc format: 1) Identify specifically the behavioral change to be achieved through each section of the videodisc program. The program should be directed toward achieving that change. 2) Identify those critical events or findings that influence the decision making process. In this regard, the videodisc does provide a useful tool for presenting nonverbal as well as verbal communication from the patient. 3) Be certain that the content of the program is clearly relevant to practice. 4) Emphasize the clinical relevance of basic science concepts where appropriate. 5) True learning is an emotional as well as an intellectual experience. Try to create a sense of involvement for the operator. 6) Be certain that the options presented to the learner through the program challenge judgment rather than recall. 7) Individual segments of the program should be short and concise to keep the viewer's attention.

Microcomputer-based teaching system. Dr. Abdulla developed a microcomputer-based teaching system that exposes the student to a comprehensive knowledge base and facilitates integration of this knowledge in approaching clinical problems. The goal is to present teaching programs and patient simulations in a computer-interactive format that is realistic, easy to use and tests judgment rather than mere recognition. The lessons are written using the C-Language and are available for use on many 16-bit machines that use MS-DOS.

Teaching programs dealing with medical simulations must be able to handle natural language entry by the students. Also, the simulations should be of high fidelity, where many of the dynamic alterations in clinical variables manifest themselves in multiple areas, and are affected by one or more interventions. That is, the simulations should mimic the real life situation as closely as possible. For example, if the user elects to administer furosemide (Lasix), hypokalemia may ensue, as reflected by electrocardiographic changes, increase in frequency of ventricular ectopic beats, muscle weakness and so forth. Also, these interventions may be initiated or discontinued at any point in the program. Finally, the user of the simulation program should have the capability to modify the program to suit his or her own needs.

Several patient simulation programs were presented. In each case, the student is encouraged to be complete in history taking, physical examination, laboratory investigation and management. Each simulation has the potential to keep track of up to 2,048 different responses entered by the student. The program is flexible and allows the student to skip certain areas or come back to others as desired. Cost effectiveness of various diagnostic and therapeutic interventions is emphasized, and the hospital bill can be summoned at any point during the workup.

The user's responses are stored in the exact manner and order in which they are entered. Through use of a special program, these answers can be reviewed by a faculty member and used to uncover or correct learning or knowledge-base deficiencies. The program has a fast response time of a few microseconds to hold the student's attention and provide the illusion of reality. In using the program, the student's name is entered to be stored in a file on the diskette. The student can interrupt the lesson at any time and return later to the same point in the lesson by reentering his or her name. The student cannot go through the same lesson more than once, unless a different name is used. The response files are "hidden" to protect them from tampering and alteration.

Each simulation uses a random-access branching format, and the lessons have the ability to recognize alphabetic, numeric or alpha-numeric responses. Immediate or delayed author-generated comments about the student's performance are provided throughout the lesson. The cost-benefit and risk-benefit ratios of each response are emphasized. In general, the feedback to the student can be quite detailed and extend to all aspects of the evaluation and management decisions. Through use of a random access laser videodisc player, the student's ability to perceive nonverbal as well as verbal messages from the patient can be tested.

In summary, this teaching system facilitates problem-based learning on the part of the student, and provides the faculty with an additional tool to evaluate clinical competence. The computer-based teaching system was designed to permit the user to develop his own patient simulations at his institution. This would require about a week of experience to learn the detailed functions of the program, but the user does not have to acquire any special programming skills.

Session VII: Learning Through Simulation: The Value of Patient Simulators; Techniques in Teaching Auscultation, Arrhythmia Management (Including Cardioversion), Swan-Ganz Catheter Insertion, Patient Management Problems and Resuscitation

Chairman: Michael S. Gordon, MD, PHD, FACC; **Panelists:** Karen Craparo, MD, Joel M. Felner, MD, FACC, David M. Lawson, BS, Abdul Sajid, EDD, Robert Waugh, MD, FACC

One of the salient features of the 1984 General Professional Education of the Physician Report (1) is the emphasis on promoting problem-solving skills during the training of medical students and residents. Simulation methodology can serve as an effective tool in realizing these recommendations. Such techniques avoid the drawbacks inherent in a totally patient-dependent curriculum. These include the nonavailability of patients displaying certain diseases at specific times in the curricular schedule, inconvenience and stress for patients and lack of opportunity to practice skills and acquire confidence when dealing with patient problems.

Simulation techniques in cardiovascular education. These include heart sound simulators, three-dimensional models such as Resusci-Anne, paper and pencil patient management simulations, computer simulations, live trained patients and multiple disease simulators. Few studies have examined the application of the skills learned on simulators to real patient encounters. Studies on the use of heart sound simulators have found that students increase their auscultatory skills after training with such devices (2). There is also general agreement that three-dimensional simulators help individuals learn cardiac life support skills. These recording mannequins demonstrate on tape the adequacy of ventilation and compression. Sensors also indicate proper hand position and pulse evaluation before cardiopulmonary resuscitation. By linking such a mannequin with interactive videodisc computer-assisted instruction, Actronics has further advanced the teaching of basic life support. It is clear that resuscitation skills deteriorate rapidly when not performed frequently and must be recertified at regular intervals to ensure optimal patient-related performance (3).

Various simulators can also teach airway management, intubation, arrhythmia identification and therapy, evaluation of Swan-Ganz catheter-derived pressures, aortic balloon pump augmented pressures, positioning of central lines and methods of defibrillation. Some of these involve the use of computer simulations and graphics to lead the student through patient management problems. Others have a built-in time clock that is an essential component in resuscitation.

"Harvey," the Cardiology Patient Simulator. The most comprehensive study of a simulation technique undertaken to date is on "Harvey," the Cardiology Patient Simulator (CPS) (4–6). This project has been carried out by a national consortium of cardiologists, engineers and educational evaluators for more than a decade. A core group from the University of Miami, the University of Arizona, Duke University, Emory University and the University of Florida has been involved since its inception. Additional significant contributions have come from Georgetown University, the Mayo Clinic, University of Nebraska, the Na-