

**Task Force 2: Pediatric Training Guidelines for Noninvasive Cardiac Imaging:
Endorsed by the American Society of Echocardiography and the Society of
Pediatric Echocardiography**

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genetics, tissue engineering, stem cell biology, or developmental biology. In all of these conferences, pediatric cardiology fellows should be provided with active roles appropriate to their level of knowledge and training.

TEACHING AND EVALUATION SKILLS

It is a fundamental responsibility in academic medicine that those with the most experience must teach. The pediatric cardiology fellow will often be the most clinically experienced house officer on a team of residents, interns, and/or medical students. The fellow in that setting should be expected to provide lectures/seminars to the team of house officers. The pediatric cardiology fellow should also be allowed the opportunity to practice clinical leadership, organizational skills, and impromptu educational activities as appropriate to his/her demonstrated level of knowledge and training. There should be occasion for observation and

critique of these skills by the attending physician as well as demonstration of these skills to the fellow by the attending.

Pediatric cardiology fellows should develop formal evaluation of trainees and training skills during their fellowship. To do so, they should participate in feedback to residents, students, and cardiology attendings throughout their rotations regarding their own educational and technical progress and the progress of other team members. Accurate self-evaluation is the most valuable skill of all and should be nurtured in all phases of pediatric cardiology training.

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APPENDIX

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INTRODUCTION

Noninvasive imaging, including echocardiography and magnetic resonance imaging (MRI), is a primary means for elucidating the anatomy and physiology of childhood heart disease. Competence in performance and interpretation of echocardiography and MRI is now essential to the practice of pediatric cardiology. Depending upon one's individual career goals, varying levels of expertise may be expected to be achieved during fellowship training. This document defines the levels of knowledge and expertise that pediatric cardiology trainees should acquire in echocardiography and MRI during training, and it offers guidelines for achieving these levels of competence.

Training guidelines have been previously published for pediatric echocardiography (1), fetal echocardiography (2), and pediatric transesophageal echocardiography (3). Those documents were reviewed and considered during preparation of these guidelines. The guidelines presented here differ in some instances from previous recommendations because this task force recognizes that training programs have changed significantly over the decade since the last guidelines were promulgated.

PEDIATRIC ECHOCARDIOGRAPHY

Echocardiography, as used in this document, includes two-dimensional imaging of the heart and related structures, M-mode echocardiography for assessment of chamber size and function, color M-mode and Doppler tissue and flow mapping, pulsed and continuous-wave spectral Doppler flow analysis, and other variations of these basic modalities used to assess the structure and function of the heart and related organs, including new technologies such as three-dimensional echocardiography as they become available.

Facilities and Environment

The pediatric echocardiography laboratory should serve a hospital with inpatient and outpatient facilities, neonatal and pediatric intensive care units, a pediatric cardiac catheterization/interventional laboratory, and an active pediatric cardiac surgical program. The pediatric echocardiography laboratory should be under the supervision of a full-time pediatric cardiologist-echocardiographer qualified to direct a laboratory, and whose primary responsibility is supervision of the laboratory. The laboratory must perform a sufficient number of pediatric transthoracic, pediatric transesophageal, and fetal

echocardiograms (1,4) each year to allow trainees sufficient exposure to both normal and abnormal examinations.

LEVELS OF EXPERTISE

Training goals defined here are to enable trainees to achieve one of two levels of expertise in echocardiography as appropriate for career goals.

Core

- Understanding of the general physical properties of ultrasound and clinical ultrasound technology.
- Ability to perform and interpret transthoracic echocardiography in normal infants, children and adolescents, and in those with childhood heart disease, with consultation as needed.
- Basic introduction to the principles of performing and interpreting transesophageal and fetal echocardiograms. Physicians with *core* expertise only are not expected to perform transesophageal and fetal echocardiograms independently.

Advanced

- Special expertise in performance and interpretation of transthoracic echocardiography in all forms of congenital and acquired pediatric heart disease, including the adult with congenital heart disease, enabling the practitioner to function independently.
- Ability to perform and interpret transesophageal and fetal echocardiography independently.
- Ability to supervise training and performance of sonographers, fellows, and other physicians.

TRAINING GUIDELINES

Core training should be achieved by all pediatric cardiology fellows during core clinical training, typically during four to six months dedicated to echocardiography over the course of the standard three-year training program. This level of expertise is anticipated to be sufficient for those fellows who do not plan to pursue echocardiography as an area of subspecialization.

Advanced training requires an additional 9 to 12 months of training and may be achieved through a dedicated experience in pediatric echocardiography after completion of core pediatric echocardiography instruction. This level of training is appropriate for those physicians who intend to be dedicated pediatric echocardiographers.

TRAINING GOALS

Successful completion of each training level should result in competence in the following specific areas.

Core

- Understanding of the physical properties of ultrasound.
- Proper, safe, and facile use of ultrasound instruments.
- Knowledge of the limitations of echocardiography.

- Recognition of cardiac structures displayed by echocardiography and the correlation between echocardiographic images and cardiac anatomy.
- Interpretation of Doppler flow information and deduction of cardiovascular physiology.
- Performance and interpretation of complete transthoracic two-dimensional and M-mode echocardiograms, Doppler color-flow mapping, and pulsed- and continuous-wave spectral Doppler flow analysis in normal pediatric patients and in those with childhood heart disease, with consultation as needed.
- Assessment of systolic, diastolic, and regional myocardial function in normal pediatric patients and those with childhood heart disease, with consultation as needed.
- Ability to review critically published clinical research in echocardiography.

Advanced

In addition to *core* competencies, other goals include:

- Independent performance and interpretation of complete transthoracic two-dimensional and M-mode echocardiograms, Doppler color-flow mapping, and pulsed- and continuous-wave spectral Doppler flow analysis in normal pediatric patients and in those with childhood heart disease.
- Independent assessment of systolic, diastolic and regional myocardial function in normal pediatric patients and in those with congenital or acquired heart disease, to include stress echocardiographic studies.
- Special expertise in the performance and interpretation of pediatric transthoracic, pediatric transesophageal, and fetal echocardiography.
- Training of sonographers and junior pediatric cardiology trainees.
- Participation in basic or clinical research in echocardiography, including presenting original data at one or more scientific meetings.

TRAINING METHODS

Each level of training may be achieved by the methods outlined in the following text or by comparable alternative methods. A summary of the recommended minimum number of procedures is found in [Table 1](#).

Core

Each trainee should perform and interpret at least 150 pediatric echocardiograms, including at least 50 in patients one year of age or younger, under the supervision of the laboratory director or other qualified staff pediatric cardiologist-echocardiographer(s). Each trainee should also review at least 150 additional pediatric echocardiograms.

In addition, the laboratory director or other staff pediatric cardiologist-echocardiographer(s) should conduct regular laboratory conferences with the trainee(s) to present illustrative cases and to teach proper interpretation and the

Table 1. Echocardiography Training—Recommended Minimum Procedure Numbers

Core training	
TTE perform and interpret (≤1 year of age)	150 (50)
TTE review	150
Advanced training*	
TTE perform and interpret (≤1 year of age)	200 (50)
TTE review	200
TEE perform and interpret	50
Fetal echocardiogram	50

*Numbers are in addition to those obtained during core training.
 TEE = transesophageal echocardiogram; TTE = transthoracic echocardiogram.

limitations of echocardiography. Pathological specimens, models, or photographs for echocardiographic-anatomic correlation are excellent teaching aids that should be incorporated wherever possible.

Integration of echocardiography into the clinical practice of pediatric cardiology should be demonstrated on inpatient and outpatient rotations and at medical-surgical management conferences.

Research training for pediatric cardiology trainees should include active participation in reviews of scientific journal articles that pertain to echocardiography.

Advanced

Each *advanced*-level trainee should perform and interpret at least 200 additional pediatric transthoracic echocardiograms and review, or perform and interpret, another 200 pediatric echocardiograms. As with core training, at least 50 of these should be done in infants one year of age or younger. Each trainee should perform a significant number of echocardiograms independently (one-third to one-half of the exams), with subsequent review and critique of the examination by the responsible staff pediatric cardiologist-echocardiographer. Teaching methods outlined in the previous text should be continued here.

Each *advanced*-level trainee should perform and interpret at least 50 pediatric transesophageal echocardiograms, including manipulation of the transducer and registration of images, under direct supervision by a dedicated pediatric cardiologist-echocardiographer. The trainee should perform intubation of the esophagus in at least 20 patients under the direct supervision of a pediatric cardiologist-echocardiographer or anesthesiologist experienced in the procedure. An ideal environment for learning pediatric transesophageal echocardiography is the operating suite during performance of intraoperative examinations, but the training experience should not be limited to this venue and should include the intensive care unit, cardiac catheterization suite, and outpatient examinations.

Each *advanced* trainee should perform and/or review at least 50 fetal echocardiograms. The trainee must master the fundamental skills of determining fetal position, situs, cardiac anatomy, and cardiac rhythm under the supervision of a dedicated pediatric cardiologist-echocardiographer.

The trainee should observe and participate in the discussion of the findings with the parents by the staff echocardiographer responsible for the examination. As the trainee's experience progresses, a significant proportion (30% to 50%) of studies should be performed independently, including cases with normal and abnormal cardiac anatomy and rhythm, with supervision by a dedicated pediatric cardiologist-echocardiographer. Each trainee should understand how to recognize and approach fetal heart failure, and he or she should understand the association of fetal heart disease with extracardiac structural abnormalities, syndromes, and chromosomal abnormalities.

Research training for pediatric cardiology trainees should include, at a minimum, active participation in reviews of scientific journal articles that pertain to echocardiography. In addition, participation in basic or clinical research in echocardiography should be encouraged.

Each *advanced*-level trainee should be given responsibility for participating in the training of sonographers and junior pediatric cardiology fellows, initially with supervision of the laboratory director and then independently and also presenting echocardiography-related teaching conferences and formal didactic lectures.

EVALUATION

The laboratory director, in consultation with the teaching staff, should evaluate each trainee in writing on a regular basis. Trainees should maintain a log of all echocardiograms performed and reviewed, including the age of the patient and the diagnosis. The log should be reviewed regularly by both the laboratory director and the training program director to ensure that each trainee is obtaining adequate and balanced experience.

The evaluation should be reviewed with each trainee and a written copy provided. If a trainee does not appear to be progressing adequately during the rotation, a meeting should be scheduled as soon as possible to inform the trainee and to discuss potential remedial measures. The evaluation should be based on achievement of the expected levels of competence in the areas outlined in the previous text.

Direct observation of the trainee during performance of echocardiograms provides information about imaging skills and understanding of the ultrasound instruments. Conferences in which echocardiograms are presented provide an opportunity to assess skills in interpretation of images and Doppler recordings. The trainees' understanding of research design and methods and ability to review research can be critically evaluated during journal club meetings or other venues for medical literature review. Teaching skills and effectiveness can be evaluated by direct observation and from evaluations by sonographers and more junior trainees and by performance at teaching conferences prepared and delivered by trainees.

PEDIATRIC CARDIOVASCULAR MAGNETIC RESONANCE IMAGING

Magnetic resonance imaging (MRI) as used in this document includes anatomic and functional cardiovascular MRI in congenital and acquired pediatric heart disease as well as in the adult with congenital heart disease. At present, there are no specific guidelines for training or credentialing in pediatric cardiovascular MRI. It is likely that the training guidelines for pediatric cardiovascular MRI proposed here will require amendment as the field evolves. These guidelines must be considered as goals and should not be considered as requirements.

LEVELS OF EXPERTISE

Trainees may achieve one of two levels of expertise in pediatric cardiovascular MRI as appropriate for career goals.

Core

- Familiarity with the general physical principles upon which MRI is based.
- Ability to view and understand MR images in normal infants, children, and adolescents and those with childhood heart disease.
- Introduction to commonly used imaging protocols and MRI terminology.

Advanced

- Thorough understanding of clinical MRI instruments and the imaging protocols used for cardiovascular imaging and physiological analysis (e.g., quantitative analysis of ventricular function and blood flow).
- Ability to independently perform and interpret all types of MRI in childhood heart disease and congenital heart disease at all ages.
- Ability to supervise training of technologists, fellows, and other physicians.

TRAINING GUIDELINES

Training in pediatric cardiovascular MRI should occur within a pediatric cardiology fellowship program and/or a pediatric radiology training program accredited by the Accreditation Council for Graduate Medical Education (ACGME). The MR laboratory should serve a hospital with both inpatient and outpatient facilities, neonatal and pediatric intensive care units, a pediatric cardiac catheterization/interventional laboratory, and an active pediatric cardiac surgical program. The MRI laboratory should be under the supervision of a full-time cardiologist and/or radiologist qualified in cardiovascular MRI, and it must perform a sufficient number of annual examinations to allow each trainee sufficient exposure to both normal and abnormal examinations.

Core training should be achieved by all pediatric cardiology fellows during the core clinical years of the program.

This level of expertise may be sufficient for those fellows who plan to practice clinical pediatric cardiology with access to a pediatric cardiologist or radiologist with special expertise in pediatric cardiovascular MRI.

Advanced training requires a minimum of six months of instruction in addition to *core* training. This level of training is appropriate for those physicians who intend to have special expertise in pediatric cardiovascular MRI and is recommended for directors of pediatric cardiovascular MRI laboratories.

TRAINING GOALS

Successful completion of each training level should result in competence in the following specific areas.

Core

- Physical principles of MRI and physiologic analysis.
- Limitations of, and contraindications to, MRI.
- Recognition of cardiac structures displayed by MRI and the correlation between MR images and cardiac anatomy.
- Basic familiarity with commonly used imaging protocols, their clinical uses, and MRI terminology.
- Critical review of published clinical research in pediatric cardiovascular MRI.

Advanced

- Thorough understanding of MRI physics, instrumentation, nomenclature, and safety.
- Special expertise in the performance and interpretation of pediatric cardiovascular MRI, including all commonly used imaging and flow analysis protocols.
- Training of technologists and junior pediatric cardiology trainees.
- Management of and quality assurance for the MRI laboratory.
- Basic or clinical research in pediatric cardiovascular MRI, including presenting original data at one or more scientific meetings.

TRAINING METHODS

Each level of training may be achieved by the methods outlined in the following text or by comparable alternative methods.

Core

Pediatric cardiology trainees should gain exposure to cardiovascular MRI through active review of scientific journal articles that pertain to pediatric cardiovascular MRI, discussion with cardiologists and radiologists who perform cardiovascular MRI, and, if possible, review of cardiovascular MRI examinations.

Advanced

During a fellowship in pediatric cardiovascular MRI, each trainee should perform and/or interpret at least 100 cardio-

vascular MRI examinations in patients with congenital or acquired childhood heart disease, including adult patients with congenital heart disease. As the trainee's experience progresses, an increasing proportion of these examinations should be performed independently, with review and critique by the laboratory director.

Research training should include continued critical review of the pediatric cardiovascular MRI literature and an opportunity to perform basic or clinical research leading to publication or presentation of scientific data.

Each trainee should be given responsibility for participating in the training of technologists and junior pediatric cardiology fellows, initially with supervision of the laboratory director and subsequently independently. In addition, each trainee should have opportunities to observe and participate in the management of the laboratory, especially quality improvement initiatives.

EVALUATION

The laboratory director, in consultation with the teaching staff, should evaluate each trainee in writing. The evaluation should be reviewed with each trainee and a written copy

provided. The trainee should maintain a log of all examinations performed and reviewed, including the age of the patient, diagnosis, and role of the trainee in the examination.

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APPENDIX

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Task Force 3: Training Guidelines for Pediatric Cardiac Catheterization and Interventional Cardiology

Endorsed by the Society for Cardiovascular Angiography and Interventions

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INTRODUCTION

The purpose of this document is to recommend minimum training experiences in cardiac catheterization for clinical fellows in pediatric cardiology training programs. Training guidelines in cardiac catheterization are well-established in adult cardiovascular medicine (1,2), and they have been considered recently in pediatric cardiology as well (3,4).

Pediatric cardiac catheterization is a unique specialty encompassing a wide range of diagnostic and therapeutic techniques applied to a diverse group of congenital and acquired cardiovascular disorders. A physician who performs a pediatric cardiac catheterization must possess the technical skills and clinical judgment to safely and accurately perform a thorough diagnostic cardiac catheterization and angiographic study. Furthermore, an interventional pediatric cardiologist must also assess the indications for a catheter intervention, including the risks of performing or not performing the procedure (i.e., requires knowledge of the

natural history of the defect), and must skillfully perform the appropriate catheter intervention. It is appropriate, therefore, to delineate minimal training requirements in cardiac catheterization for pediatric cardiology trainees.

There are no studies relating training experiences to subsequent clinical skill in pediatric cardiac catheterization. Therefore, the recommendations in Task Force 3 represent the opinions of the authors. To help guide this process, all Accreditation Council for Graduate Medical Education (ACGME)-accredited pediatric cardiology training programs were surveyed in 2001 to inquire about current practices and opinions regarding fellow training in pediatric cardiac catheterization and intervention. Thirty-two programs responded. The responses represented the opinions of fellowship directors (n = 21), catheterization laboratory directors (n = 15), and division directors (n = 13) (in some programs one individual holds more than one position). This document draws on this Training Program Survey to help define training guidelines in this specialty.

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