This document describes the clinical and physical environment in which the pediatric patient with heart disease can undergo accurate and safe diagnostic and therapeutic procedures. Effective utilization of facilities, development of new technologies, and deployment of personnel capable of providing care for the fetus, infant, child, and young adult with heart disease are outlined. Guidelines in this statement update a previous document published in 1978; these current guidelines are in concert with those developed by the Joint Commission on Accreditation of Health Care Organizations and are intended for use by health planning agencies and health service organizations to evaluate existing pediatric cardiac centers and to establish the need for new centers.2,5

Young patients with heart disease have unique medical problems that can be met best by a team with training and expertise in the management of such pediatric patients. The primary purpose of this document is to recommend guidelines by which evaluation and treatment can be accomplished safely and effectively and to offer mechanisms to assist in assuring excellence in the quality of pediatric cardiology care.

GENERAL BACKGROUND

Pediatric cardiology patients require continuity and expertise in patient care. A pediatric cardiologist, along with the patient’s primary physician, should provide a continuing care program. In some centers, pediatric cardiologists who have expertise in the management of patients with congenital heart disease may provide new or continuing care for adults with congenital heart defects; in others, an orderly transfer of medical management between pediatric and adult cardiologists will provide the best care for older patients.

THE CENTER

A center is an institution or closely affiliated group of facilities providing comprehensive pediatric cardiology care, including medical and surgical diagnosis and treatment, to a population with at least 30,000 live births per year. Appropriately equipped, staffed, and supported centers serving larger populations are preferable to multiple, minimum-population centers. If multiple services already have been established in close proximity (as within the same health planning district) to provide services for populations with 30,000 live births or less, the services should be consolidated into one center. Best results are obtained in cardiac centers where frequent involvement with the problems presented leads to expertise in management. Thus, if smaller centers have been established because of tradition, well-established patient referral lines, or patterns that serve a state or other well-defined geographic area, these centers should be maintained and no other center established until the live births in the area reach more than 30,000 per year per center.

To coordinate the needs of infants at high risk, tertiary neonatal intensive care units and pediatric cardiology centers should be contained within the same health care facilities. In these centers, the pediatric cardiologist should be available for consultation on all cardiac problems. Because the need for neonatal units is about 1 per 10,000 live births and the need for pediatric cardiology centers is 1 per 30,000 live births, fewer cardiology than neo-
The integration of echocardiographic, hemodynamic, extracorporeal perfusion technique, and anatomy, embryology, physiology, pathology, pharmacology, and angiography, with interpretation of each under the direction of a pediatric cardiologist.

**PEDIATRIC CARDIOLOGY STAFF**

An approved pediatric cardiology diagnostic center, or one seeking approval, should be under the direction of a physician certified by the American Board of Pediatrics and the Sub-Board of Pediatric Cardiology.

A pediatric cardiologist should be qualified, by training and experience, in pediatrics and pediatric cardiology to provide evaluation, prenatal and postnatal diagnosis, and preoperative and postoperative services to pediatric cardiology patients. He or she should maintain board certification in pediatrics and pediatric cardiology.

For those who completed their training after 1978, certification by the American Board of Pediatrics in pediatrics and pediatric cardiology is necessary. All board-eligible pediatric cardiologists actively engaged in the subspecialty should become board-certified.

A center should have at least two pediatric cardiologists to serve patient needs. Centers with large outpatient, teaching, and research responsibilities will require additional medical personnel.

**PEDIATRIC CARDIAC SURGICAL STAFF**

There should be at least two board-qualified cardiac surgeons on the staff of a hospital with a cardiac surgical program; at least one surgeon should be certified by the American Board of Thoracic Surgery. One surgeon should be readily available at all times. Responsibility rests on both the hospital administration and the director of the program to ensure adequate professional staff coverage at all times, and to integrate hospital support systems and services to manage medical and surgical emergencies effectively.

The cardiac surgeon requires a full background in basic medical principles and surgical techniques, with special competence in pediatric cardiology. This includes the disciplines of cardiopulmonary anatomy, embryology, physiology, pathology, pharmacology, extracorporeal perfusion technique, and the integration of echocardiographic, hemodynamic, and angiographic data in infants, children, and adolescents. He or she should be able to direct a surgical team in the performance of all current cardiac surgical procedures applicable to pediatric cardiology patients. The cardiac surgeon’s training should include special emphasis in cardiovascular surgery in infants and children. If the American Board of Thoracic Surgery develops a special certificate of competence in pediatric cardiovascular and thoracic surgery in addition to the standard cardiovascular and thoracic board examination, at least one surgeon from the center should hold such a certificate.

**OTHER MEDICAL STAFF**

Staff should include physicians with recognized competence to provide pediatric patients necessary services in hematology, nephrology, neurology, neonatology, pulmonology, endocrinology-genetics, surgery, infectious diseases, radiology, anesthesiology, intensive care, and pathology. It is preferable that these physicians have certificates of pediatric proficiency or board certifications in their subspecialty if such certificates or boards exist.

Nurses specially trained in managing specific age groups with heart disease are essential. They include cardiac nurse specialists as well as surgical, intensive care, and ward nurses. Frequent reassignment of nurses outside their area of special training is undesirable. Continuing in-service education must be incorporated into each nursing program.

Technicians may be trained to assist in invasive and noninvasive procedures for pediatric cardiac patients. Certification of these people by appropriate certifying agencies should be sought.

Qualified medical social workers, or the equivalent, must be available within the institution to assist with the anxiety, fear, and worry common to patients’ families when cardiac diagnosis and treatment are being implemented. The case worker should be familiar with state and federal programs for the financial support and rehabilitation of cardiac patients.

**FACILITIES**

The specific optimal criteria for hospital resources for the care of patients with heart disease described in the Hospital Categorization Guidelines of the Joint Commission on Accreditation of Hospitals are endorsed. Pediatric Cardiology ambulatory services, supervised by a pediatric cardiologist, also should be readily available. Emergency service must be continuously available.

**NONINVASIVE PROCEDURES**

Available services should include electrocardiography, nuclear cardiology, ambulatory electrocardiographic monitoring, exercise testing, and echocardiography, with interpretation of each under the direction of a pediatric cardiologist.
Exercise testing requires electrocardiographic and blood pressure monitoring, with possible special facilities for oxygen consumption and cardiac output determination. Personnel able to recognize and treat medical emergencies should be in attendance during these studies. Emergency resuscitation equipment, including a cardiac defibrillator and ventilatory assistance devices, must be immediately available. A center dedicated to the care of patients with life-threatening arrhythmias should provide means for telemetry. Echocardiographic studies in the fetus, infant, child, and adolescent require specialized equipment for complete M-mode, two-dimensional, and Doppler examination. Increasing utilization of color flow Doppler studies suggests that this equipment will be a necessary facet of echocardiographic evaluation. Personnel should be available on continuous call. All echocardiographic examinations should be performed under the direction of a pediatric cardiologist. Current specialized training during fellowship has been delineated. Physician staff review of each echocardiographic examination is mandatory.

**INPATIENT SERVICES**

Comprehensive, specialized services for pediatric patients with heart disease should be provided in a hospital equipped to care for children as designated by the *Hospital Categorization Guidelines*. These units should be capable of providing comprehensive and optimal diagnostic and therapeutic services.

**CARDIAC CATHETERIZATION LABORATORY**

Personnel should be available on continuous call. The physician directing or actively performing catheterizations in infants and children should fulfill the qualifications for a pediatric cardiologist. Pediatric cardiology trainees should perform cardiac catheterizations under the supervision of such a pediatric cardiologist.

A graduate nurse or technician with special training in cardiovascular techniques and in the care of pediatric patients, plus two or more additional personnel to include physicians, nurses, or technicians, should be present for each procedure.

The equipment necessary for a catheterization laboratory includes:

1. Multiple-channel recording apparatus for the continuous display and recording of intracardiac pressures, electrocardiograms, and other selected physiologic variables.
2. Equipment to measure oxygen consumption and to determine the cardiac output in patients of all ages.
3. Equipment to analyze hemoglobin-oxygen saturation and measure pH and blood partial pressure of cardiac dioxide and oxygen. Results of these studies should be immediately available. Laboratories in which infants are cared for should be equipped with units able to use small samples of blood for analysis. A transcutaneous oximeter for continuous monitoring of tissue oxygenation is a necessity when performing invasive procedures on high-risk infants and children.
4. Image intensification roentgenographic apparatus capable of video and cine recording, biplane imaging equipment, and a pressure injector that permits rapid injection of controlled amounts of radiopaque contrast material are essential. Low ionic or recently developed nonionic radio-opaque contrast materials should be available.
5. Intracardiac electrophysiologic studies represent a specialized area of cardiac catheterization requiring additional medical expertise and technical support. In centers without available pediatric expertise, these studies may be performed in conjunction with an adult electrophysiologist, or patients may be referred to a more specialized center. When performing electrophysiologic studies, the catheterization laboratory team should be particularly well versed and coordinated in performing cardioversion and cardiopulmonary resuscitation. Facilities for these specialized studies should include: a physiologic recorder capable of displaying and recording at least three simultaneous electrocardiograms, six intracardiac signals, and a blood pressure; a “freeze” oscilloscope; a programmable stimulator capable of delivering three or more extrastimuli; and electrophysiologic catheters designed for children.
6. Interventional catheterization procedures represent a specialized area of cardiac catheterization requiring additional medical expertise, and technical and surgical support. Specialized equipment for angioplasty, as well as equipment for catheter or prosthesis retrieval, are required. Immediate availability of surgical intervention in the same facility is necessary in the event of a major complication.
7. Patient support devices should include resuscitation equipment and supplies available at all times for emergency use in the laboratory. The equipment should include: a defibrillator, capable of delivering energy at low doses and of synchronized cardioversion; laryngoscopes with endotracheal tubes appropriate for all ages; an oxygen source; equipment for oxygen administration in assisted respiratory ventilation; a suction device; emergency drugs; transvenous pacemaker; a body temperature-monitoring device; and a warming device for infants. At least two medical personnel...
trained in the use of this equipment should be available in the laboratory. The equipment should be checked periodically for reliable performance.

OPERATING ROOM AND SURGICAL FACILITIES

Operating room and surgical support facilities should be available and equipped as outlined in the report of the Intersociety Commission for Heart Disease Resources. This support should include a physician with training in pediatric/cardiovascular anesthesia.

CASE LOAD

A minimum case load is essential to stimulate and maintain the quality of support necessary for safe and effective diagnostic procedures and cardiac surgery. Several previous recommendations for case loads have been made. There have been a number of changes in the training and practice of pediatric cardiologists; thus, the following new guidelines incorporating previous principles have been formulated. These reflect the number of procedures expected at a center providing quality service to a population of 30,000 live births per year. A board-certified pediatric cardiologist with catheterization laboratory experience will require a minimum number of catheterizations (1 to 2 per week) to maintain skills. However, a pediatric cardiology diagnostic and treatment center providing high quality diagnostic, interventional, and electrophysiologic procedures, plus pediatric cardiology training, will require a minimum of 150 catheterizations per year to maintain staff expertise. Half of these should be performed in neonates or infants. In surgical programs serving a pediatric population, at least 100 pediatric cardiac surgical procedures (75 with extracorporeal circulation) per year are necessary for the professional team to maintain skills. Higher case numbers may be required to support cardiovascular training.

Establishment of a new cardiac center should be based on the needs of the community and available case loads. Competing low-volume programs in close geographic proximity dilute case material and make it difficult for any hospital to maintain adequate experience. To assess the needs for additional pediatric cardiology and cardiac surgical programs, the community inventory assessment suggested by the Intersociety Commission for Heart Disease Resources is endorsed as a guide.

QUALITY CONTROL AND REVIEW

Each center providing cardiac care to children should participate in a program that assesses the quality of care. Currently, the Joint Commission on Accreditation of Hospitals has outlined standards regarding quality assurance in hospitals. These standards mandate that each clinical service in a hospital prospectively assess quality of care using particular indicators. The assessment is performed through the responsible hospital administrative staff and medical staff committees. Members of a pediatric cardiology diagnostic and treatment center should avail themselves of these processes in their own hospital.

The previous guidelines for pediatric cardiology diagnostic and treatment centers suggested that peer review of pediatric cardiology centers should be performed every 3 years by a team of regionally appointed, qualified, nonaffiliated consultants, at least one of whom is a board-certified pediatric cardiologist. The purpose of such a review is to determine if the center meets an acceptable level of care on the basis of an internal audit and a site visit of the center. The review should determine whether diagnostic and surgical results are acceptable according to current practice. If the review identifies deficiencies, constructive recommendations should be made. Corrections of major deficiencies should then be assessed by a similar review team within a designated period of time.

The Section of Cardiology of the American Academy of Pediatrics endorses voluntary peer review. The Section will assist centers voluntarily desiring peer review by providing consultants available for site reviews and by making a sample site visit protocol available.

As an alternative to a site visit which would evaluate both process and outcome parameters, a center may choose to participate in a regional data system that statistically evaluates outcomes of cases. The center must submit all cases to such a system; the data should be analyzed so that statistical comparisons can be made with the experience of other centers. The data system should provide a format for discussion of the data and quality of care and a method to assess improvement in care.

CONCLUSIONS

This document is an attempt to offer guidelines for the establishment and maintenance of a diagnostic and treatment center, which will provide current and future optimum care to the pediatric patient with heart disease. Although each center has its own needs, priorities, and abilities, certain characteristics should be common to all. These form the basis of the present “guidelines.”
REFERENCES


2. Hospital Categorization Guidelines: Optimal Criteria for Hospital Resources for the Care of Patients with Heart Disease, Stroke, and End-State Kidney Disease. Chicago: Joint Commission on Accreditation of Hospitals; 1974


4. Ad Hoc Committee on Standards for Cardiac Diagnostic and Surgical Centers of the Council on Cardiovascular Disease in the Young. Standards for Cardiac Diagnostic and Surgical Centers. New York: American Heart Association; 1974


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