GUIDELINES

Guidelines for Optimal Physician Training in Echocardiography

Recommendations of the American Society of Echocardiography Committee for Physician Training in Echocardiography*

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Over the past few years, the clinical use of echocardiography has continued to expand. Echocardiographic techniques are used widely to define normal and abnormal cardiac anatomy, evaluate cardiac chamber sizes and dynamics, assess valvular and pericardial diseases, detect intracavitary masses, measure pressure gradients across discrete stenoses, determine flow volumes, detect and assess the severity of valvular regurgitation, demonstrate and quantitate intracardiac shunts, and measure the timing of cardiac events. These and related applications have led to the increasing use of echocardiography in the diagnostic evaluation of many cardiac disorders. Echocardiography requires considerable theoretical knowledge, technical skill and practical experience to be used in an optimal manner. Previous publications have suggested guidelines for physician training in the techniques of M-mode and two-dimensional echocardiography. The clinical applications of echocardiography continue to grow, however, and Doppler techniques for evaluating blood flow have become an established component of the echocardiographic evaluation of many disorders. This article presents the current recommendations of the American Society of Echocardiography as to the background knowledge, the nature and amount of practical experience, and the type of training site that are optimal for the training of physicians who take responsibility for the conduct and interpretation of echocardiographic studies. (J Am Soc Echo 1988;1:278-84.)

Societies that represent professionals who practice certain cardiovascular diagnostic techniques have from time to time set forth what they consider to be optimal standards for the performance and utilization of these techniques.[1-10] In the case of noninvasive evaluation of cardiac structure and function using ultrasonic techniques, the American Society of Echocardiography has provided direction. This Society, representing more than 3000 physicians and sonographers who practice echocardiography, has published recommended measurement standards for M-mode echocardiography,[11] nomenclature and display standards for two-dimensional echocardiographic images,[12] and techniques and applications for contrast echocardiography.[13] In addition, this Society has prepared documents* that establish standards for physician training in M-mode and two-dimensional echocardiography,[14] education and training of the sonographer,[15] identification of myo-

*Reprinted from Pearlman AS, Gardin JM, Martin RP, et al. Am J Cardiol 1987;60:158-63.

*These documents are available by request from the American Society of Echocardiography, P.O. Box 2598, Raleigh, NC 27602.

cardial wall segments,[16] terminology and display conventions for Doppler echocardiography,[17] and nomenclature for cardiac septa.[18]

Continuing evolution of two-dimensional echocardiographic techniques and applications, coupled with the explosive growth of Doppler echocardiography over the past several years, has stimulated the American Society of Echocardiography to instruct the Committee for Physician Training in Echocardiography to develop updated guidelines for optimal physician training in the field of echocardiography. The guidelines that follow represent the current recommendations of the American Society of Echocardiography for the training of physicians who are responsible for the performance and interpretation of echocardiographic examinations.

GENERAL OVERVIEW

The comprehensive echocardiographic evaluation of the patient with known or suspected heart disease may involve the use of several related diagnostic ultrasonic techniques: M-mode, two-dimensional, and Doppler echocardiography. In a given patient, any or all of these modalities may be used to assess the nature and severity of a suspected cardiac disorder. In some cases, contrast echocardiographic techniques, stress echocardiography, or invasive echocardiographic studies may also be appropriate. We consider these to be a family of diagnostic techniques and will refer to them under the general term *echocardiography*. Each of these techniques has its set of specific underlying principles, instrumentation, applications, advantages, and shortcomings. Nonetheless, we emphasize that these are related and usually complementary techniques; they are not competing diagnostic procedures to be used independently. For this reason, physicians who take responsibility for the performance and interpretation of echocardiographic studies should have a clear understanding of the fundamental principles of M-mode, two-dimensional and Doppler echocardiography, and practical experience with all of these techniques.

This document set forth our recommendations as to what constitutes optimal physician training in echocardiography, rather than establishing requirements for training in cardiac noninvasive diagnostic testing. We recommend relatively extensive exposure to the theoretical principles and the practical applications of the various echocardiographic techniques. We believe that, although it may not always be easy to accomplish, adherence to these guidelines will increase the likelihood that echocardiographic studies will yield accurate and clinically meaningful data, thereby leading to improved patient care.

Echocardiographic studies are relatively inexpensive compared with other forms of cardiac diagnostic testing, and the necessary instrumentation is readily available from a number of manufacturers. Because these studies are noninvasive and apparently noninjurious, and because they provide valuable diagnostic information in a wide variety of cardiac disorders, many physicians (cardiologists and noncardiologists) may be tempted to consider providing echocardiographic services. Although it is neither our intent nor our desire to restrict the performance and use of high-quality echocardiographic studies, it is our firm conviction that substantial training is needed to provide optimal echocardiographic services. In other words, it is much more difficult to acquire the necessary skills than to purchase the needed equipment. Echocardiographic examinations are not automated or technically routine; transducer positioning, instrument controls, and examination technique all must be adapted to the patient being studied and the problems being evaluated. The physician responsible for the conduct and content of echocardiographic studies must be thoroughly familiar with these technical details in order to evaluate the quality of the data and arrive at the proper diagnostic conclusions. The responsible physician also must be familiar with normal and abnormal cardiac structure, dynamics, and blood flow. Finally, the proper use of echocardiographic findings for clinical decision-making requires not only significant expertise in echocardiography but also substantial understanding of cardiovascular disease in general. Thus, physicians responsible for echocardiographic studies need to have considerable skills, and these skills are not acquired quickly.

Physicians who supervise echocardiographic studies and interpret the significance of the findings must be not only capable of interpreting the findings, but also trained and adequately skilled in performing the examination. One must know how to acquire echocardiographic recordings in order to judge the technical quality and reliability of the data. Moreover, the recording of echocardiographic images and Doppler flow waveforms provides an ideal means to learn the tomographic anatomy of the heart, permits the operator to define the spatial relation between different cardiac structures and assists in the understanding of flow dynamics. In addition, performance of the study is an invaluable aid to recognizing the

audible Doppler frequencies that characterize cardiovascular blood flow. Although most clinical echocardiographic studies in the United States now are actually performed by trained technical personnel, often the responsible physician may need to perform part or all of the examination in order to clarify incomplete or confusing findings. He or she must also be knowledgeable in examination technique in order to provide appropriate supervision to others who perform echocardiographic studies. The person performing these studies must have not only considerable technical ability but also the experience and judgment to evaluate the findings accurately, immediately, and continuously during data acquisition. Otherwise, adequate data may not be recorded and the results of the study may be inconclusive, misleading, or erroneous. For all of these reasons, the supervising physician must be skilled in examination techniques as well as diagnostic interpretation in order to ensure studies of optimal technical (and thus diagnostic) quality.

The echocardiographic examination should answer those questions posed by the referring physician, but it should also attempt to detect and quantitate abnormalities that may be clinically inapparent or unsuspected. In this way, individual patients will receive the greatest benefit from these studies.

RECOMMENDED BACKGROUND KNOWLEDGE

Physicians who take responsibility for the performance and interpretation of echocardiographic studies should have (1) a detailed understanding of the physical principles of image formation and blood flow velocity measurement using ultrasound; (2) substantial familiarity with echocardiographic instrumentation and an understanding of how to use it properly and safely; (3) a thorough knowledge of cardiac anatomy, physiology, hemodynamics, and pathology; (4) a detailed understanding of the fluid dynamics of normal and abnormal cardiovascular blood flow; (5) substantial familiarity with the echocardiographic techniques used to evaluate cardiovascular anatomy, dynamics, and blood flow in the clinical setting; (6) the experience needed to recognize and interpret both normal and abnormal images and blood flow patterns and the ability to relate these findings to anatomic, physiologic, hemodynamic, and pathologic findings; (7) experience with cardiac auscultation, electrocardiography, chest radiography, cardiac catheterization and angiography, and other cardiac diagnostic techniques, in order to relate echocardiographic findings to the results of these examination methods, when available; (8) an understanding of the clinical problems of each patient and the presumed differential diagnoses; and (9) the ability to use echocardiographic techniques to investigate these differential diagnoses.

These guidelines also set forth our recommendations for the nature and amount of practical training that we believe appropriate for those physicians who will be responsible for echocardiographic studies. It is ideal when this experience can be gained during a period of formal training in a well-established cardiac noninvasive laboratory. Such a training program will enable the physician-trainee to acquire, in a supervised setting, a working knowledge of the physical principles and the various techniques of echocardiography, and it will allow him or her to become sufficiently skilled and experienced to perform and interpret echocardiographic studies independently. The physician-trainee must become familiar with normal and abnormal images of cardiac structure and dynamics and must learn to recognize the audible patterns of normal and pathologic blood flow. Optimally, the training program will allow the physician-trainee to develop experience in evaluating the wide variety of diagnostic challenges seen in an active, hospital-based echocardiographic practice.

RECOMMENDED PRACTICAL EXPERIENCE

Physicians training in echocardiography ideally should spend a specified period of time in an active echocardiographic laboratory, working under the direction of an established and experienced physician-echocardiographer who has achieved at least level 3 competence (Table 1). The rate at which a given physician-trainee becomes skilled in performing and interpreting echocardiographic studies will depend on his or her previous training, knowledge and technical abilities, the number and type of patients examined, and the teaching abilities of the laboratory personnel and the physician-supervisor. We recommend that each trainee keep a log of those studies that he or she has performed or interpreted during training, including the procedures performed and the diagnoses made.

Practical Experience Recommended for Physicians in Cardiology Training Programs (Fellowships)

The recent Bethesda Conference on Adult Cardiology Training[19] recommended three levels of training in echocardiography for cardiology fellows, leading to three corresponding levels of expertise. The first,

Table 1 Levels of training in echocardiography

	Objectives	Duration	No. of cases
Physicians in cardiology training program			
Level 1	Introductory experience	3 months	150 2D/M-mode examinations 75 Doppler examinations
Level 2	Sufficient experience to take responsibility for echocardiographic studies	3 additional months (beyond level 1)	150 2D/M-mode examinations 150 Doppler examinations
Level 3	Sufficient expertise to direct an echocardiography laboratory	6 additional months (beyond level 2)	450 examinations (using both imaging and Doppler)
Physicians in postcardiology training			
	Responsibility for performance and interpretation of echocardiograms	Variable; level of achievement equivalent to level 2 above	250-300 patients (2D/M-mode and Doppler examinations)
	Direct echo laboratory in hospital or large group practice	Variable; level of expertise equivalent to level 3 above	450 patients (2D/M-mode and Doppler examinations)

2D, Two-dimensional.

or basic, level of training would be an introductory experience designed to familiarize every cardiology fellow with the techniques, applications, and shortcomings of echocardiography; its completion would not qualify the trainee to perform or interpret echocardiograms independently. The second, or intermediate, level of training would provide sufficient additional experience to qualify the trainee to take independent responsibility for the performance and interpretation of echocardiographic studies. The third, or advanced, level of training would provide enough expertise to qualify the trainee to direct an echocardiographic laboratory in an academic or community hospital, or a group practice setting. We endorse these three tiers of training (Table 1) as appropriate.

All cardiology trainees should spend approximately 3 months undergoing a period of introductory training in echocardiography. This period of training should be devoted primarily to echocardiography; the trainee should not be expected to spend more than 20% of his or her time in other clinical activities. During this introductory period of training, each fellow optimally should perform and interpret at least 150 echocardiographic imaging studies, using both two-dimensional and M-mode techniques. The fellow should also perform and interpret at least 75 Doppler examinations during this same period of training. Although we recommend a smaller number of Doppler examinations than echocardiographic imaging studies, this should not be interpreted to mean that Doppler studies are relatively unimportant. We believe that a basic understanding of tomographic cardiac anatomy and dynamics provides a helpful framework for learning and understanding Doppler evaluation of blood flow dynamics, and we recognize that in many laboratories, Doppler studies are not performed in all patients (although the percentage in whom these studies *are* done is increasing). All echocardiographic studies should be performed "in a noninvasive echocardiographic laboratory which is under the direction of an established physician echocardiographer who oversees the performance and interpretation of all studies."[14] Such a period of intensive study should allow the physician-trainee to develop an appreciation of the principles of echocardiographic imaging and instrumentation, the techniques of patient examination, the tomographic anatomy of the heart and great vessels, and cardiac dynamics as visualized by both two-dimensional and M-mode echocardiography. The trainee also would become familiar with Doppler principles and instrumentation, examination techniques, and both audible and graphic outputs of Doppler data. This experience will give the physician-trainee better insight into how echocardiography can be used to assess cardiac anatomy and function and lead to a better understanding of the clinical indications for echocardiographic evaluation. It should also help the physician-trainee to better appreciate the difference between adequate and inadequate echo/Doppler data.

For the cardiology trainee to be considered sufficiently experienced to take full responsibility for independent interpretation and reporting of the findings and significance of echocardiographic studies, additional supervised experience in performing and interpreting at least 150 echocardiographic imaging studies and 150 Doppler blood flow evaluations, over a period of approximately 3 months, is rec-

ommended. During this second period of practical experience, the trainee should not be assigned other major responsibilities. This additional practical training period is intended to provide the physician-trainee a substantial body of experience in assessing abnormalities of cardiac structure and dynamics, measuring cardiac chamber and wall dimensions, quantitating ventricular function, determining flow velocities, calculating pressure gradients, computing flow volumes, determining the severity of regurgitant lesions, detecting and measuring shunts, and defining the timing of events during the cardiac cycle. Ideally, this period of training should provide exposure to a broad range of patients and clinical problems, with particular emphasis on the kinds of patients and disorders most likely encountered in the physician-trainee's actual practice. At the end of this second period of training, the cardiology fellow should have achieved a level of experience and competence sufficient to allow him or her to function independently in an established echocardiography laboratory.

For cardiology fellows who plan to direct an echocardiography laboratory, we recommend an additional 6-month period of training. During this period, which again should be devoted primarily to echocardiography, the cardiology trainee should perform or interpret an additional 450 echocardiographic studies, including both echocardiographic imaging and Doppler techniques. This additional training, which should involve patients with a wide variety of acquired and congenital cardiac disorders, would provide the trainee with sufficient experience so that he or she could take full responsibility for supervision and training of cardiac sonographers, performance of echocardiographic studies when appropriate, interpretation of echocardiographic studies, supervision of physicians training in echocardiography, and the integration of echocardiography into the overall activities of the cardiology program at his or her institution. For a cardiology trainee to attain this level of expertise, a total of 12 months of intensive training, involving echo/Doppler studies in a total of at least 750 patients, is recommended.

Practical Experience Recommended for Physicians After Cardiology Training (that is, in Practice)

This situation creates a dilemma. We realize that a period of intensive study such as that described may not be easily accomplished for many physicians who already have completed their formal training in cardiology, given the constraints of their clinical practices. On the other hand, we also recognize the technically demanding nature of ultrasonic imaging and Doppler examinations, know that performing and interpreting these studies both require substantial skill, and believe that a significant amount of guidance from an experienced physician-echocardiographer is highly desirable. In this regard, it may be useful to consider the training needed to perform and interpret electrophysiologic studies or the expertise needed to select appropriate candidates for percutaneous transluminal coronary angioplasty and to perform the dilation procedures. Physicians who have had no formal training in these techniques certainly can retrain and thereby become competent in one or another of these areas, but not without significant effort. We believe that echocardiography is similar in complexity, and these considerations lead us to suggest that achievement of a level of expertise equivalent to that recommended for cardiology fellows (Table 1) is also desirable for the physician in practice who wants to perform or interpret, or both, echocardiographic studies independently. This is particularly true for physicians who will be responsible for hospital-based echocardiographic laboratories, because they are likely to be called on to evaluate critically ill patients in whom diagnostic information must be obtained efficiently and accurately.

It is difficult to specify the length of training needed for the physician in practice to achieve a level of competence equivalent to that of a cardiology fellow who has had 6 months (or more) of formal training in echocardiography, because practicing cardiologists come from a variety of backgrounds. In general, physicians who have finished fellowship optimally should perform and interpret echocardiographic studies in at least 250 to 300 patients before they consider themselves sufficient in expertise to make independent diagnostic judgments and to use these results to determine patient management. Some of these studies could be performed in the trainee's own institution, but it would be optimal if most of these patient studies were performed and interpreted under the supervision of an experienced physician-echocardiographer, and these studies should include both imaging and Dopper echocardiographic techniques. Many physicians who have finished cardiology fellowship training already have had experience with M-mode and two-dimensional echocardiography; their familiarity with echocardiographic anatomy and cardiac dynamics, their knowledge of hemodynamics, and their ability to correlate echocardiographic findings with other clinical and laboratory data will certainly help them to learn Doppler echocardiography. We encourage practicing cardiologists

who wish to use echocardiographic techniques in an optimal manner to obtain intensive instruction in both performing and interpreting echocardiographic imaging and Doppler studies, whenever feasible, in a laboratory experienced with these techniques. In some instances, it may be more realistic for the physician in practice to obtain this training as an aggregate of multiple blocks of time.

TRAINING SITE

It is optimal when training in echocardiography can be obtained as part of a formal, full-time cardiology training program. This training program should have an established echocardiographic laboratory run by a full-time physician-director who is experienced in all phases of echocardiography, and who has achieved at least level 3 competence. Optimally, the echocardiography laboratory should be located within an active medical institution that has both inpatient and outpatient services, critical care and coronary care units, cardiac catheterization/angiographic facilities, a cardiac surgical program, and an active emergency room. The echocardiography laboratory should perform echocardiographic studies on at least 1000 patients per year, and should be experienced in M-mode, two-dimensional, and Doppler techniques. As novel developments such as color Doppler flow imaging become available and clinically useful, the relevant techniques and clinical applications also should be incorporated into the training program. Familiarity with related special procedures such as contrast echocardiography, stress echocardiography, and invasive echocardiographic techniques is also desirable. The range of patient problems and noninvasive findings seen in such a setting, and the availability of hemodynamic and anatomic data for comparison, should afford the physician-trainee a broad exposure to the clinical applications of echocardiography.

CONTINUING EDUCATION

The techniques and clinical applications of echocardiography are evolving rapidly, and there is every reason to expect this evolution to continue in the future. Therefore, all physicians responsible for the performance and interpretation of echocardiographic studies, whether they were trained as part of a formal cardiology fellowship training program or obtained equivalent postfellowship training, should maintain active and ongoing continuing education in this field. They should seek to compare the quality, completeness, and results of their echocardiographic studies with those presented in professional journals and at scientific meetings. Wherever possible, they should also assess the validity of their findings in patients undergoing cardiac catheterization, cardiac surgery, or postmortem examination.

A wide range of continuing medical educational programs is available to provide the practicing physician-echocardiographer with ongoing updates in echocardiographic techniques and applications. These programs also provide the physician with a mechanism for assessing his or her skills and proficiency. However, short postgraduate courses and brief workshops of 1 week or less, although widely available and often of good quality, are not sufficient in scope or depth to constitute by themselves adequate training in technical or interpretive skills. These courses and workshops are a meaningful supplement to formal training, and they may provide a useful overview of the field, a helpful framework for further learning, and a valuable exposure to new concepts. However, by themselves, they clearly do not provide the degree of experience needed to perform and interpret echocardiographic studies independently.

In conclusion, optimal use of echocardiographic techniques for diagnosis and clinical decision-making is based on a great deal of theoretical knowledge, important technical abilities, and significant clinical experience with echocardiographic applications. Proper development of these skills requires substantial training, which optimally should be carried out under the guidance of an experienced physician-echocardiographer. We recommend three levels of training (introductory, intermediate, and advanced) in echocardiography for cardiology fellows, and recommend that physicians who have already completed their fellowship training attain equivalent levels of expertise appropriate to their needs. We believe it ideal when this training is carried out as part of a formal cardiology training program. Finally, we recognize that the guidelines we have proposed provide only a general framework for training in the rapidly evolving field of echocardiography. Thus, special expertise (beyond the guidelines recommended here) may well be needed for the physician who uses echocardiography for specialized applications such as complex congenital heart disease, transesophageal echocardiography, or invasive studies.

In preparing the current recommendations, we have tried to maintain consistency with previous documents that dealt with physician training in

echocardiography, whenever that appeared appropriate. Accordingly, the current guidelines were formulated keeping in mind the reports of the Inter-Society Commission for Heart Disease Resources—Echocardiography Study Group,[2] the American Society of Echocardiography Committee on Physician Training in Adult M-Mode and Two-Dimensional Echocardiography,[14] and the 17th Bethesda Conference: Adult Cardiology Training—Task Force IV: Training in Echocardiography.[19] Similarities between the current report and these predecessors are unavoidable and intentional.

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