Special Article

A Cardiovascular Teaching Laboratory: The Master Class in Ambulatory Teaching

Charles F. Wooley[1], Elizabeth A. Sparks[1], Sharon Olsen[1], Harisios Boudoulas[2]

[1]Division of Cardiology, Department of Internal Medicine, College of Medicine and Public Health, The Ohio State University, Columbus Ohio, USA; [2]Biomedical Research Foundation, Academy of Athens, Greece

Key words:
Cardiovascular diagnosis, diagnostic techniques, teaching laboratory.

This study was supported by the Overstreet Cardiovascular Teaching and Research Laboratory, Division of Cardiology, Department of Internal Medicine, The Ohio State University College of Medicine.

Manuscript received:
October 2, 2007;
Accepted:
October 31, 2007.

Address:
Charles F. Wooley

Division of Cardiology
The Ohio State University College of Medicine
Heart Lung Research Institute
473 W. 12th Ave
Columbus, Ohio 43210, USA
e-mail:
Charles.Wooley@osumc.edu

"We should aim at using the methods of education rather than instruction. We must teach the student how to collect the facts, to verify them, to assign a value to them, and how to draw conclusions from them and test those conclusions; in short, how to form a judgement."

George Pickering, 1958[1]

For decades, outpatient teaching has been equated with the outpatient clinic or facility, with brief, discontinuous patient encounters in a variety of settings. In spite of diverse suggested remedies, the result has been a difficult environment for learning and teaching. In addition, medical students possess limited clinical information at the time of their initial physical diagnosis experience. Reinforcement of the basic tenets of the medical history and the physical examination is frequently inconsistent during the clinical years. Senior medical students, medical house officers, or fellows in training have a continuing need for integration of advanced physical diagnostic techniques in their clinical experiences.

We developed the Cardiovascular Teaching Laboratory (CVTL) in order to address these concerns. The patient and the Student of Medicine (SOM) come together in a patient-oriented, clinical diagnostic laboratory environment dedicated to learning and teaching contemporary internal medicine, cardiology, and cardiovascular physical diagnosis.

We present the CVTL as an ambulatory teaching model, the outgrowth of a concept that places ambulatory learning and teaching in a dignified, contemporary setting and emphasizes the central role of the patient interacting with the SOM and the attending physician. The individual patient interview, physical examination and laboratory studies are performed using the traditional case-method approach with emphasis on the use of diagnostic logic. The final diagnosis incorporates the results of state-of-the-art laboratory testing.

During an eight-year experience in the CVTL, 141 Students of Medicine (SOMs) – including fourth year medical students, medical house officers, cardiology fellows, and visiting scholars – saw approximately 1,400 patients.

The cardiovascular teaching laboratory participants

The CVTL associate

The CVTL Associate was the key individual in the day-to-day laboratory function. Our most recent CVTL Associate (EAS), a nurse with clinical cardiovascular experience, trained and skilled in dealing with pa-

tients with cardiovascular disorders, received additional training in medical history taking, physical diagnosis, graphic recording and cardiovascular imaging. The first CVTL Associate (SO) had extensive experience in cardiology catheterization laboratory procedures, was qualified as a medical sonographer, and received additional training in clinical examination and cardiovascular graphics.

The CVTL Associate arranged the scheduling of all laboratory activities, explained the laboratory procedures to the patient, introduced the patient to the SOMs and was available while they performed the clinical evaluation. After the medical history and physical examination had been completed, recordings of the jugular venous pulse, the carotid arterial pulse, the apex cardiogram and the electrocardiogram, echophonocardiographic and Doppler studies were performed by the CVTL Associate with the participation of the students.

The CVTL Associate reviewed the individual patient data with the students in preparation for their formal presentations to the senior clinicians, participated in all aspects of the review and presentation process, and was the primary contact person for all laboratory activities.

Senior clinicians

Two senior clinicians (HB, CFW) developed, organized and supervised the laboratory activities throughout the eight-year period. Both were trained in internal medicine and cardiology and were academic clinicians with clinical investigative interests. They selected the patients, reviewed the case presentations with the SOMs, and correlated and coordinated the results of the diagnostic studies with continuing patient care.

Students of medicine

SOMs have included fourth-year medical students; medical, surgical and anesthesia house officers; cardiology fellows; and visiting scholars. Selection for a one-month elective rotation was based on an interview of the student by the senior clinicians to assess motivation, interest, and intensity.

Two fourth-year medical students working together made a good combination; they stimulated and taught each other, shared information, and previewed and critiqued each other's clinical evaluations prior to presentation. When an additional SOM—at either the house officer, cardiology fellow, or visiting scholar level—participated, he or she served as a mentor for the fourth-year medical students, incorporating their advanced clinical knowledge into the patient evaluations and participating in the clinical evaluations on a regular rotation. This was a mutually beneficial arrangement since, in the contemporary in-hospital setting, medical house staff and cardiology fellows have fewer opportunities to develop mentoring and teaching skills. Visiting-scholar programs were developed for individuals who desired to spend extended periods in the CVTL and participate in clinical investigative projects.

Patient population

Patients with cardiovascular disorders were carefully selected from a broad cross-section of patients seen in clinical practice by the two senior cardiologists, or were referred by their clinician associates. Selection criteria included a well-defined history of a medical or cardiovascular disorder or disease, the individual patient's physical findings, the impact of therapy on the history of their medical disorder, and the patient's willingness and consent to participate in the program as part of their initial, follow-up, or yearly clinical evaluation.

All patients met criteria for clinical diagnostic studies of the types performed in the clinical diagnostic laboratory. A complete laboratory report was generated with input from the SOMs.

Physical facility

The CVTL was developed as a three-room unit with a designed flow pattern (Figure 1). The workroom (Room A) was equipped with a large worktable for the review and analysis of the hard-copy records from the graphic and imaging recordings, and an X-ray view box. A large, wall-mounted, white display board is used for the graphic presentation of individual natural history and clinical data. A small, dedicated library was stocked with books on current cardiology, physical diagnosis, anatomy and physiology, teaching slide collections, and basic history of medicine texts. This carefully selected mini-library was supplemented by The Ohio State University Health Sciences Library for review of current journals, topic searches, and further reading. The CVTL Associate's desk, with a desktop computer and patient files, was also in this room.

The patient-interview, physical-examination, and physiologic-recording room (Room B), had acoustic tile and was relatively soundproof. An adjustable examining table allowed a smooth transition from the patient interview and physical examination to the

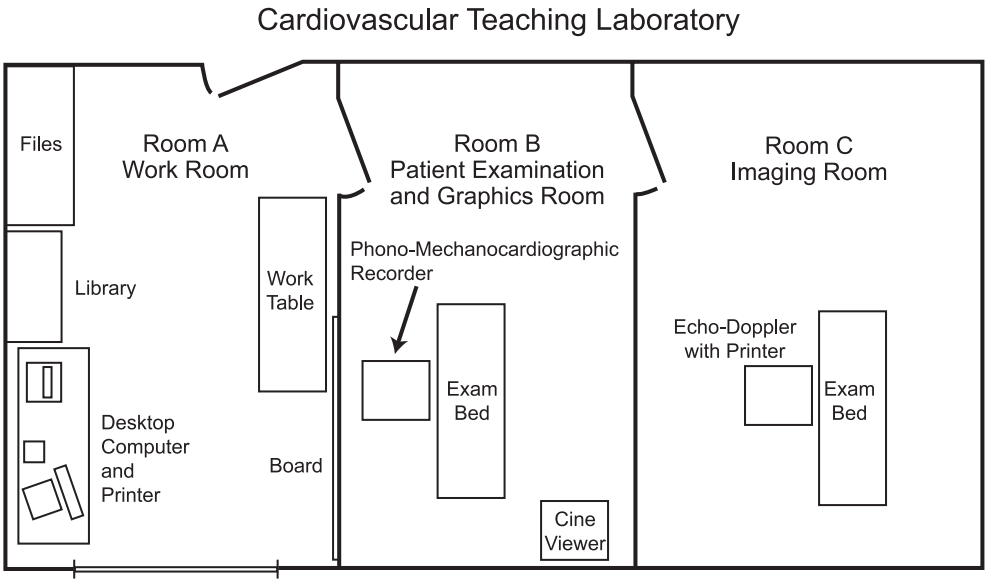

Figure 1. Physical arrangement of the cardiovascular teaching laboratory.

recording of cardiovascular graphics. An 8890B-Hewlett Packard multi-channel recording system was used for electrocardiography, phonocardiography, and recording of the jugular venous pulse, the carotid arterial pulse, and the apex cardiogram. When appropriate, patient photography and videotaping were also performed in this room.

The imaging room (Room C), contained a Hewlett Packard Sonos 1000 echo-Doppler color flow system specifically adapted for simultaneous heart sound and graphic recordings, so that simultaneous heart sounds, murmurs, or pressure pulse display were an integral part of the imaging process. The VCR unit, which is part of the diagnostic imaging system, was used to review the echo-Doppler patient studies and also for review of classic cardiovascular films on video tape for introductory, review, or supplementary purposes. An imaging station was available for review of angiocardiographic cine films.

Support for the laboratory

The CVTL was initially funded by an endowment from James W. Overstreet through the Columbus Foundation, Columbus, Ohio, with the assistance of Everett Reese and Joseph M. Ryan, MD. Additional support came from the Ohio State University College of Medicine, the Department of Internal Medicine, and the Division of Cardiology. The Hewlett Packard Corporation supported the development of innovative technology for the Laboratory.

A single bill, developed for the interpretation of the electrocardiogram and the two-dimensional color-flow Doppler study by the staff cardiologist, provided salary support for the CVTL Associate.

CVTL activities

Introduction to the laboratory

Two days were used for the introduction to the laboratory. The senior clinicians set forth the expectations for the month and reviewed the basic functions of the laboratory.

Pretest

Students took a written pretest on the first day of the rotation, which assessed their knowledge of basic cardiovascular anatomy, physiology, pathophysiology, and terminology. The pretest emphasized basic cardiovascular physiology and pathophysiology, the dynamic events within the cardiac cycle, basic terminology, and anatomic-imaging correlates. The student then appraised the pretest results, and followed this with text-oriented remediation; this approach set the stage for the type of ancillary reading that was expected throughout the month.

Anatomic dissection

A detailed anatomic review began with a protocol-directed, fresh porcine- or beef-heart dissection, with emphasis on the anatomic bases for physical diagnostic, echocardiographic, angiographic and anatomic cross-

sectional relations. A teaching slide collection and selected videotapes of human cardiac anatomy were available to supplement or extend the anatomic review.

Laboratory syllabus

A laboratory syllabus incorporated our guidelines for advanced medical-history taking and physical examination, known locally as the "Thinking Person's Medical History and Physical Examination."[2] Selected articles from the medical literature that place emphasis on the mechanisms of cardiovascular symptoms and physical findings were included.

Graphics and imaging

An introductory, subject-oriented exercise introduced the techniques of cardiovascular graphic recordings, echophonocardiographic and two-dimensional echo-Doppler imaging and recordings. One of the SOMs served as the subject for this activity. This was followed by a presentation of the basic principles for interpretation of these data.

Daily activities

Individual patient studies were scheduled for each morning. Afternoons were set aside for data review, individual study, and case presentations.

A three-day cycle was established for each patient study. Day One was the patient study day and the SOM began a review and analysis of information from the Day One patient study that afternoon. Topic-directed supplemental reading took place in the evenings. Day Two was intended for data review and organization. A formal presentation of the Day One patient took place in the afternoon on Day Three of the cycle.

Day one: patient study

Ambulatory patients with cardiovascular disorders came to the laboratory each morning for individual outpatient visits of two to three hours duration. One patient was seen in the laboratory each morning. Each patient was presented as an "unknown" to the SOMs.

Both SOMs participated in each patient evaluation; however, one SOM had the primary responsibility for an individual patient, and the responsibility was rotated. Uninterrupted time with the patient was a basic, important prerequisite for the individual patient evaluation.

"The Thinking Person's Medical History and Physical Examination" places emphasis on chronological history taking, an in-depth family history, and the art of thinking during the history and physical examination, with analysis of the patient's symptoms in pathophysiological terms. A thoughtful, focused physical examination included anthropometrics, an arterial survey, a venous survey, postural auscultation, an assessment in hemodynamic terms, and a global physical evaluation for systemic and connective tissue disorders. A tentative diagnosis was then developed by the SOM (Figure 2).

Graphic studies with simultaneous large-screen visualization of actual data were then performed. The first test was a standard 12-lead electrocardiogram, followed by a 2-microphone phonocardiogram with simultaneous electrocardiogram, followed by sequential recording of simultaneous carotid arterial pulse tracing, jugular venous pulse, and the apex cardiogram. Analysis of the impact of these physiological phenomena and recordings on the working or tentative diagnosis followed each recording (Figure 2). Next, echophonocardiographic studies with M-mode, two-dimensional echocardiogram and color-flow echo-Doppler studies were performed. Two monitor screens and in-room speakers were used to display simultaneous recordings of heart sounds and murmurs. Reappraisal of the clinical diagnosis followed each step (Figure 2).

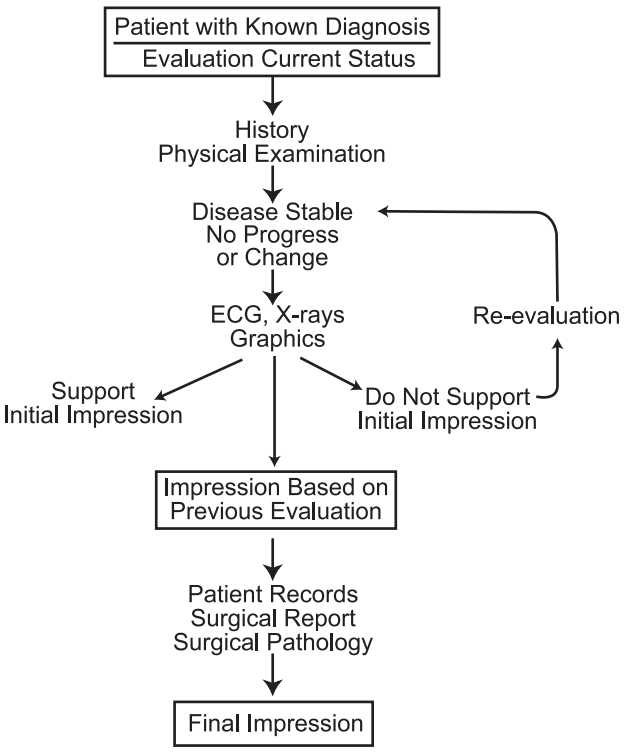

Figure 2. Student of medicine diagnostic process.

The SOM reviewed the hard-copy recordings and videotapes with the CVTL Associate during the afternoon of the individual patient study day. All pertinent patient records, including the patient's medical file, attending physicians' notes and correspondence, cardiac catheterization reports, surgical records, etc., were available for review and analysis. The SOM then initiated appropriate topic-directed reading.

Day two: analysis and reading

A new patient was seen each day. In addition to being a regular patient study day, Day Two in the individual patient cycle was intended for analysis, organization and correlation of the Day One patient data. Extensive, topic- or subject-directed reading was anticipated prior to the formal presentation on the afternoon of the third day.

Day three: formal presentation

The formal presentation took place in the presence of the five or six individuals involved in the laboratory activities. The graphic mode of presentation was used (Figure 3), with emphasis upon content, clarity of the presentation, effective use of the graphic method of presentation, and the use of diagnostic logic. *Élan*—a word meaning vigor, spirit, or enthusiasm and typically revealed by assurance or brilliance of manner or performance—was the catchword for the presentation mode. Correlation of the historical, physical diagnostic, clinical, and laboratory data was stressed (Figures 2 and 4).

Each step in the diagnostic process was reviewed sequentially by the senior faculty member performing the individual review. Following the presentation of the history and physical examination, a diagnosis, or differential diagnosis, was considered. Hard copies of the graphic records and the videotapes of the imaging studies were reviewed, with emphasis on the fit of these data with the clinical impression. The desirable or undesirable effects of previous or current diagnostic and therapeutic interventions were considered in detail.

Diagnoses that seemed appropriate at the particular time in the course of the natural history of the patient and in view of the available supporting data were discussed. The relative value and the limitations of various diagnostic techniques were also consid-

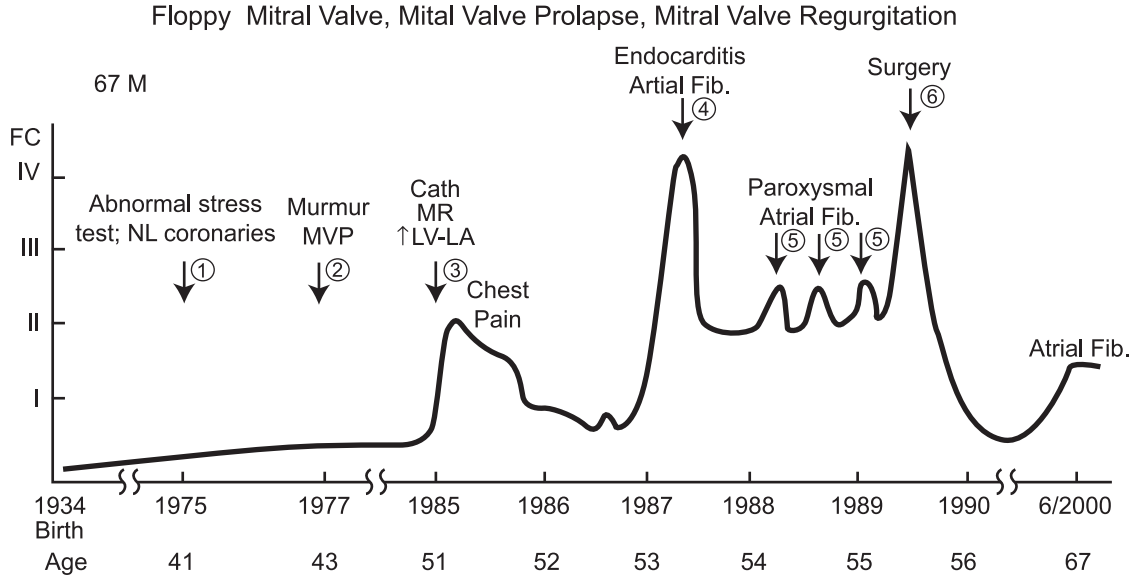

Figure 3. Example of a graphic presentation by a student of medicine. Fifty-six-year-old man with chronic mitral valvular regurgitation associated with a floppy mitral valve producing mitral valve prolapse. New York Heart Association functional classification (FC) is on the vertical axis. Year of birth (1934), patient age and the calendar year are on the horizontal axis. Events are indicated by arrows (left to right: abnormal electrocardiographic stress test; normal (NL) coronary anatomy at catheterization; murmur detection and diagnosis of mitral valve prolapse (MVP); catheterization (Cath); mitral valvular regurgitation (MR); left ventricular, left atrial enlargement (LV-LA); atrial fibrillation and infectious endocarditis; paroxysmal atrial fibrillation; cardiovascular surgery.

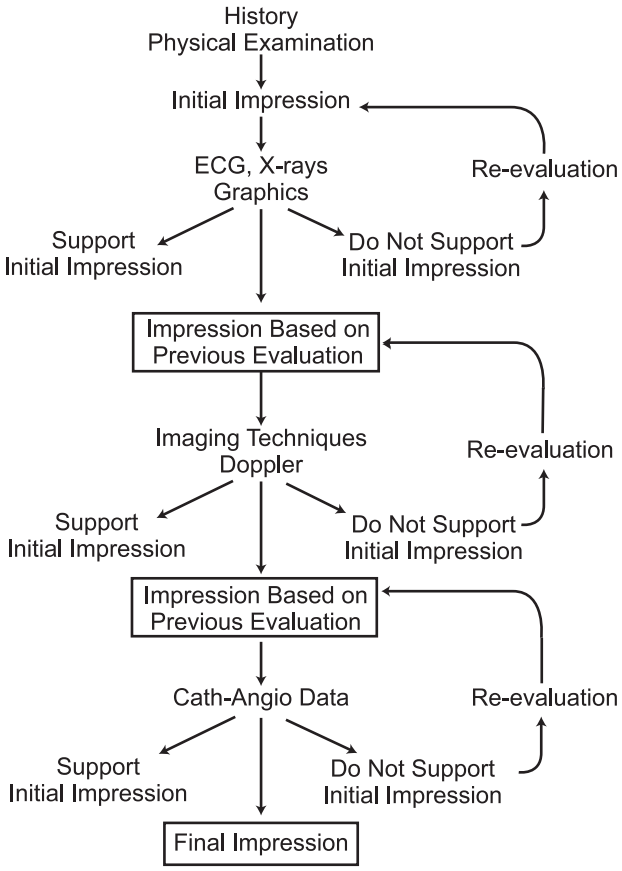

Figure 4. Diagnostic process in a patient with previously established diagnosis.

ered. Symptoms of uncertain origin or without apparent clinical correlates were discussed. The mosaic approach—which correlates patient history, family history, symptoms, physical findings, and test results to reach a diagnosis—was consistently stressed, and emphasis was placed on contemporary nosology and the bases for classification of diseases or disorders. Recommendations were presented for additional investigative or diagnostic studies, and plans for therapy and follow-up outlined. A final report was generated for the patient chart and the referring physician.

This master-class approach involved the faculty member providing analysis and critique of the presentation and review process (Figure 5). We were particularly interested in new insights, observations, concepts, or correlations developed by individual SOMs that were appropriate to, or beyond their level of training and experience. Commendation for positive accomplishments, original insights, suggestions for improvement and references for additional reading are part of this process. Recommendations usually involved improvements in medical history analysis; the significance and pathophysiology of physical findings; clarity, technique and method of the graphic presentation; or the analysis of the cumulative diagnostic process.

As a basis for continued learning, reference, and personal teaching purposes, students were encouraged to develop their own files or folders of the materials derived from the individual patient studies and the presentations, along with pertinent articles or bibliography.

Performance analysis

During the course of the month, particular emphasis was placed on consistent improvement in all spheres of activity, particularly in organization of data and effective methods of presentation. Patients gave us their analyses of the performance, attitude, professional behavior, efficiency of history-taking and physical-diagnosis processes, and level of personal interest displayed by the SOMs. These analyses were particularly important in our overall evaluation of student performance, and in improving patient acceptance and participation in CVTL activities.

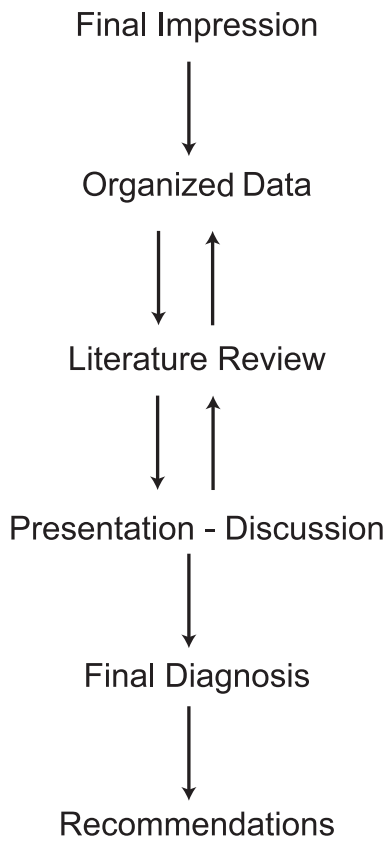

Figure 5. Student of medicine diagnostic process from impression to diagnosis.

Analysis of a SOM's performance by the CVTL Associate and by the senior faculty placed emphasis on the level and degrees of improvement in interpretation of the clinical history, in physical diagnostic skills, and in the understanding of the pathophysiology behind symptoms and physical diagnostic mechanisms, and the laboratory correlates (Figure 6). Organization and presentation of individual patient data, evaluation of the overall clinical problem, the fit between physical findings and the graphic or imaging recordings, and the overall use of diagnostic logic received more emphasis as the month progressed.

A written, detailed case study at the end of the month was optional. This was required initially, but became an invited option that acknowledged superior performance. A written case study stimulated further development of the written and graphic form of expression—the illustrative case report—as a complement to the daily oral and graphic presentation format. An excellent written case study served as the basis for invited presentation at a regular cardiology staff conference, or a formal written case report.

SOMs analyzed their personal experiences with a written critique at the end of the month, with emphasis on expectations, accomplishments, and difficulties or problems. Constructive suggestions modified CVTL function and faculty thinking over the years. We were particularly interested in the students' analyses of things learned, new experiences, or concepts that arose from the clinical encounters. Student evaluation forms required by the Department of Internal Medicine were based on a scale with 5.0 as the highest rating; CVTL-experience evaluations were consistently in the 4.75–5.0 range. There was never a negative evaluation of the one-month rotation, and it evolved into a highly sought-after elective among fourth-year students.

Performance Evaluation

Understanding of physical diagnosis mechanisms & correlates

Organization and presentation of data

Evaluation of the clinical problem

Use of diagnostic logic

Use of the graphic method

Original concepts, ideas

Medical knowledge

COMMENTS of REVIEWER

Figure 6. Student of medicine performance evaluation outline used by senior faculty.

Discussion

Historically, advances in medicine and physical diagnosis have been closely associated with the incorporation of technology into the diagnostic process. Elaboration of the physical principles underlying clinical physical diagnostic observations, using the technology of each era, has characterized the advances of enduring value. Although most physical diagnostic phenomena have physiologic bases which permit transduction, display, imaging, recording, and analysis, the actual learning and teaching has been considered a bedside activity. With the exception of simulation as a substitute for patient contact, advanced physical diagnosis retains tutorial and descriptive overtones. As the traditional "bedside" disappeared, and time-motion-money philosophy intruded upon ambulatory patient care activities, the opportunity for intensive exposure to experienced senior clinicians has declined.

The CVTL provided an environment for learning about the intrinsic value and uniqueness of the individual patient's medical history, the correct methods of physical diagnosis, the role of the patient in these cooperative activities, and the concepts of diagnostic logic in a patient-oriented, technologically integrated setting. Our basic assumptions were that SOMs learn in unique ways, and are intelligent individuals who respond to challenges. These factors are frequently overlooked in the medical school setting. Or as Einstein noted, "It is, in fact, nothing short of a miracle that the modern methods of instruction have not entirely strangled the holy curiosity of inquiry; for this delicate little plant, aside from stimulation, stands mainly in need of freedom; for without this it goes to wrack and ruin without fail."[3]

We began the CVTL with didactic concepts in a structured setting; however, we soon observed how positively individual SOMs responded to an environment dedicated to *learning*. Real-life patients with real-life problems are extraordinarily effective instructors. In general, patients were quite willing to participate in the CVTL format. Patient benefits included a comprehensive individual case study, state-of-the-art diagnos-

tic analysis, and a careful, periodic review of their individual clinical status. Patients who returned on an annual basis provided the next echelon of SOMs with the opportunity to view the natural history of clinical disease, medical disorders, and the effects of therapy.

Individual conceptual analysis by SOMs was a slow process initially. However, within a week or ten days, most were comfortable with thoughtful analyses of the medical history, the physical examination, graphic records, and dynamic images, and proceeded quite rapidly with interpretation and correlations on their own. Increasing self-confidence in history taking, in the physical diagnosis process, and in the daily challenge, stimulated renewed interest during the second half of the month. Every day brought new experiences, with an "unknown" patient, and a fresh challenge for an inquisitive SOM. Feedback occurred immediately, on a daily basis, and in particular on Day Three of the cycle.

The initial pretest exercise with individual remediation, the cardiac anatomic dissection exercise with a clinically relevant anatomic protocol, and the viewing of introductory video tapes and slides provided a background for daily encounters with patients with unknown medical disorders. Each patient experience presented an individual pretest and post-test evaluation as the SOMs checked their own progress. Analysis of the level of performance could be shifted to accommodate varying levels of prior experience and training.

Repetition and the use of aural and audiovisual methods, with instrumentation providing new images of anatomic and physiologic events, incorporated elements for interactive learning. All these methods were combined for individual problem solving. The SOM then had the opportunity to participate one-on-one with a senior faculty member in a master-class setting, and both student and faculty member had the opportunity to defend their theses as part of the presentation, discussion, and review in front of the small group.

Graphic methods are superb tools for learning and for teaching a generation of students for whom graphics and images are staples. Holding and using transducers, the viewing of actual physiologic recordings, and the handling of hard copies of graphic records provide a natural extension of the hands-on methods of the physical examination.

Learning to make temporal and dimensional measurements from graphic records requires user response to the materials. The strengths and limitations of the medical history, the physical examination, and the laboratory tests quickly became apparent. The value of the complementary use of information, and awareness of the mosaic approach to the organization of information in reaching a diagnosis gradually emerged.

Individual study and review were blended with group review and discussion. Interactions among the SOMs themselves were important parts of the teaching laboratory experience. Analysis and discussion of coherence or discrepancies between symptoms, physical findings, and the value and limitations of laboratory tests and recordings provided valuable lessons in the diagnostic process.

Academic functions

The CVTL environment provided multiple opportunities for exposing SOMs, including visiting scholars, to ongoing, or *de novo* clinical research and collaborative investigations. Seeking solutions to clinical problems in the Marfan patient population prompted the development of a Marfan Syndrome-Connective Tissue Disorders Clinic, analysis of aortic function and physical diagnostic correlates in the Marfan syndrome patients.[4-6] The CVTL provided the environment for multigeneration studies in a family with heritable cardiac conduction and myocardial disease, and introduced SOMs to modern clinical genetic research.[7-10] The students also participated in a series of ongoing basic investigative studies of the natural history of patients with floppy mitral valve,[11-14] aortic function,[15-17] atrial function,[18-20] and left bundle branch block.[21]

Conclusions drawn from the CVTL experience

"The difference between memory and thinking is that memory is an accumulation of facts; thinking is the movement of facts. If you begin to move facts, you discover that you can build buildings that no one has built before. One of the problems with thinking questions is that they put the instructor at risk. You see, there is no assurance at all that our bright young students cannot construct a better means of approaching our thinking questions than we can. Faculty members must be willing to accept the potential of being aced when they ask thinking questions."

Eugene A. Stead, Jr.[22]

The CVTL provided an intense learning and thinking experience with small-group interaction and dynamics. Medical history-taking, physical examination, visual, aural, graphic and imaging methods were utilized in quantitating and conceptualizing patient symptoms and physical diagnostic phenomena. Daily analysis of the diagnostic process required the faculty

to pay greater attention to the types of clinical reasoning that were appropriate to the clinical problem. Kassirer[23] considered these matters at length in a detailed review of strategies and provided an extensive evaluation of the diagnostic process for clinicians.

Teachers in academic medical settings have seen extraordinary expenditures directed towards patient care, diagnostic, administrative, and research activities. Rarely have they demanded equal time, space, equipment, salaries, and financial support for the continued development of teaching faculty, including the implementation of innovative, technology-based teaching programs with first class facilities.

Curricular reforms, like tax reforms, are recurrent phenomena. Frequently, the concepts come from medical educators and foundations. On the local level, they are usually mediated through central administrative sources, always work from the top down, and are usually driven by appointed committees that do not perform the day-to-day teaching functions. Rarely are these sources and committees around to see the end results. Young faculty members are quick to recognize extensive teaching commitments as academic blind alleys.

Emphasis placed on the development of skilled medical school teachers should be accompanied by a level of support and contemporary environments at least as auspicious and well equipped as that bequeathed to our administrative and research brethren.[24] In addition to the precious commodity of time, the gifted teacher interacting with the reactive student in an environment such as the CVTL requires dedicated space, support personnel, and technological capabilities similar to those provided to medical researchers and clinician investigators (Figure 7).

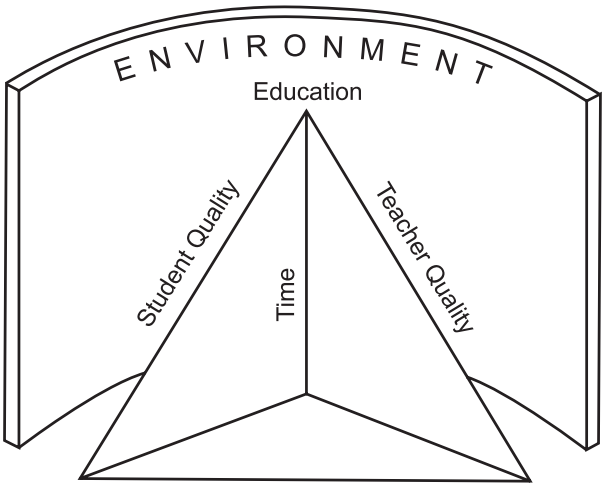

Figure 7. The final product in education is related to the quality of the student, the quality of the teacher, the time involved in the learning and teaching process, and the environment in which these activities take place.

Ambulatory teaching units

Dauphinee[25] discussed future teaching formats involving more ambulatory teaching that would "require new financial and structural changes in teaching units." Moore's[26] analysis of the realities of teaching and learning in the ambulatory setting, and the means for overcoming the barriers to change, is comprehensive, addresses many of the problems and concerns that we have experienced, and is a rich source of guidelines for facilitative program change.

If we are to turn these universal and challenging problems into opportunities to learn and to teach, a number of models, experiments, and answers should be anticipated. The CVTL represents a model that can be modified in any number of ways to serve a variety of ambulatory teaching circumstances, depending on the imagination and innovation employed by teaching faculty.[27,28]

Similar teaching laboratories are possible in the disciplines of general internal medicine, neurology, gastroenterology, endocrinology, infectious disease, hematology-oncology, physical medicine, surgical specialties, and more. Such facilities would allow clinical teachers in these fields to incorporate the rich heritage of history taking, physical examination, graphic phenomena, state-of-the-art imaging procedures, and diagnostic logic currently enjoyed by internal medicine, pediatrics, family medicine, surgery, obstetrics-gynecology, and psychiatry.

Acknowledgments

The authors gratefully acknowledge the financial support from the Columbus Foundation, Columbus, Ohio, towards the creation of the Overstreet Cardiovascular Teaching and Research Laboratory. Mr. Everett Reese and Dr. Joseph M. Ryan shared the vision and contributed to the establishment of the laboratory in many ways.

Dr. Manuel Tzagournis, Dean, the College of Medicine, and Vice President for Medical Affairs; Dr. E.L. Mazzaferri, Chairman, Department of Internal Medicine; Dr. Richard P. Lewis (1972-1986), Dr. Carl V. Leier (1986-1998), Directors, Division of Cardiology, provided space for the laboratory, along with continuing intellectual, professional and financial support.

Ann Elliot was our editorial consultant; Natalie Nance provided bibliographic assistance; Dennis Mathias created the graphic designs; Penny Rogers and Deborah Dimar prepared the manuscript.

The Hewlett-Packard Company, in particular Ray Swift, provided us with continuing assistance in instrumentation development and improvements.

References

1. Pickering G: Medicine's challenge to the educator. BMJ 1958; 2: 1117.
2. Wooley CF: The History and Physical Examination, in Warren J, Lewis RP (eds.): Diagnostic Procedures in Cardiology: A Clinician's Guide. Year Book Medical Publishers, Inc., Chicago, 1985: pp 33-50.
3. Sayen J: Einstein in America. The Scientist's Conscience in the Age of Hitler and Hiroshima. New York: Crown Publishers, Inc, 1985.
4. Bowen J, Boudoulas HB, Wooley CF: Cardiovascular disease of connective tissue origin. Am J Med 1987; 82: 481-488.
5. Hirata K, Triposkiadis F, Sparks EA, Bowen J, Wooley CF, Boudoulas HB: The Marfan syndrome: abnormal aortic elastic properties. J Am Coll Cardiol 1991; 18: 57-63.
6. Hirata K, Triposkiadis F, Sparks EA, Bowen J, Boudoulas HB, Wooley CF: The Marfan syndrome: Cardiovascular physical findings and diagnostic correlates. Am Heart J 1992; 123: 743-752.
7. Graber HL, Unverferth DV, Baker PB, Ryan JM, Fontana ME, Wooley CF: Evolution of a hereditary cardiac conduction and muscle disorder: A study involving a family with six generations affected. Circulation 1986; 74: 21-35.
8. Kass S, MacRae C, Graber HL, et al: A gene defect that causes conduction system disease and dilated cardiomyopathy maps to chromosome 1p1-1q1. Nature Genetics 1994; 7: 546-551.
9. Nelson SD, Sparks EA, Graber HL, et al: Clinical characteristics of sudden death victims in heritable (chromosome 1p1-1q1) conduction and myocardial disease. J Am Coll Cardiol 1998; 32: 1717-1723.
10. Sparks EA, Graber HL, Boudoulas H, Nelson SD, Baker III PB, Wooley CF: Atrial myopathy and atrial fibrillation: phenotypes in heritable cardiac conduction and myocardial disease. European Heart Journal Supplements 2000; 2 (Supplement K): K78-K90.
11. Boudoulas HB, Wooley CF: Mitral valve prolapse and the mitral valve prolapse syndrome, in Yu PN, Goodwin JF (eds.): Progress in Cardiology. Lea & Febiger, Philadelphia, 1986: pp 275-309.
12. Boudoulas HB, Wooley CF: Mitral valve prolapse syndrome: Neuroendocrinological aspects. Herz 1988; 13: 249-258.
13. Boudoulas HB, Kolibash AJ, Baker PB, King B, Wooley CF: Mitral valve prolapse and the mitral valve prolapse syndrome: A diagnostic classification and pathogenesis of symptoms. Am Heart J 1989; 118: 796-818.
14. Boudoulas HB, Schaal SF, Stang JM, Fontana ME, Kolibash AJ, Wooley CF: Mitral valve prolapse: Cardiac arrest with long-term survival. Int J Cardiol 1990; 26: 37-44.
15. Stefanadis C, Wooley CF, Bush CA, Kolibash AJ, Boudoulas HB: Aortic abnormalities in coronary artery disease. Am J Cardiol 1987; 59: 1300-1304.
16. Stefanadis C, Wooley CF, Bush CA, Kolibash AJ, Geleris P, Boudoulas HB: Segmental analysis of the ascending aorta: Definition of normality and classification of aortic dilation. J Cardiogr 1989; 19: 945-953.
17. Boudoulas H, Toutouzas P, Wooley CF: Functional Abnormalities of the Aorta. Futura Publishing Company, Mount Kisco, 1996.
18. Boudoulas HB, Triposkiadis F, Barrington W, Wooley CF: Left atrial volumes and function in patients with mitral stenosis in sinus rhythm. Acta Cardiol 1991; XLVI: 147-152.
19. Boudoulas HB, Starling RC, Vavuranakis M, et al: Left atrial volumes and function in orthotopic cardiac transplantation. Am Heart J 1995; 129: 774-782.
20. Boudoulas H, Boudoulas D, Sparks EA, Pearson AC, Nagaraja HN, Wooley CF: Left atrial performance indices in chronic mitral valve disease. J Heart Valve Dis 1995; 4 (Supplement II): S242-S248.
21. Grines CL, Bashore TM, Boudoulas HB, Olson SM, Shafer P, Wooley CF: Functional abnormalities in isolated bundle branch block: The effect of interventricular asynchrony. Circulation 1989; 79: 845-853.
22. Stead EA Jr: How do we produce an educated person? in Warren JV, Trzebiatowski GL (eds.): Medical Education for the 21st Century. The Ohio State University College of Medicine, Columbus, 1984: pp 141-152.
23. Kassirer J: Diagnostic reasoning. Ann Intern Med 1989; 110: 893-900.
24. Boudoulas H: There is no substitute for talent. Hellenic J Cardiol 2005; 46: 375.
25. Dauphinee WD: Clinical education: The legacy of Osler revisited. Acad Med 1990; 65: 568-573.
26. Moore GT: Opening the ambulatory setting: Teaching medical students what they need to know, in: Gastel B, Rogers DE (eds.): Clinical Education and the Doctor of Tomorrow. The New York Academy of Medicine, New York, 1989: pp 81-90.
27. Vardas PE: Modernisation of scientific institutions: an urgent need for variability and progress. Hellenic J Cardiol 2006; 47: 253.
28. Stefanadis C: The young cardiologist facing the renaissance of cardiovascular disease. Hellenic J Cardiol 2005; 46: 377.