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Adult Congenital Heart Disease

Variations in Adult Congenital Heart Disease Training in Adult and Pediatric Cardiology Fellowship Programs

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OBJECTIVES The purpose of this study was to evaluate adult congenital heart disease (CHD) training among U.S. cardiology fellowship programs.

BACKGROUND Although training recommendations for caring for adults with CHD exist, the educational patterns and numbers of specialists remain unknown.

METHODS We surveyed U.S. directors of 170 adult cardiology and 45 pediatric cardiology (PC) fellowship programs. Adult program surveys contained 1 single-response and 10 multiple-choice questions; pediatric program surveys contained 1 single-response and 13 multiple-choice questions.

RESULTS Ninety-four adult cardiology fellowship directors (55%) and 34 PC directors (76%) responded. Of adult programs, 70% were in university hospitals and 40% were associated with PC groups. Those with PC-affiliation had more adult CHD clinics ($p < 0.02$) and more adult CHD inpatient ($p < 0.02$) and outpatient ($p < 0.002$) visits than those without PC affiliation. Most PC programs were in children's hospitals (38%) or children's hospitals within adult hospitals (50%). Eighty-two percent had associated adult cardiology programs. Pediatric programs followed adult CHD patients in various care settings. Over one-third of adult and pediatric programs had ≤3 lectures annually regarding adult CHD. Nine adult and 2 pediatric programs offered adult CHD fellowships, and only 31 adult and 11 pediatric fellows pursued advanced CHD training in the last 10 years.

CONCLUSIONS Adult CHD didactic and clinical experiences for cardiology fellows vary widely. Few programs offer advanced CHD training, and the number of specially trained physicians is unlikely to meet projected workforce requirements. Adult cardiology programs with PC affiliation have increased CHD experience and might provide good educational models. (J Am Coll Cardiol 2005;46:893–8) © 2005 by the American College of Cardiology Foundation

Estimates suggest that there are 650,000 to 1.3 million adults with congenital heart disease (CHD) in the U.S., and that this number is projected to continue growing at 5% per year for at least the next several years (1–3). Importantly, at least one-half of these patients will likely require care by a physician specializing in CHD (1,2,4). This large number of adult CHD patients and their increasing complexity pose a dilemma for both patients and physicians: who will care for the patients? Although pediatric cardiologists are trained in the diagnosis and treatment of CHD, they lack training in the other medical and psychosocial issues of adult patients. Similarly, adult cardiologists, although familiar with the illnesses of adulthood, receive relatively little CHD training. Many CHD patients continue to see a pediatric cardiologist into adulthood, but approximately 4% of patients seen by general adult cardiologists have CHD (5). Recent evidence strongly suggests that there are not enough physicians with specialized training to care for the increasing number of adult CHD patients (2).

Training in CHD for adult cardiology fellows was addressed by the American College of Cardiology in the 1995 Recommendations for Training in Adult Cardiovascular Medicine Core Cardiology Training (COCATS) Task Force 9, the COCATS II revision in 2002, and in the 32nd Bethesda Conference Task Force 3 (6–8). At the present time, there are no formal recommendations for adult CHD training in pediatric cardiology (PC) fellowship programs. In light of these guidelines and predictions of increased workforce needs, this study examines training patterns for all cardiology fellows in adult CHD.

METHODS

We surveyed the program directors of accredited (by the Accreditation Council for Graduate Medical Education) adult cardiology and PC fellowship programs in the U.S.

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Abbreviations and Acronyms

CHD = congenital heart disease
COCATS = Core Cardiology Training (Recommendations for Training in Adult Cardiovascular Medicine)
PC = pediatric cardiology

Each survey was sent by facsimile up to three times to non-respondents over a four-month period, leaving at least one month each time to respond. In the adult program director survey, there were 1 single-answer and 10 multiple-choice questions; in the pediatric program director survey, there were 1 single-answer and 13 multiple-choice questions. The pediatric program directors survey required additional questions, owing to the presence of free-standing children's hospitals and different regulations regarding care of adults in pediatric facilities. Both surveys investigated the following areas: program demographics (size, geographic location, setting, hospital type, affiliation with pediatric or adult cardiology for programs of the opposite type, and predominant patient insurance type), educational components (didactic lectures and specified adult CHD fellowship training program), patient exposure (number of inpatients and outpatients evaluated, locations of care delivery and a dedicated adult CHD clinic), and the number of fellows obtaining additional adult CHD training in the past 10 years. For the patient exposure questions, the diagnoses of patent foramen ovale, bicuspid aortic valve, and mitral valve prolapse were excluded.

Survey response percentages were calculated with the total number of responses per question as the denominator for that question. For the single-response questions, answers were tabulated. Descriptive statistics were obtained for the overall group. In the adult survey group, we used multivariate logistic regression to evaluate factors associated with CHD didactic training and patient exposure. Categorical data was compared with the chi-square test. A p value <0.05 was considered statistically significant, and all statistical analyses were performed with SPSS 12 for Windows (SPSS Inc., Chicago, Illinois).

RESULTS

The survey was sent to 170 of the 180 adult cardiology fellowship training programs, because 10 were unreachable by fax. The pediatric survey was sent to all 45 PC fellowship program directors. Ninety-four adult (55%) and 34 pediatric (76%) program directors responded. Descriptive results from adult and pediatric programs are displayed in Tables 1 and 2, respectively. Forty percent of responding adult programs were affiliated with PC groups, and 82% of pediatric programs were affiliated with adult cardiology groups. Seventy percent of adult responders and 100% of pediatric responders were affiliated with or at university hospitals. Of the adult programs, 70% were in university hospitals and the other 30% of responders were divided between community hospitals, county hospitals, Veterans Administration hospitals, and other types of facilities. In the pediatric programs, 38% were in free-standing children's hospitals, 50% were in children's hospitals within an adult hospital, and 12% were in tertiary hospitals. Both adult and pediatric programs were geographically well distributed, and most of the fellowship programs were medium-sized with 6 to 20 adult fellows (76%) or 4 to 9 pediatric fellows (59%). For adult programs, the non-responders were not significantly different in the percentage of university hospitals ($p > 0.11$) or geographic distribution ($p > 0.39$). Over one-half of the 11 non-responding pediatric programs were in the South and none were in the West. The Central and East distributions were similar to responders. When asked about the predominant type of insurance for their patient population, 53% of adult programs and 50% of pediatric programs reported public insurance, and the rest were divided

Table 1. Descriptive Characteristics of CHD Training in Adult Cardiology Fellowship Programs

	Adult Cardiology (n = 94)
University affiliation	66 (70%)
Program type	
University hospital	66 (70%)
Community	11 (12%)
County	2 (2%)
VA	1 (1%)
Other	14 (15%)
Geography	(n = 94)
East	36 (38%)
Midwest/Central	20 (21%)
South	21 (22%)
West	17 (18%)
Predominant insurance source	(n = 93)
Public	49 (53%)
Private	27 (18%)
HMO	8 (9%)
Uninsured	2 (2%)
Mixed/other	17 (18%)
Number of fellows	(n = 93)
1–5	8 (9%)
6–10	26 (28%)
11–20	45 (48%)
>20	14 (15%)
Didactic lectures	(n = 94)
1–3	37 (39%)
4–6	33 (35%)
7–10	12 (13%)
>10	12 (13%)
ACHD clinic and setting	(n = 93)
General cardiology	53 (57%)
>1/week ACHD	7 (8%)
Weekly ACHD	10 (11%)
2×/month ACHD	8 (9%)
Monthly ACHD	6 (6%)
Other	9 (10%)
ACHD fellowship programs	9 (10%)
Fellows in past 10 yrs	31

ACHD = adults with congenital heart disease; CHD = congenital heart disease; HMO = health maintenance organization; VA = Veterans Administration.

Table 2. Descriptive Characteristics of CHD Training in Pediatric Cardiology Fellowship Programs

	Pediatric Cardiology (n = 34)
Program type	
University affiliation	34 (100%)
Children's hospital	13 (38%)
Children's within adult hospital	17 (50%)
Combined	4 (12%)
Geography	(n = 34)
East	10 (29%)
Midwest/Central	11 (32%)
South	6 (18%)
West	7 (21%)
Predominant insurance source	(n = 32)
Public	16 (50%)
Private	9 (28%)
HMO	5 (16%)
Uninsured	0 (0%)
Mixed/other	2 (6%)
Number of fellows	(n = 34)
1–3	9 (26%)
4–6	14 (41%)
7–9	6 (18%)
≥10	5 (15%)
Didactic lectures	(n = 34)
1–3	14 (41%)
4–6	9 (26%)
7–10	6 (18%)
>10	5 (15%)
ACHD clinic and setting	(n = 28)
General cardiology	13 (46%)
>1/week ACHD	3 (10%)
Weekly ACHD	6 (21%)
2×/month ACHD	3 (11%)
Monthly ACHD	1 (4%)
Other	2 (7%)
ACHD fellowship programs	2 (6%)
Fellows in past 10 yrs	11

Abbreviations as in Table 1.

between private insurance, health maintenance organization, uninsured, and mixed or other types of insurance.

All cardiology fellowship programs had some didactic training in adult CHD but over one-third of adult and pediatric programs had ≤3 lectures per year (Tables 1 and 2). In the adult cardiology fellowship programs, over 60% evaluated ≤10 outpatients with CHD per month, and only 19% saw >20 per month (Fig. 1). Regarding inpatients, over two-thirds of adult programs (69%) evaluated <5 per month, and only 10% of programs saw ≥11 per month (Fig. 1). In the majority of adult programs (57%), adult CHD outpatients were followed in the general cardiology clinics. The other programs had dedicated clinics for adult CHD patients ranging from monthly to >1 per week (Table 1).

In multivariate logistic regression analysis, there was no relation between inpatient exposure or didactic lectures and geographic location, setting, primary patient insurance type, or affiliation with a PC program; however, the relation between both outpatient experience and a specified adult CHD clinic to PC affiliation was statistically significant. Programs with (n = 38) and without (n = 45) PC affiliation were compared in a univariate analysis to assess differences in training and program characteristics (Table 3). The programs in which an affiliation with PC could not be determined were excluded. There were no significant differences in geographic location, setting, primary insurance source, number of fellows, or number of didactic lectures per year. Adult cardiology fellowship programs with PC affiliation had significantly more exposure to CHD inpatients ($p = 0.02$) and outpatients ($p = 0.002$) and were more likely to have a dedicated adult CHD clinic ($p = 0.02$).

In addition to the questions asked of adult program directors, the pediatric program directors were asked about the setting of adult CHD patient evaluation. Regarding the evaluation of adult inpatients, 12% did not allow adults to be seen in the pediatric facility, 18% saw <5 per month, 37% saw 5 to 10, and 33% saw >11 per month (Fig. 2). Fifteen programs responded that the adult inpatients were admitted to both pediatric and adult hospitals or exclusively to adult facilities. In this mixed group, the patients were predominantly treated by adult CHD specialists (60%), a combination of pediatric and adult cardiologists (27%), or other models using nurse practitioners or adult cardiologists (6% each). For outpatient care, 3% did not allow the care of adults in the pediatric clinic, 40% saw >30 adult CHD patients per month, another 39% saw 11 to 29 per month, 12% saw 5 to 10 per month and 6% evaluated <5 per month (Fig. 2). In 11 of the pediatric programs, adult CHD patients were also or exclusively followed at sites other than

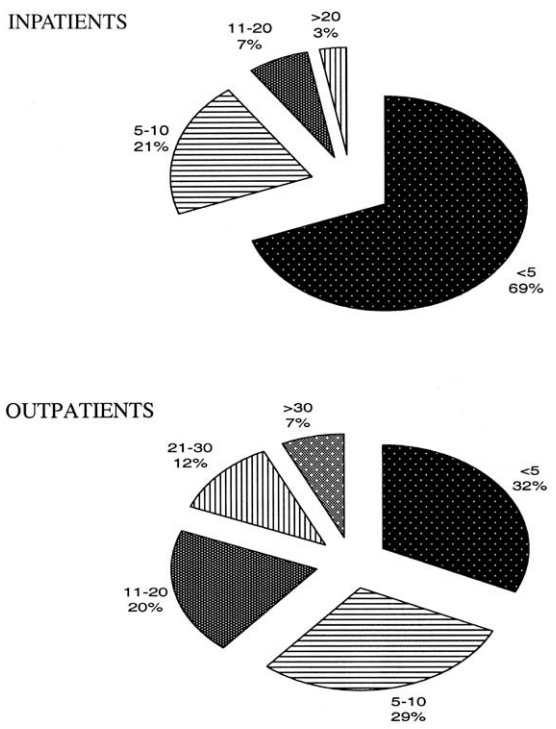

Figure 1. Average number of adult congenital heart disease inpatients and outpatients evaluated per month in the adult cardiology fellowship programs.

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Table 3. Comparison of Congenital Heart Disease Training Between Adult Cardiology Fellowship Programs With or Without Affiliated Pediatric Cardiology

	With Pediatric Cardiology (n = 38)	Without Pediatric Cardiology (n = 45)	p Value
Primary insurance			0.05
Private	12	4	
HMO	3	2	
Public	17	30	
Uninsured	0	2	
Other or multiple responses	6	7	
Geographic region			0.9
East	13	18	
Central	9	10	
South	8	10	
West	8	7	
Setting			0.1
Urban	21	24	
Small urban	15	10	
Suburban	2	5	
Rural	0	4	
Number of fellows in program			0.12
1–5	1	7	
6–10	8	11	
11–20	21	18	
>20	8	5	
Number of didactic lectures per yr			0.81
0	0	0	
1–3	15	20	
4–6	13	15	
7–10	4	6	
>10	6	4	
Number of ACHD outpatients/month			0.002
0–10	15	30	
>10	23	10	
Number of ACHD inpatients/month			0.02
<5	21	35	
≥5	17	9	
Type of specified ACHD clinics/month			0.02
No specified ACHD clinic	20	34	
At least monthly ACHD clinic	18	10	

The numbers do not add up to the total number of respondents in some questions. This is because not all respondents answered every question.
Abbreviations as in Table 1.

the PC clinic. Of these 11, 7 sent patients to adult CHD centers, 1 each had patients followed in clinics with adult and pediatric cardiologists or adult cardiologists alone, and 2 were followed in other types of settings. When patients were followed in the pediatric outpatient clinic, 46% were seen along with general PC clinics, 46% were seen in clinics specifically for adult CHD patients varying from monthly to >1 per week, and 7% were seen in other settings (Table 2).

Regarding specified adult CHD fellowship training programs, nine adult cardiology programs offered a fourth-year fellowship in adult CHD. According to the adult program directors, over the last 10 years, only 31 of approximately 6,500 to 7,000 adult cardiology fellows trained nationally (9) received this additional training in adult CHD. In pediatrics, only two program directors responded as having a program in place. Two additional programs responded that they would have adult CHD fellowship programs soon. When asked about the number of fellows from pediatric programs obtaining adult CHD training in the past 10 years, the program directors recalled only 11 of approximately 700 PC fellows trained in that time period.

DISCUSSION

Training of adult cardiology and PC fellows in adult CHD varies widely among training programs. The COCATS (1995) and COCATS II (2002) guidelines describe training for three levels of expertise in CHD for adult cardiology fellows (6,7). Level 1 is recommended for all fellows and includes at least three hours of didactic lectures to cover CHD topics of anatomy, physiology, pathology, genetics, natural history, and clinical presentation, along with patient exposure on a regular basis and involvement in an ongoing adult or pediatric CHD clinic. Levels 2 and 3 require an

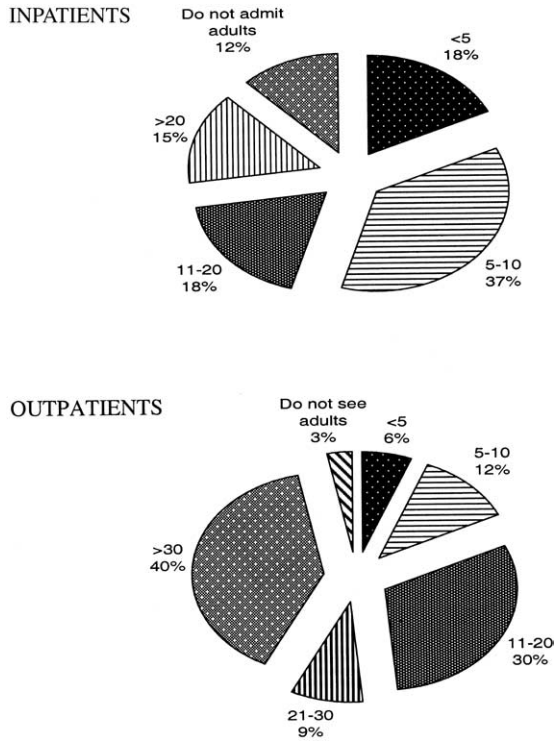

Figure 2. Average number of adult congenital heart disease inpatients and outpatients evaluated per month in children's hospitals in the pediatric fellowship programs.

additional one to two years of training and include the ability to independently perform transthoracic and transesophageal echocardiography and diagnostic catheterization. Pediatric cardiology fellows are well-trained in CHD but lack expertise in adult onset disease and the approach to the adult patient. At the present time, there are no formal training guidelines for pediatric fellows regarding the care of adults with CHD. Our results suggest that a number of adult cardiology programs are providing Level 1 training or even less. The pediatric fellows receive about the same distribution of lectures on adult CHD topics but seem to evaluate a larger number of patients, given that there are more outpatients reported in the clinics and fewer fellows per program than in the adult programs.

The pediatric programs have a wide variety of models of caring for adult patients involving different physical inpatient and outpatient settings as well as different affiliations with other providers, including adult CHD specialists, adult cardiologists, and nurse practitioners. Impressively, the number of fellows receiving specialized training in CHD from adult or pediatric programs is low, and only a few centers in the country provide this training. The majority of the fellows with specialized training to care for adults with CHD are coming from programs based in adult cardiology, although, as a percentage of fellows graduating from adult cardiology and PC fellowships, more are coming from pediatrics (0.4% vs. 1.4%).

The actual number of adult CHD specialists currently required is unknown, but can be estimated from published reports. In 1996, there were approximately 21,000 active cardiovascular disease practitioners (including 1,400 pediatric cardiologists and 300 cardiothoracic surgeons). The estimated number of general cardiology patients followed by each adult cardiologist was 1,032 (10). A conservative current estimate of adult CHD patients requiring specialized care is 250,000 patients (2). With the estimate of 1,032 patients per cardiologist, this population needs at least 250 geographically diverse full-time physicians specializing in adult CHD. Because these patients are typically more complex than the general adult cardiology patient, this population will likely require an even larger number of physicians. Importantly, the relatively small number of U.S. pediatric cardiologists, and only approximately 75 new training positions yearly, will not be able to completely absorb this large patient group. Although we recognize that our survey results might be contaminated by recall bias and that more adult CHD-trained practitioners might exist, the number of adult and pediatric cardiologists with special training in the care of adults with CHD remains far below that required to serve this population.

Although various solutions have been proposed to increase the workforce to care for adult CHD patients, the shortage is already great. Suggestions for combined adult-pediatric cardiology fellowship programs and an increased role for medicine-pediatrics residents are excellent but face significant challenges and will take time to fully implement (4,11). A potentially more practical solution is to use existing successful models as a basis to improve coordination in the training of physicians and the clinical care of adults with CHD. Larger regional academic centers should be encouraged to formalize programs to care for adult CHD patients and educate adult cardiology and PC fellows. Care in other regions might include adult and pediatric cardiologists forming alliances or consulting with one another and adult CHD specialists. Our data show that the PC-affiliated adult cardiology programs offer greater adult CHD-patient experience, suggesting that, for fellow education, it is important for adult cardiology programs to develop training relationships with pediatric cardiologists. This approach might include more detailed curriculum guidelines for teaching such topics as embryology, CHD physiology, and the influence of adult conditions, such as coronary artery disease, diabetes, or pregnancy. This same integrative approach would also improve the education of PC fellows with regard to adults with CHD and adult-onset cardiovascular disease. Although not a focus of this study, this integration might also prove beneficial to the education of PC fellows in the prevention of risk factors for adult cardiovascular disease that are now appearing in childhood, such as obesity, hypertension, and metabolic syndrome.

Our study has some important limitations. The response rates of 55% and 76%, although good for physician surveys (12), might not be representative of all cardiology fellowship training programs. Also, the information obtained from program directors might be limited by recall bias, although

it is more likely that the results overestimate education, patient exposure, and even program diversity, because the programs with little adult CHD training might have been less likely to respond.

Conclusions. The training of adult cardiology and PC fellows in CHD varies widely and occurs in multiple types of settings. Importantly, there are few programs offering advanced adult CHD training, and this study suggests that the number of fellows currently receiving specialized training in CHD will not meet estimated workforce requirements. Adult cardiology fellowship programs with affiliated PC programs have increased exposure to patients with CHD and might provide good models for an evolving CHD educational model.

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REFERENCES

1. Warnes CA, Liberthson R, Danielson GK, et al. Task force 1: the changing profile of congenital heart disease in adult life. J Am Coll Cardiol 2001;37:1170–5.
2. Hoffman JI, Kaplan S, Liberthson RR. Prevalence of congenital heart disease. Am Heart J 2004;147:425–39.
3. Niwa K, Perloff JK, Webb GD, et al. Survey of specialized tertiary care facilities for adults with congenital heart disease. Int J Card 2004;96:211–6.
4. Webb CL, Jenkins KJ, Karpawich PP, et al. Collaborative care for adults with congenital heart disease. Circulation 2002;105:2318–23.
5. Vetrovec GW, Gardin JM, Gregory JJ, et al. Adult cardiovascular physician resources and needs assessment. Report of the 1992 and 1993 American College of Cardiology surveys on physician training and resource requirements. J Am Coll Cardiol 1995;26:1125–32.
6. Skorton DJ, Cheitlin MD, Freed MD, et al. Guidelines for training in adult cardiovascular medicine. Core Cardiology Training Symposium (COCATS). Task force 9: training in the care of adult patients with congenital heart disease. J Am Coll Cardiol 1995;25:31–3.
7. Beller GA, Bonow RO, Fuster V. Core Cardiology Training Symposium (COCATS). ACC revised recommendations for training in adult cardiovascular medicine. Core Cardiology Training II (COCATS 2). J Am Coll Cardiol 2002;39:1242–6.
8. Child JS, Collins-Nakai RL, Alpert JS, et al. Task force 3: workforce description and educational requirements for the care of adults with congenital heart disease. J Am Coll Cardiol 2001;37:1183–7.
9. Fye WB, Hirshfield JW. 35th Bethesda Conference: cardiology's workforce crisis: a pragmatic approach. J Am Coll Cardiol 2004;44:216–75.
10. Foot DK, Lewis RP, Pearson TA, Beller GA. Demographics and cardiology, 1950–2000. J Am Coll Cardiol 2000;35:1067–81.
11. Sanders SP. We know how many—but how? Am Heart J 2004;147:398–400.
12. Taylor AJ, Udelson JE, Fuster V. Training cardiovascular fellows in cardiovascular magnetic resonance and vascular imaging; current status following the core cardiovascular training symposium (COCATS-2) guidelines. J Am Coll Cardiol 2004;43:2108–12.