Introduction

Pediatric cardiology was established as a subspecialty of the American Board of Pediatrics and began certification in 1951. Although the field initially comprised cardiologists with both internal medicine and pediatric training, the paths of adult and pediatric cardiology have diverged until presently there is very little overlap of interest and expertise in the areas of noninvasive and invasive diagnostic techniques, arrhythmia management and the medical and surgical treatment of infants and children with congenital heart disease. A growing area of considerable overlap is the care of the adult with congenital heart disease.

The clinical foundation of pediatric cardiology is early diagnosis and intervention for congenital heart disease. Because of emphasis on the infant and fetus, it has become necessary for the pediatric cardiologist to have a full understanding of the developmental biology of the immature cardiovascular system, as well as comprehensive knowledge of the wide spectrum of cardiovascular diseases encountered in this age group. Likewise, cardiovascular involvement in systemic illnesses, such as acquired immunodeficiency syndrome (AIDS) and Kawasaki disease, and the multisystem management of children receiving heart transplants requires an in-depth knowledge of general pediatric care. Thus, it is imperative for cardiologists caring for children to be fully trained in pediatrics as well as in cardiovascular disease.

There are few areas of medicine embracing as many aspects of patient care as pediatric cardiology. The variations of cardiac malformations are so numerous that even in a tertiary care center specializing in the care of complex patients, lesions are encountered for the first time on a regular basis. Each anatomic variation has distinct physiologic and evolutionary consequences. Pediatric cardiologists are involved regularly with continuity of care, inpatient care of the critically ill and performance of highly technical diagnostic and interventional techniques. It is no longer feasible for a single physician to be truly expert in all areas because of the elaboration of highly specialized skills in the areas of fetal medicine, interventional catheterization and complex arrhythmia management. Hence the tendency exists for pediatric cardiologists to practice together in university, children's hospital and private subspecialty group settings. The need to collaborate closely with the cardiovascular surgeon and the requirement for an appropriately designed and staffed cardiac catheterization laboratory has resulted in the distribution of pediatric cardiologists in densely populated urban areas.

Although many of the cardiovascular abnormalities affecting children require costly technology, the outcome of disease treated early is usually excellent, reducing the lifetime costs of medical care and resulting in a productive person capable of contributing importantly to society. Considering the balance of contribution and cost over many decades of extended life, treatment of heart disease in the child compares favorably with treatment of cancer, adult cardiovascular disease and many infectious diseases.

There are several issues to be addressed with respect to providing access to care for children with heart disease. The first is the issue of the future need for subspecialists in the discipline and, therefore, training programs. With the increased need for diversification of skills within pediatric cardiology, there will be a need for continued regionalization of secondary and tertiary care in centers with both medical and surgical expertise and a large catchment area for patients. Based on the previous recommendations of the American Academy of Pediatrics that pediatric cardiology centers should serve an area generating at least 30,000 live births/year (1), there should be fostering of regional centers serving a population of at least 2 to 4 million people, thus providing optimal numbers of patients for management, education and research. Because the majority of practicing pediatric cardiologists practice in academic centers, which have been shown to generate best survival results (2), it is imperative to recognize the need to adjust their time commitment for direct patient care by their other activities. There must also continue to be a major emphasis on clinical and basic research, which provide the foundation for progress in patient care. There have been major advances in the past 20 years in the management of congenital heart disease, including the development of treatment strategies for virtually all
children with cardiac defects. However, there remain many children with complex heart disease requiring a long hospital stay and extended care for continued disability. Thus, it is important to recognize that expanded clinical research efforts are a prerequisite to enhance future management strategies in the most cost-effective manner.

Finally, the care of the adult with congenital heart disease should continue to be a high priority. There is an ever-expanding population who are best cared for by a team that includes both pediatric and adult cardiologists. There is need to foster the interest and training of cardiologists in this area to best serve this subgroup of patients.

Quantitative Approach to Work Force (Need)

Compared with the number of adults with coronary and rheumatic heart disease, ~7 million, the number of children with heart disease is relatively small. 640,000 by a recent estimate (3). Of these, 440,000 have congenital heart disease; 160,000 have arrhythmia; and 40,000 have cardiomyopathy, rheumatic heart disease, Kawasaki disease, and other acquired conditions, including an increasingly large cohort with human immunodeficiency virus (HIV) heart disease (4–13).

Approximately 25% of infants born with congenital cardiac malformations, 2.3 to 3/1,000, have severe enough disease to require cardiac catheterization or surgery, or both, in the first year of life (14). First-year mortality can be as high as 35%, with >80% of the survivors requiring ongoing pediatric cardiology visits (9,14). With 4 million live births in the United States each year, there are ~32,000 new patients with congenital heart disease, of whom 10,000 will present as severely or critically ill infants. The estimated cost was $10,000/child ($32,800 in 1992 dollars) for the first year of life alone (Jenkins KJ, personal communication) (2).

Surgery for congenital heart disease is frequently palliative rather than curative. Ongoing care is invariably necessary, and multiple operations are not uncommon. In 1988 there were 2,100 cardiac operations in California in children <18 years old (2). The average cost was >$43,000 ($60,000 in 1992 dollars when adjusted for inflation) (Jenkins KJ, personal communication). Extrapolating for the United States as a whole, the total cost for surgery alone was >$1 billion. Preoperative, periparative, postoperative and long-term care requires the expertise acquired in pediatric cardiology training. Diagnostic and therapeutic pediatric cardiology involves high technology. For example, the charges for some visits to the cardiologist, including physician fees, radiology, electrocardiograms and two-dimensional echocardiography, may approach $1,000 in some centers. A conservative estimate of the total costs for pediatric cardiovascular care is $1.5 to $2 billion/year. With 0.3% of the pediatric admissions, pediatric cardiology represents 3% of the hospital costs.

In 1969, there were 64 million children in the United States <18 years old (15). This represents a caseload of 1,962/pediatrician, or 1,320/child health care provider. By dividing the 64 million children <18 years old by 1,000 board-certified pediatric cardiologists, there are 64,000 children/pediatric cardiologist and ~1,770 children are referred for cardiovascular evaluation per pediatric cardiologist. These data compare favorably with the managed care data from Southern California Kaiser, where there are 60,000 children/pediatric cardiologist (Weisberger C, personal communication). According to a recent survey, 75% of the pediatric cardiologist's time is spent on direct patient care, with the remainder in teaching, research, administration and public service (16). Although these data are helpful, future assessment will require a determination of the number of visits necessary per diagnosis to relate this to the total number of workdays given the known pediatric cardiology work force.

The Underserved

The low incidence of pediatric heart disease and the large distances between pediatric heart centers make the distribution of care problematic. For example, in Wyoming, where there were 6,800 live births in 1991 (17), it would be expected that only 15 to 20 from 2.3 to 3/1,000 children would be born with severe congenital heart disease each year. The logistic issues of finding these children and bringing them to a pediatric cardiologist for prompt diagnostics and treatment are significant, especially when one takes into account that financial and geographic factors are frequently correlated. Pediatric cardiologists have, in general, succeeded in overcoming geographic barriers by developing outreach clinics and bringing care to patients in rural areas. In many areas of the country, regional clinics staffed by pediatric cardiologists from specialty centers make referral for tertiary care available in remote areas.

The problem of access of infants and children with congenital and acquired heart disease requires significant study. For the truly poor, Medicaid or Children with Special Needs funds are usually available, yet a significant proportion of children below the poverty line, however, are not covered by Medicaid (18–21). Even those above the poverty line may be uninsured either because the parents' employer does not provide coverage or coverage has been denied for cardiac disease because it is a "preexisting condition." Even for those with inpatient coverage, outpatient costs may be uncovered or only partially covered, and the deductible for repeated inpatient or outpatient visits may be confiscatory. These uncovered costs are usually absorbed by teaching hospitals and pediatric cardiologists.

Until universal health care with community rating is available, access to health care will be rationed by economics.
The Academic Health Center in Pediatric Cardiology

The academic health center has traditionally served the missions of patient care, education, research and service. Funding for these missions is being threatened by new methods of reimbursement. These changes require new approaches by the academic health center and federal and state funding authorities.

Patient Care

Academic health care centers must continue to serve as models of clinical excellence with quality of patient care as the primary goal. Pediatric cardiologists in these centers are now in competition for patients with physicians in the private sector because echocardiography has allowed for proliferation of many pediatric cardiologists outside academic centers. Centers also compete with other academic health centers and are ill-equipped for such competition in a managed care model. Because cost is easier to measure than quality, it is likely that in the near term, decisions on where a patient is to be referred will be based almost completely on cost. Academic health centers must learn quickly how to assess costs and utilize the principles of efficiency and economies of scale. Sharing some facilities with an adult medical cardiology program may be desirable from the standpoint of efficiency, education and research collaboration. However, in such arrangements the distinct needs of children and specific requirements for space, time and reimbursement for pediatric patients must be well understood and honored. In certain smaller divisions of pediatric cardiology, it may not be efficient to have completely separate facilities for an ambulatory clinic, noninvasive testing and cardiac catheterization. In the examination of cost and efficiency, seeing the greatest number of patients in the shortest possible time using the fewest capital resources is paramount, but the well-being of the child is also paramount, and quality of care must be preserved.

On the other hand, quality of care will become more measurable. Academic health centers need to become aware of the evolving measures for this dimension and take part in their development for children. Measures of quality besides mortality and morbidity and relating to patient quality of life and satisfaction will become increasingly important. Further, there is a need to document the complexity of patients' diagnoses seen in academic centers. Methods to document the severity of illness must be found, including severity-adjusted mortality, morbidity and other quality indexes. Reimbursement must be based on the severity-adjusted indexes to preserve quality of care.

The structure of a pediatric cardiology division must also be examined closely. Before the current major emphasis on cost containment, sub-subspecialization (e.g., dedicated echocardiographers) was encouraged. However, such categorization is inefficient. If the echocardiographer exclusively performs ultrasound studies, he or she needs designated periods of time to do research, teaching and service, requiring the hiring of another person. For small services, this is untenable. There are a number of possible solutions:

1. Encourage development of multitalented clinicians (two people trained in both catheterization and echocardiography instead of two of each). Although this may be the wave of the future, retraining will be difficult for large numbers of pediatric cardiologists. A second alternative is to train more subspecialists in several subdisciplines such as echocardiography and catheterization. Unfortunately, because of the expanding knowledge and technical requirements in these areas, such bundling of areas of expertise would most likely result in loss of either proficiency or advances in the more technical areas of clinical care that characterize pediatric cardiology.

2. Acquire a larger patient base. This has been the approach used traditionally by a number of academic pediatric cardiology divisions and involves the establishment of outreach clinics (sometimes at a great distance from the medical center, but necessary to the medical center as a source of patients). It is likely that these efforts will be examined carefully for their return over the next several years as patient referrals are more controlled by cost and regional contracting and less by quality and individual preference by the referring physician.

3. Form alliances with other academic health centers and pediatric cardiologists in private practice. This is an attractive option if two relatively small programs can pool their faculty to take care of a larger number of patients. A potential disadvantage of joint programs in the future is the difficulty in negotiating with payors for a package contract in pediatric cardiology when the institutions in which they reside are negotiating as separate entities. The attraction of private practitioners to mutually advantageous alliances with academic centers is a goal that should be pursued. Another important alliance is with adult cardiologists to provide coordinated care for the increasing population of adults with congenital heart disease; optimal patient care requires expertise in both pediatric and adult cardiology.

Education

Academic pediatric cardiologists teach not only medical students, residents and fellows, but also other faculty members and provide ongoing advice and instruction to pediatricians and pediatric cardiologists in the private sector. The commitments to teaching are not all formal and quantifiable with respect to the number of months on rounds, the number of lectures given, the time spent in teaching conferences for fellows (up to 15 h/week for some faculty members in some programs) or teaching fellows while sitting in the office. In medical schools there are numerous committees concerned with education, ranging from house staff selection to curriculum committees. At present, these activities are not specifically funded. The closest attempt to pay for such services is
the Medicare Indirect Medical Education Adjustment. The problem with this adjustment is that the true cost of medical education for these services has not been quantified, thus allowing for the amount of the adjustment to be changed at will. At present, no national health care proposal has fully considered the issue of medical education. As patient care dollars become more explicitly related to patient care, mechanisms must be found to sustain excellence in medical education. Such funding should be a high priority in any new national or regional health care funding proposal.

Training in Pediatric Cardiology

It has been >5 years since training requirements for pediatric cardiologists have been reviewed. As a first step in reexamining those requirements, a survey was recently completed assessing current training practices in pediatric cardiology programs; 33 of 41 programs returned the survey (Table 1). Although the component parts of each program are similar, there is wide variation in the emphasis and the allocation of time to develop specific skills among training programs. This should be evaluated in the process of setting new guidelines.

It is important to continue to regionalize pediatric cardiovascular care to provide for adequate numbers of patients for optimal training of fellows, residents and medical students. For programs falling below minimally acceptable patient volumes, there should be a stimulus to merge with other programs, provide for training with clinical faculty in the private sector or terminate its subspecialty training program.

Research

Both basic and applied research are vital underpinnings of improvement of health care. It is only recently, with the renewed emphasis on cost-effective health care, that clinical outcomes research has once again become respectable. Both basic laboratory investigation and investigation of patient outcomes must be funded on the basis of reasoned setting of priorities with a zero base rather than continuing along traditional lines. At present, most pediatric cardiologists who devote the majority of their time to laboratory research do not generate enough dollars to pay for their salary. Practically no clinical research is funded by granting agencies, yet faculty are expected to generate clinical research projects, organize large multicenter studies and supervise clinical research of fellows. These activities must be prioritized and paid for explicitly (as with education) because there will not be the average in clinical dollars to fund these activities. Explicit allocations for research funding must be a part of any new national or regional health care funding proposal.

Partnerships in Delivery of Cardiovascular Care

The nonphysician practitioner is defined in this report as either a physician assistant, a pediatric nurse practitioner or a specialty nurse who works exclusively with a pediatric cardiologist. These providers may improve the comprehensive nature of the clinical practice of pediatric cardiology from the very practical role of facilitating scheduling, admission evaluations and discharge planning to the more complex responsibilities of managing postoperative evaluations and patient/family education.

Currently, most large clinical pediatric cardiology programs employ several nurse specialists. Analysis is required to assess the manner in which they can extend the efficiency and comprehensive nature of pediatric cardiology practice.

If subspecialty training programs are restricted (and we think that no justification exists for this), the role of nurse partners will necessarily expand. There is a relatively fixed number of children with congenital heart disease, and if the number of practicing pediatric cardiologists were to be reduced, then this will require consideration of innovative ways of extending a single practitioner's influence. With proper training and experience, a nurse specialist may provide some clinical screening for congenital heart disease and thus effectively support primary care providers and facilitate access to a pediatric cardiologist when necessary. Clearly, it must be understood that alternative approaches may consist of utilizing existing community resources and promoting creative alliances for the improvement of patient care.
Pediatric Cardiology, Pediatrics and Adult Cardiology

As we approach the year 2000, it is critical for pediatric cardiology to examine its role as it relates to general pediatrics and adult cardiology. What will be the future of that relationship? How will pediatricians and pediatric cardiologists interact? It is important for us to try to establish the basis of those relationships as we forge a new health care model in this country.

Pediatrics and Pediatric Cardiology

Similar to general pediatrics, there is a distribution of pediatric cardiologists to the urban setting; 85% of pediatric cardiologists practice in an urban setting, 12% in the suburbs and only 3% rural (22). In a recent survey, 88% of the pediatric cardiologists polled did only pediatric cardiology, and very few did any primary care pediatrics (16). The corollary is true of general pediatric care in relation to pediatric cardiology, where cardiology issues are not within the top 1.6% of the most common complaints nor within the top 0.8% in terms of most common diagnoses (23). Thus, it would be difficult for a generalist physician to maintain expertise in delivery of cardiac care to children.

A recent study (23) evaluated the cost-effectiveness of consulting a pediatric cardiologist in the evaluation of a cardiac murmur versus the primary care pediatrician directly ordering an echocardiogram. The cost of the primary echocardiography strategy was $793/patient, whereas that of the primary echocardiography strategy was $793/patient, yielding a significant advantage of $257/patient for the cardiology referral strategy. The conclusion was that pediatric cardiology consultation is the preferred approach for evaluation of a cardiac murmur.

It is also critical that the pediatric cardiologist work with the pediatrician in the area of preventive cardiology. The early identification of cardiovascular risk factors, such as elevated low density lipoprotein cholesterol, low high density lipoprotein cholesterol, smoking, hypertension, diabetes, obesity and lack of physical activity, are the province of pediatrics and pediatric cardiologists working together. General pediatricians should provide the primary contact with a large segment of the population at risk for cardiovascular disease, but a communication network needs to be established with a pediatric cardiology center related to medical management and new developments in the field.

Pediatric and Adult Cardiology

In marked contrast to adult cardiology, with its ~800 new trainees/year, pediatric training programs produce 60 to 65 new board-eligible physicians yearly (25). Further, 16 years ago the American Board of Pediatrics and the Subboard of Pediatric Cardiology initiated the requirement recently adopted by adult cardiology of at least 1 year of fellowship training devoted to research.

Figure 1 (and Figure 6, Task Force 5) demonstrates the distribution of pediatric cardiologists and adult cardiologists related to population density. It is very clear from these figures that there are many more adult cardiologists than pediatric cardiologists in this country. In fact, in 1993, there are ~1,000 board-certified pediatric cardiologists, whereas adult cardiology programs turn out ~1,100 to 1,500 new adult cardiologists each year through their training programs.

Given the nonuniform geographic distribution of pediatric cardiologists in the country and the significantly larger number of adult cardiologists, which more closely parallels the general distribution of the population, some services usually performed by pediatric cardiologists are sometimes provided by adult cardiologists. In a recent survey of adult cardiologists conducted by the ACC, 87% reported that they had received no additional formal training in pediatric cardiology (beyond basic training).* Any adult cardiologist involved in pediatric cardiology care should be in direct communication with the pediatric cardiology center in that geographic region. Such communication, as well as other network telecommunications that save patients travel time and potentially improve health care in other ways, should be reimbursed for both physicians. It is estimated that there are 500,000 to 600,000 adult patients with congenital heart disease currently in the United States who may be underserved significantly by our medical care system. Because of the requirement for expertise in congenital heart disease as it presents in the adult and in general internal medicine, the health care needs of adult patients must be met through close collaboration of pediatric and adult cardiology colleagues.

Projecting Work Force Needs

In 1993 there were 1,074 board-certified pediatric cardiologists in the United States, a number well within the 1980 Graduate Medical Education Advisory Committee projections of need for 1990 (26). The growth of the physician workforce (from 512 since 1979) has been accompanied by a dramatic improvement in mortality and the functional outcome of children with complex heart disease, due in large part to the development of specialized and labor-intensive areas of expertise, such as prenatal diagnosis and management of heart disease, perioperative support of the surgical repair of very young infants, interventional catheter techniques that have replaced or complemented surgical repair, interventional techniques for the treatment of cardiac arrhythmias and cardiac transplantation in children. Growth of knowledge and skill in these areas has produced a larger population of survivors who require ongoing care. Therefore, the slight increase in the physician workforce has paralleled the increasing needs for cardiovascular care among the pediatric population.

Forty-eight training programs in pediatric cardiology were accredited and recognized by the Accreditation Council for Graduate Medical Education in 1993 to 1994. Of these, 43 programs had at least two trainees. In 1993 to 1994 there were a total of 82 first-year trainees, which represents only 3.1% of pediatric trainees completing residency programs. In view of these small numbers, any reduction in the pediatric cardiology workforce is likely to impair access to appropriate cardiovascular care for the most medically underserved population, the nation’s children.

It is the obligation of the medical care provider to do more for patients than simply provide quality health care. Children with heart disease need strong advocacy to ensure that they are not considered "little adults" and that resources for their care are based only on an assessment of needs, and not influenced by financial disincentives.

**Recommendations**

1. Because the fundamental referral relationships of pediatric generalists and specialists are different from their counterparts in adult medicine, data and recommendations for adults should not be applied to children. Policies affecting the pediatric cardiology workforce necessary for the care of heart disease in the young should be based on data generated from the ongoing needs of such patients rather than on arbitrary percentages.

2. The number of training positions in pediatric cardiology should be based on an iterative data-driven process. It is particularly important that research careers receive a high priority in any new educational guidelines.

3. National and regional work force policies should include provisions for education, research and training; these missions should be funded explicitly.

4. Formation of regional academic health care centers in pediatric cardiology serving a population of 2 to 4 million people should be encouraged, thus providing optimal numbers of patients for patient care, education and research.

5. A comprehensive analysis should be performed examining potential new alliances of pediatric cardiologists with other care givers. These relationships should recognize the vulnerable nature of children with heart disease, and those who provide their care should be appropriately trained in the care of children.

6. Alliances with adult cardiologists in the management of adult congenital heart disease patients should be fostered to jointly develop centers of excellence for the care of these patients.
7. Universal coverage for comprehensive cardiology care should be provided for children. Preexisting conditions should not be considered grounds for stopping or decreasing coverage for infants, children or adults with congenital heart disease either before or after cardiac surgery. Government reimbursement should at least be comparable to current Medicare guidelines.

Conclusions

Available data indicate that the number of pediatric cardiologists is similar to a health maintenance organization model and that the clinical work hours per week of pediatric cardiologists have not changed over 20 years, suggesting that the pediatric cardiology work force is in balance. However, continuing evaluation of work force needs is necessary. Universal health care coverage, as outlined in recommendation 7, will be necessary to ensure adequate access to pediatric cardiology care.

References

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