

A Proposal for Training in Pediatric Cardiac Anesthesia

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Despite a relatively universally applicable knowledge base and skill set, training and experience in pediatric cardiac anesthesia in currently organized basic anesthesia and Adult Cardiothoracic Anesthesia fellowship programs are very limited and not uniformly available. Experience during Pediatric Anesthesia fellowship training is uniformly available but of limited duration and varying intensity. We present a schema, developed by a working group of the Congenital Cardiac Anesthesia Society, for training in pediatric cardiac anesthesia that pediatric cardiac anesthesia educators internationally should consider as a template to be modified as necessary.

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Pediatric cardiac anesthesia is a distinct area of clinical practice with a distinct knowledge base that must be mastered. There are currently no formal training guidelines or certification processes in pediatric cardiac anesthesia. In contrast, other subspecialty areas integral to the care of patients with congenital heart disease have standardized training programs. Pediatric cardiac surgery requires 8–10 yr of postgraduate training, pediatric cardiology 6–8 yr of postgraduate training, and pediatric cardiac critical care medicine 7–9 yr of postgraduate training. Pediatric cardiac anesthesia has evolved on an institutional basis leading to wide international discrepancies in training. At the same time, there have been great advances in surgical interventions, nonsurgical interventions, and medical therapies for congenital heart disease. This, along with improved outcomes, has led to surgical and nonsurgical treatments being offered to higher risk patients than in the past. Improved prenatal diagnosis has further contributed to an increased number of patients presenting with congenital heart disease. Pediatric cardiac anesthesiologists have played a pivotal role in the advancement of care. Standardized and regimented training is needed to ensure high quality

of care and continued successes with the treatment of congenital heart disease.

In 2008, a working group of the Congenital Cardiac Anesthesia Society* comprised the entire Board of Directors of Congenital Cardiac Anesthesia Society and other members of the pediatric anesthesia community sought to evaluate the current status of pediatric cardiac anesthesia training and to address the current lack of delineated training criteria in pediatric cardiac anesthesia both in the United States and internationally. The group subsequently developed a proposal outlining appropriate syllabus and training requirements for additional training in pediatric cardiac anesthesia. We present this proposal to a wider readership to stimulate discussion within the pediatric cardiac anesthesia community.

CURRENT TRAINING IN PEDIATRIC CARDIAC ANESTHESIA

The working group sought to characterize the current status of training in pediatric cardiac anesthesia. There are currently 131 American Council on Graduate Medical Education (ACGME) accredited anesthesia residencies, 45 ACGME accredited Pediatric Anesthesia fellowships, 44 ACGME accredited Adult Cardiothoracic Anesthesia fellowships, and 29 non-ACGME accredited Adult Cardiothoracic Anesthesia fellowships in the United States.†‡ One author (JAD) communicated directly with one or more of the following individuals regarding resident and fellowship training

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*Congenital Cardiac Anesthesia Society website. Available at: <http://www.pedsanesthesia.org/ccas/>. Accessed February 27, 2008.

†Accreditation Council for Graduate Medical Education website. Available at: <http://www.acgme.org/adspublic/>. Accessed February 27, 2009.

‡Society of Cardiovascular Anesthesiologists website. Available at: <http://www.scahq.org/sca3/fellowships/>. Accessed February 27, 2009.

in pediatric cardiac anesthesia in all of these aforementioned programs: department chair, cardiac or pediatric anesthesia section chiefs, fellowship directors, or residency program directors. In many circumstances, an internal "crosscheck" of the accuracy of the information was obtained as both the trainees' home institution and the institution providing the trainees' pediatric anesthesia experience were surveyed. Additional information was provided by direct experience of the members of the working group.

In 64% of ACGME accredited residency programs, hands-on experience with pediatric cardiac anesthesia during basic anesthesia training is described as "none" ($n = 61$) or "rare" ($n = 23$). In the remaining 47 programs, typical exposure is during the CA-2 and CA-3 yr with residents caring for 5–10 patients undergoing procedures requiring cardiopulmonary bypass (CPB). In seven of these programs, resident participation was described as "elective" or "optional." In a few programs, residents care for as many as 20–30 CPB patients. In some institutions, experience is supplemented by care of patients undergoing cardiac catheterization and noncardiac surgical procedures. Complexity varies from program to program and, in approximately half of programs that provide exposure, resident involvement is inconsistent from year to year due to low (≤ 100 cases/yr) case volume.

Although there is typically exposure to pediatric cardiac anesthesia during additional training in pediatric anesthesia, specific syllabus content, case numbers, and duration of rotations are left unaddressed. In Great Britain, the training for pediatric cardiac anesthesia is left unaddressed in both the pediatric and cardiac training sections of the Royal College training requirements.[§] In the United States, training in several anesthesia subspecialties has been defined and regulated, including Pediatric Anesthesia and Adult Cardiothoracic Anesthesia, both of which have 12-mo fellowships accredited by the ACGME.^{||¶} Pediatric Anesthesia fellowship training requires some exposure to pediatric cardiac anesthesia; however, the duration and intensity are unspecified.^{||} Pediatric cardiac anesthesia experience is "encouraged" but not required as a component of an Adult Cardiothoracic Anesthesia fellowship.^{¶¶}

Pediatric Anesthesia fellows in all 45 ACGME accredited programs have at least a 2-mo cardiac experience during the 12-mo fellowship. The typical fellowship experience involves 25–50 CPB cases. In two thirds of the programs, this exposure occurs in 1-mo blocks,

and in the remainder, the experience is distributed throughout the year. Approximately one quarter of the pediatric fellows use elective time to obtain an additional month or 2 of experience. Presently, only 34% (15 of 44) of ACGME accredited and 7% (2 of 29) of nonaccredited fellowships in Adult Cardiothoracic Anesthesia have mandatory pediatric cardiac anesthesia exposure with the remaining programs offering an elective experience of varying duration. Typical mandatory exposure is 1–2 mo with 20–30 CPB cases. The words "rarely" or "occasionally" were most commonly used by the individuals surveyed to describe the frequency with which Adult Cardiothoracic Anesthesia fellows use available elective time to pursue training in pediatric cardiac anesthesia. Presumably, accreditation of US training programs in Adult Cardiothoracic Anesthesia has resulted in imposition of specific requirements for fellows, particularly in acquisition of echocardiographic skills that leave little, if any, time for outside electives.

Although some centers may, on occasion, take on a trainee for specialized additional training in pediatric cardiac anesthesia, we are currently aware of only three fulltime, 12-mo pediatric cardiac anesthesia training programs: those at the Freeman Hospital, Newcastle, United Kingdom, the Texas Children's Hospital, Houston, and at Children's Hospital Boston. Children's Hospital of Philadelphia offers a 12-mo pediatric anesthesia/pediatric cardiac anesthesia continuum with 6 mo devoted to pediatric cardiac anesthesia. Several other programs in the United States offer additional training in pediatric cardiac anesthesia for intervals of 3–12 mo on an *ad hoc* basis. One of the authors (VCB) recently surveyed colleagues in 15 diverse and representative countries: Australia, Belgium, Canada, China, Croatia, France, Germany, Israel, Japan, Lebanon, Norway, South Africa, United Kingdom, United States, and Uzbekistan.[#] With the exception of these organized training programs, training in pediatric cardiac anesthesia was universally approached in an informal way, as an apprenticeship so to speak, after basic training in anesthesia or pediatric anesthesia. It was assumed that additional education and experience would accrue on the job, in practice with more experienced colleagues. Interestingly, all three program directors (Newcastle, Houston, and Boston) have indicated that they believe that even after finishing this additional year of training in pediatric cardiac anesthesia their trainees will require 1–2 yr of additional mentorship.

[§]The CCT in Anesthesia. IV: Competency Based Specialist Registrar Years 3, 4 and 5. Training and Assessment. Available at: <http://www.rcoa.ac.uk/docs/CCTptiv.pdf>. Accessed February 27, 2009.

^{||}Accreditation Council for Graduate Medical Education. Program Requirements for Residency Education in Pediatric Anesthesiology. Available at: http://www.acgme.org/acWebsite/downloads/RRC_progReq/042pr704_u1204.pdf. Accessed February 27, 2009.

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[#]Personal communication, presented at the World Summit on Pediatric and Congenital Heart Surgery Services, Education and Cardiac Care in Children and Adults with Congenital Heart Disease. Montreal, June 2008.

IS THERE A NEED FOR ADDITIONAL TRAINING IN PEDIATRIC CARDIAC ANESTHESIA?

The Kennedy report was produced by a commission established under the auspices of the British Secretary of State for Health after concerns about poor outcomes in complex cardiac services for infants at the Bristol Royal Infirmary from 1984 to 1995 went unaddressed by local authorities. It recommended national standards in all aspects of care for children with congenital heart disease, including anesthesia.** Subsequently, a Review Group to examine pediatric and congenital cardiac services in England, Wales, and Northern Ireland was convened.†† The Report of the Pediatric and Congenital Cardiac Services Review Group in Great Britain stated in 2003 that: "There is currently no evidence that variation in training or experience of anesthetists have any bearing on outcomes in pediatric and congenital cardiac surgery. This is not surprising as there have been no studies specifically addressing this issue. There is, however, agreement among those involved in this area (patients, parents, and health professionals) that anesthetists involved in pediatric and congenital cardiac surgery should, like the surgeons and cardiologists, have minimum standards for training and experience." In addition, the Group recommended that this training should occur at recognized training centers. Based on consensus views, the report listed appropriate knowledge and skills competences, and noted that maintenance of expertise would require ongoing experience with pediatric cardiac cases. In a 2007 postal survey (33 of 67 questionnaires were returned), 73% of British pediatric cardiac anesthetists indicated that the Royal College of Anesthetists should specify training standards.¹ However, as yet, the Royal College has not specified such standards.

HOW MUCH TRAINING IN PEDIATRIC CARDIAC ANESTHESIA IS REQUIRED?

Although there is clearly no precise answer, it is instructional to consider both what is currently done and how one might structure a training program. In the Newcastle program, trainees are expected to do 300–350 cases, of which >200 are to be in the cardiac operating rooms, attend multidisciplinary catheterization conference, and take night call in the pediatric intensive care unit. In Houston, fellows will have completed additional training in pediatric or adult cardiac anesthesia. They spend 8–9 mo caring for children in the operating rooms with heart disease, cardiac catheterization laboratory, magnetic resonance suite, etc.,

**Kennedy I. The Report of the public inquiry into children's heart surgery at the Bristol Royal Infirmary 1984–1995. Available at: <http://www.bristol-inquiry.org.uk/final%5Freport/>. Accessed February 27, 2009.

††Report of the Pediatric and Congenital Cardiac Services Review Group, London. Available at: <http://www.advisorybodies.doh.gov.uk/childcardiac/>. Accessed February 27, 2009.

have a 1–2 mo experience in echocardiography, a 1 mo rotation in the pediatric cardiac intensive care unit, and a 2–4 wk rotation with the perfusionists. It is presumed they will have done 80 CPB cases and 60 non-CPB cases with at least 25% in patients <30 days of age, and 50% in patients <1 yr of age, as well as 50 mentored transesophageal echocardiogram (TEE) examinations. The program in Boston is similar. Trainees spend 8–9 mo caring for children with heart disease in the operating rooms, cardiac catheterization laboratory, magnetic resonance suite, etc., and have 3–4 mo of elective time spent in echocardiography, the pediatric cardiac intensive care unit, and the general pediatric operating rooms. Interestingly, despite the fact that certifying agencies currently require competency-based training criteria and will likely continue to do so, the above-defined programs continue to define training in terms of specific rotation durations or numbers of cases needed.

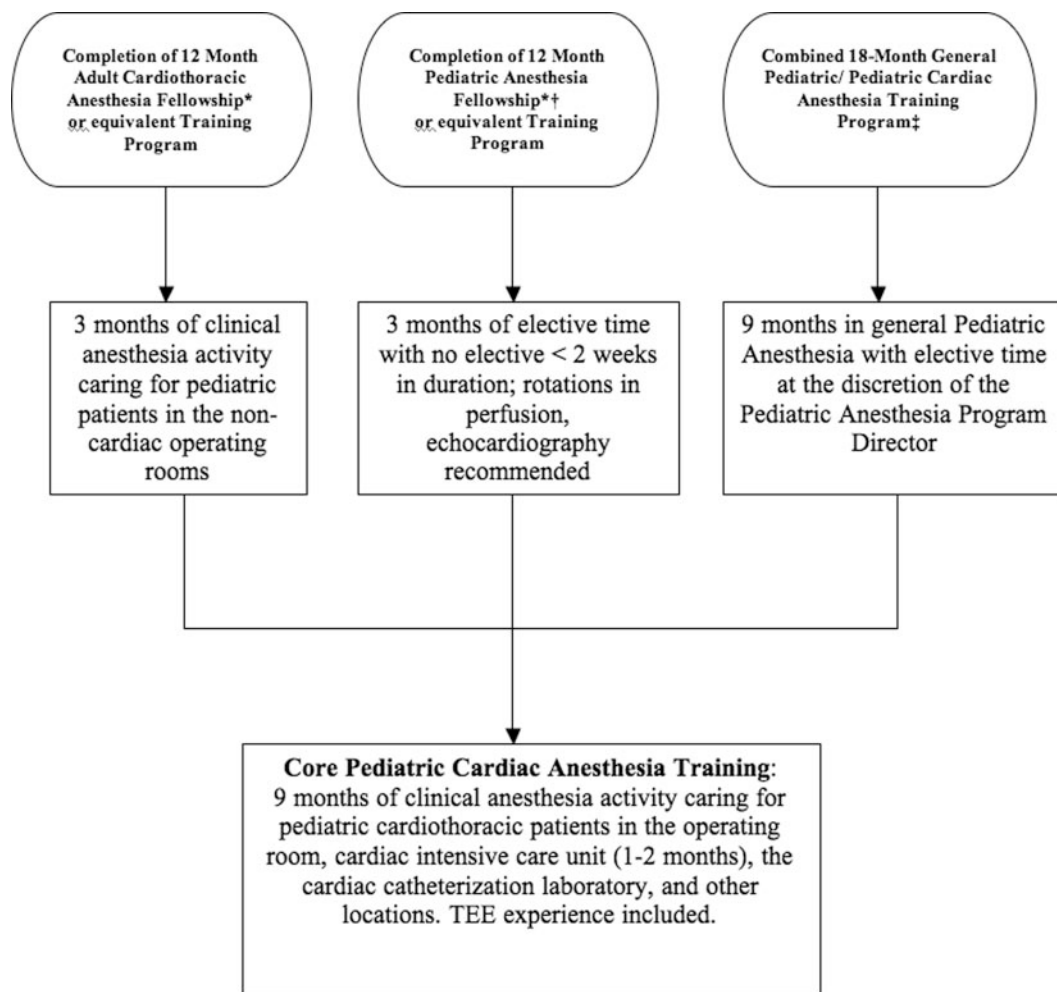
Both of these latter two programs also have an organized didactic teaching program for trainees and 1 day per week of nonclinical time for academic pursuits. It is noted that the echocardiographic experience at both centers would almost certainly be inadequate to acquire sufficient experience for certification in Special Competence in Perioperative Transesophageal Echocardiography. This certification that requires passing the PTEeXAM in addition to interpretation of 300 examinations "of a wide spectrum of cardiac diagnoses" under supervision, of which 150 must be personally performed, is a core experience in US Adult Cardiothoracic Anesthesia training programs.‡‡ In addition, it is highly unlikely that the American Society of Echocardiography recommendation that physicians (regardless of specialty) achieve the equivalent experience of a Level 2 pediatric echocardiographer (400 transthoracic examinations) with a strong knowledge base in congenital heart disease before they begin to learn how to perform and interpret TEE in pediatric patients could be realized.²

HOW WOULD ONE CONSTRUCT A PEDIATRIC CARDIAC ANESTHESIA TRAINING PROGRAM DE NOVO?

There are no data defining an optimal training program, but we do have the results of two British postal surveys. In 2001, the results of a survey of British pediatric cardiac anesthesia consultants were presented.§§ Those doing solely pediatric cases thought that trainees should have a median of 12 mo of general pediatric anesthesia experience, 4 mo of pediatric cardiac experience, and 3 mo of adult cardiac experience. Those who practiced both adult and pediatric anesthesia thought that there should be a median

‡‡National Board of Echocardiography, PTEeXAM. Available at: <http://www.echoboards.org/>. Accessed February 27, 2009.

§§Davis A. Training in Pediatric Cardiac Anesthesia. Presented at the joint Association of Pediatric Anesthetists/Association of Cardiothoracic Anesthetists meeting, Liverpool, March, 2001.



* In the U.S., meets ACGME certification requirements

† Time spent in Pediatric Cardiac Anesthesia during a Pediatric Anesthesia Fellowship or equivalent Training Program may be counted toward the 9 month requirement at the discretion of the Pediatric Cardiac Anesthesia Program Director

‡ In the U.S., would meet ACGME certification requirements for general Pediatric Anesthesia Fellowship

Figure 1. A schema for training in pediatric cardiac anesthesia. Trainees will enter one of the three arms based on their previous training after basic training in anesthesiology. TEE = transesophageal echocardiography; ACGME = American Council on Graduate Medical Education.

of 6 mo each of all three. White and Murphy's postal survey of British consultant pediatric cardiac anesthesiologists revealed that the respondents preferred 12 mo of training (during the registrarship in anesthesia) in general pediatric anesthesia and 6 mo in each of pediatric cardiac anesthesia, pediatric intensive care, and adult cardiac anesthesia.¹ These authors appreciated that training of this duration was unlikely to be acquired during a registrarship and that additional training would be required, either in the United Kingdom or abroad.¹

A PROPOSED TRAINING PROGRAM IN PEDIATRIC CARDIAC ANESTHESIA

After initial extensive discussions within the working group, a preliminary proposal was prepared by one of the authors (JAD). This was submitted to the

group for comment and modification, and changes were made by consensus. The final document was presented to the group for comment and approval. The group appreciated that prospective trainees would come from a variety of backgrounds. In addition, it was the consensus of the group that independent practice of pediatric cardiac anesthesia for the full breadth and complexity of evolving surgical and interventional catheterization procedures would require training in addition to that provided in a typical Adult Cardiothoracic or Pediatric Anesthesia Fellowship. Thus, our proposal provides three distinct pathways (Fig. 1). The proposal assumes that trainees will have already completed basic residency/registrar training in anesthesia, adequate to fulfill the local national training requirements leading to certification

Table 1. Didactic Components of a Proposed Pediatric Cardiac Anesthesia Training Program

1. Embryology and morphology; nomenclature of congenital heart disease
2. Pathophysiology, pharmacology, and clinical management of patients with the full spectrum of pediatric congenital and acquired heart disease
3. Pathophysiology, pharmacology, and clinical management of patients pre- and postheart, lung, or heart-lung transplantation
4. Noninvasive cardiovascular evaluation: electrocardiography, echocardiography, computed tomography, and magnetic resonance imaging
5. Cardiac catheterization, including interventional procedures
6. Preanesthetic evaluation of pediatric cardiothoracic patients
7. Pharmacodynamics and pharmacokinetics of medications used in the treatment of children with cardiothoracic disorders, including anesthetics and vasoactive medications
8. Extracorporeal circulation (including cardiopulmonary bypass, low-flow cardiopulmonary bypass, deep hypothermic circulatory arrest, antegrade cerebral perfusion, extracorporeal oxygenation [ECMO]), management of anticoagulation while on extracorporeal circulation, myocardial preservation
9. Circulatory assist devices
10. Pacemaker insertion and modes of action
11. Postanesthetic critical care of pediatric cardiothoracic surgical patients, including ventilator management
12. Pain management of pediatric cardiothoracic surgical patients
13. Research methodology and statistical analysis
14. Quality assurance and improvement
15. Ethical issues
16. Natural history, pathophysiology, and anesthetic care of the adult with congenital heart disease, both for cardiac and noncardiac surgery

by the American Board of Anesthesiology, Royal College of Anesthetists in the United Kingdom, or similar certifying bodies in the rest of the world. In addition to basic anesthesia training, applicants should have already completed appropriate fellowship training in either pediatric or cardiac anesthesia. The group appreciated that many, if not most, graduates would combine a practice of pediatric cardiac anesthesia with a general pediatric anesthesia practice. Thus, a third pathway, combining both pediatric anesthesia and pediatric cardiac anesthesia training within an 18-mo combined program was developed.

All trainees would have a 9-mo core clinical experience. This training period would be devoted to caring for children (and possibly adults) in the operating room with congenital heart disease, the cardiac intensive care unit, the cardiac catheterization laboratory, and other locations. All trainees, regardless of which track they followed, would complete the didactic program outlined in Table 1 and would have a full understanding of those topics. All trainees would have an understanding of the application of TEE in the perioperative management of children and adults

with congenital heart disease. There would be a structured TEE experience and didactic program that would include exposure to TEE in adults with congenital heart disease. In some programs, the faculty cardiac anesthesiologists would mentor the TEE experience, whereas in others pediatric cardiologists would need to provide the mentoring.

In this 9-mo period, trainees would be expected to have intraoperative experience with at least 50 children in the first year of life and 25 in the first month of life. It is presumed that the majority of these children would have surgery requiring CPB. In addition, trainees would be expected to participate in the care of children with heart disease during at least 50 diagnostic or therapeutic procedures. These recommendations are generally similar to the median requirements suggested by the respondents to the White and Murphy survey.¹ The major difference is that those respondents suggested a median of 6 mo of adult cardiac anesthesia. This requirement would at least, in part, be addressed in our proposal by the several months of adult cardiac anesthesia training that occur during basic anesthesia training.

For Trainees Entering From a Pediatric Anesthesia Fellowship or Equivalent Training Program

Trainees would spend 9 of the 12 mo in the core clinical experience, as described above, and 3 mo in elective rotations. Time spent in pediatric cardiac anesthesia during the core pediatric anesthesia fellowship could be counted against the 9-mo core clinical requirement at the discretion of the pediatric cardiac anesthesia program director.

For Trainees Entering From an Adult Cardiac Anesthesia Fellowship or Equivalent Training Program

Trainees would spend 9 of the 12 mo in the core clinical experience, as described above, and 3 mo caring for neonates, infants, and children in the regular, noncardiac operating rooms.

For Trainees in the 18-mo Continuum

Trainees would spend 9 of the 18 mo in the core clinical experience, as described above, with 9 mo in the pediatric anesthesia training program. Elective time would be allocated at the discretion of the pediatric anesthesia program director.

Didactic Components

The didactic components would supplement the clinical experience and allow trainees to acquire the knowledge to care for pediatric cardiothoracic patients. The areas to be covered are presented in Table 1.

SUMMARY

Despite a relatively universally applicable knowledge base and skill set, training and experience requirements in pediatric cardiac anesthesia remain undefined. Even in countries such as the United States

that currently have defined training programs in pediatric anesthesia and adult cardiac anesthesia, this issue has not been comprehensively addressed. We present a schema for training in pediatric cardiac anesthesia, which pediatric cardiac anesthesia educators internationally should consider as a template to be modified as necessary to fit their own regional or national requirements.

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