Teaching and learning in congenital cardiac anesthesia

Alan Jay Schwartz

“Pedantic” is a description teachers wish to avoid. In the interest of doing this, I offer a fifth grader’s biography of the great teacher Socrates: “Socrates was a man. Socrates was a Greek. Socrates went around telling people what to do. They poisoned him!”

Education

This chapter about education on anesthesia for patients with congenital heart disease (CHD) is not intended in such a manner that I risk Socrates’ fate but rather is intended to be provocative and to give cause for thought to an important subject not often reflected upon. All of anesthesia education can be easily considered in the following question (DE Greenhow, pers. comm., 1982):

“How shall who teach what to whom for what purpose now and in the future?!"

Anesthesia education is presented using this question as the framework for consideration. This chapter provides a philosophy of teaching anesthesia and a detailed proposal for anesthesia education in pediatric cardiac anesthesia.

Teaching, in a narrow sense, the way most of us think about it, is an activity by an individual aimed at causing another person to know some new fact or to know how to accomplish some new task. The focus appears to rest on the teacher and the activity of teaching. It does not take long to realize, however, that this way of looking at the teaching/learning activity has misplaced emphasis. If not with the teaching activity, where does the emphasis belong? The answer to this question lies in understanding the definition of education.

Education is an all-encompassing process (not merely a specific activity) resulting in a change in behavior on the part of the student/learner. The focus of education is the learner, not the teacher. It is the student who is educated by interacting with an environment that provides experience(s). Education is a change in behavior based on experiences. The experiences most often include the student interacting with a teacher but are almost never limited to that alone. The entire milieu defines the total experience. When the milieu changes, so may the education; that is, the change in behavior exhibited by the student may vary dramatically if the milieu is varied.

Picture the educational setting in which a cardiac or pediatric anesthesiology resident is learning how to use epinephrine when weaning a patient from cardiopulmonary bypass (CPB). The knowledge and skills that must be learned include application of the pharmacological principles of catecholamines to the pathophysiology of cardiovascular disease by turning on a mechanical infusion pump to deliver the indicated dose of a medication while technically monitoring for dose response and toxicity. Learning these facts and the skills sufficient to employ them is much different when done from a textbook or a preoperative conference with a faculty preceptor than when done during the operating room (OR) interaction between the surgeon and anesthesiologist, where varied opinions may consider dopamine a more sound physiologic choice or intermittent boluses a better administration technique. The interposition of the concerned surgeon and real-time patient setting between the student and the knowledge and skills to be learned changes the learning environment and, hence, the educational experience for the resident. More is learned than the facts and psychomotor skills. As the attitudes of both the anesthesiologist and the surgeon are displayed during the resolution of the questions about the “best” drug to use and the “right” way to give it, the resident learns how these two types of practitioners are supposed to relate to one another.

It seems obvious, therefore, that there is more to consider than just teaching. What more is there to the anesthesiologist’s responsibility than just teaching those around her or him? Answering the component parts of the question posed at the beginning of this chapter provides the answer.
Anesthesia education and congenital heart disease

Care of the child or adult with a congenital cardiac lesion has been an important part of cardiac surgical and cardiology practice since the beginning of the 20th century. In 1907, for example, Munro described ligation of a patent ductus arteriosus. In 1946, Alfred Blalock, a surgeon, and Helen Taussig, a pediatrician, recognized that surgically creating an arterial–pulmonary shunt palliated patients with congenital cardiac defects that reduced pulmonary blood flow. Use of deep hypothermia and circulatory arrest or low flow techniques has allowed surgeons to perform corrective “open heart” procedures on children and adults with cyanotic CHD. In 1967, Rashkind and colleagues described the balloon atrial septostomy to palliate babies with transposition of the great arteries. In the 1980s and 1990s, Norwood and others developed cardiac surgical operations to palliate children with hypoplastic left heart syndrome.

In less than 100 years, cardiac surgical and cardiology practice became highly sophisticated with respect to the care of patients with congenital cardiac lesions.

The rapid growth of sophisticated cardiac surgical and cardiology non-surgical diagnostic and therapeutic procedures for congenital cardiac lesions logically mandated comprehensive education of anesthesiologists specializing in the cardiac and/or pediatric anesthesiology subspecialties. The 3-year core anesthesiology residency program does not permit sufficient in-depth education about anesthesia for patients with congenital cardiac problems. The knowledge and skills necessary for the care of patients with congenital cardiac disease are different than those required for the care of patients with acquired valvular and ischemic cardiac diseases.

The “complete cardiac anesthesiologist” devoted to the care of patients with congenital cardiac lesions must immerse her/himself in a systematic program of clinical and didactic education about congenital cardiac anesthesia. This can only be achieved within a subspecialty residency (fellowship) in either cardiac or pediatric anesthesiology. Ideally, this is best achieved through the implementation of a standardized curriculum (see below). Understanding cardiovascular and pulmonary physiology is essential for the safe delivery of anesthesia patient care to patients with congenital cardiac lesions.

The scope of anesthesia patient care for patients with congenital cardiac disease

Cardiac anesthesia is that care required to safely facilitate all indicated surgical and medical diagnostic and/or therapeutic procedures performed on patients with cardiac disease. Three essential requirements must be met for adequate performance of these procedures: (i) patient safety; (ii) “ideal” operating conditions; and (iii) patient comfort. The ideal anesthetic intervention accomplishes all three requirements at the same time. The reality of safe anesthetic practice mandates that patient safety be paramount followed in order of priority by operating conditions and comfort.

The surgical, therapeutic and diagnostic interventions that require cardiac anesthesia patient care can be classified in several ways. Procedure site, anatomic alterations or physiologic derangements are some of the commonly utilized classification schema. A classification system that includes all cardiothoracic interventions, surgical and medical, requiring an associated anesthetic intervention best defines the scope of cardiac anesthesiology.

Non-surgical interventions that require the care of an anesthesiologist or anesthesia care team to ensure patient safety, optimal conditions for the intervention to take place and patient comfort are more common for patients with congenital cardiac disease than those with acquired and ischemic heart disease. Non-surgical diagnostic and therapeutic interventions often require both the monitoring vigilance and pharmacological and physiological manipulations that anesthesia patient care provides. Diagnostic and/or therapeutic procedures in the radiology and cardiac catheterization suites and cardiac non-invasive and electrophysiological laboratories are examples of areas where patients with CHD are frequently evaluated and treated. Participation of the fully educated cardiac anesthesiology expert in the care of patients with congenital cardiac lesions in these non-OR sites as well as the OR is essential.

A proposed anesthesiology curriculum for care of patients with congenital heart disease

The cardiac and pediatric anesthesiology subspecialty fellow will care for a wide variety of patients with CHD. These patients will undergo surgical or non-surgical diagnostic and/or therapeutic procedures to evaluate, palliate or correct their congenital cardiac lesion or for some other primary disease process with an underlying congenital cardiac problem being a comorbidity. The suggested curriculum for learning/teaching cardiac anesthesiology is specific application to the care of patients with CHD is anchored in the curriculum for the core residency education of all anesthesiologists.

A standardized curriculum does not exist for a fellowship program for a resident who has completed the required core anesthesiology training and desires to become a specialist in cardiac anesthesia specifically focused at the care of patients with congenital cardiac disease. A review process evaluating the educational experience provided by these programs is not required. While this training may be and most often is of the highest quality, without an accepted set of standardized evaluation criteria and a review to see that the criteria are met, it is impossible to comment upon the depth, breadth and quality of the education provided in these settings.
CHAPTER 2 Teaching and learning in congenital cardiac anesthesia

There are at least two reasons why an accepted structure for such a fellowship program does not exist. The major explanation is that without an agreed upon approach emanating from an “authority” such as the Anesthesiology Residency Review Committee (RRC), there is no need for any program to meet specified requirements. Until a standard for cardiothoracic anesthesiology education is defined, institutions will conduct their programs by their own definition. This has resulted in great variability between programs. The second reason why a standard curriculum does not exist is that programs train residents in areas where they have the resources, i.e. case material and faculty with teaching expertise. If they do not have the resources they will not include an aspect of cardiothoracic anesthesiology in their training program even though this may be a very important area of training that is critical to the “full” education of a cardiothoracic anesthesiology specialist.

Many believe that the educational standard would be enhanced if an accreditation mechanism were developed for cardiac anesthesiology training programs. To this end, the Society of Cardiovascular Anesthesiologists (SCA), the largest organization in the world representing practitioners of this subspecialty, has developed a proposal for accreditation of training programs in cardiothoracic anesthesiology. There is no initiative underway to develop a certification process for cardiothoracic anesthesiologists (a process whereby a physician becomes certified as a specialist in anesthesiology when he or she voluntarily elects to complete certification requirements defined by the American Board of Anesthesiology (ABA)).

The SCA proposal for accreditation of training programs in cardiothoracic anesthesiology includes a “Pediatric Cardiac Anesthesiology Track” that is applicable to both children and adults with CHD.

“Pediatric cardiothoracic anesthesiology residency track” (pers. comm. with permission, SCA, Richmond, VA)

Required core

1 Six months OR clinical activity providing a minimum of 80 surgical procedures on pediatric patients requiring CPB and 60 patients undergoing cardiac surgical procedures not requiring the use of CPB. At least 25% of these patients should be neonates, and 50% of all patients should be infants up to 1 year of age. The resident should be actively involved in the management of patients on extracorporeal membrane oxygenation (ECMO) and with ventricular assist devices.

2 It is strongly recommended that the resident have experience in the management of pediatric patients for cardiac pacemaker and automatic implantable cardiac defibrillator placement, surgical treatment of cardiac arrhythmias, cardiac catheterization, and cardiac electrophysiologic diagnostic/therapeutic procedures.

3 Three months of experience combining evaluation of pediatric patients utilizing echocardiography and cardiac catheterization. This will also include the anesthetic management of pediatric patients in the cardiac catheterization laboratory. Cardiac evaluation should also include cardiac magnetic resonance imaging (MRI) and exercise testing to evaluate a pediatric patient’s functional capacity. Echocardiography, cardiac catheterization, and other non-invasive cardiac evaluation training may be done in conjunction with OR clinical activity or as independently designed rotations.

4 It is strongly recommended that the resident have a 1-month experience managing pediatric cardiothoracic surgical patients in a critical care setting. This experience may include the management of non-surgical cardiothoracic patients.

Elective rotations

1 Two months of elective rotations (none < 2 weeks in duration) from the following pediatric categories: inpatient or outpatient cardiology, invasive cardiology, inpatient or outpatient pulmonary medicine, medical or surgical critical care, and extracorporeal perfusion technology.”

The SCA proposal also recommends a didactic curriculum that covers topics applicable to both adult and pediatric cardiac anesthesiology education. The suggested didactic curriculum includes the following:

“The didactic curriculum, provided through lectures, conferences and workshops should supplement clinical experience as necessary for the subspecialty resident to acquire the knowledge to care for cardiothoracic patients and conditions outlined in the guidelines for the minimum clinical experience for each resident. The didactic components should include the following areas, with emphasis on how cardiothoracic diseases affect the administration of anesthesia and life support for cardiothoracic patients. The didactic program for the adult and pediatric cardiothoracic anesthesiology residency tracks will focus primarily on topics pertinent to their respective patient populations. The following represents guidelines for the minimum didactic experience and academic project (see below) for each resident. Some of the topics listed constitute components of the Core Residency in Anesthesiology. They are included in the requirements for the Cardiothoracic Anesthesiology Residency to emphasize their importance to the foundation of the discipline of cardiothoracic anesthesiology and stress the need to reinforce and enrich them in the subspecialty residency educational program:

1 Embryological development of the cardiothoracic structures.

2 Pathophysiology, pharmacology and clinical management of patients with cardiac disease including cardiomyopathy, heart failure, cardiac tamponade, ischemic heart disease, acquired and congenital valvular heart disease,
CHD, electrophysiologic disturbances, and neoplastic and infectious cardiac diseases.

3 Pathophysiology, pharmacology and clinical management of patients with respiratory disease including pleural, bronchopulmonary, neoplastic, infectious and inflammatory diseases.

4 Pathophysiology, pharmacology and clinical management of patients with thoracic vascular, tracheal, esophageal and mediastinal diseases, including infectious, neoplastic and inflammatory processes.


(a) TEE training must be based upon the advanced echocardiography training objectives of the American Society of Echocardiography and the SCA Guidelines for Training in Perioperative Echocardiography.5

6 Cardiac catheterization procedures and diagnostic interpretation; invasive cardiac catheterization procedures including angioplasty, stenting, and transcatheter laser and mechanical ablations.

7 Non-invasive pulmonary evaluation: pulmonary function tests, blood gas and acid-base analysis, oximetry, capnography, pulmonary imaging.

8 Pre-anesthetic evaluation and preparation of cardiothoracic patients.

9 Pharmacokinetics and pharmacodynamics of medications prescribed for medical management of cardiothoracic patients.

10 Peri-anesthetic monitoring: non-invasive and invasive (intra-arterial, central venous, pulmonary artery, mixed venous saturation, cardiac output).

11 Pharmacokinetics and pharmacodynamics of anesthetic medications prescribed for cardiothoracic patients.

12 Extracorporeal circulation including myocardial preservation, effects of CPB on pharmacokinetics and pharmacodynamics, cardiothoracic, respiratory, neurological, metabolic, endocrine, hematological, renal and thermoregulatory effects of CPB, and coagulation/anticoagulation before, during and after CPB.

13 Pharmacokinetics and pharmacodynamics of medications prescribed for management of hemodynamic instability: inotropes, chronotropes, vasoconstrictors, vasodilators.

14 Circulatory assist devices: intra-aortic balloon counterpulsation, left and right ventricular assist devices, and biventricular assist devices.

15 Cardiac surgical procedures: adult and pediatric, minimally invasive, myocardial revascularization, valve repair and replacement, pericardial, neoplastic procedures, and heart and/or lung transplantation.

16 Thoracic aortic surgery: ascending, transverse and descending aortic surgery with circulatory arrest, CPB employing low flow and/or retrograde perfusion.

17 Esophageal surgery: varices, neoplastic, colon interposition, foreign body, stricture.

18 Pulmonary surgery: thoracoscopic or open; lung reduction, bronchopulmonary lavage, one lung ventilation, lobectomy, pneumonectomy and bronchoscopy; fiberoptic, rigid, laser resection.

19 Post-anesthetic critical care of cardiothoracic surgical patients.

20 Ventilators.

21 Pain management of cardiothoracic surgical patients.

22 Research methodology/statistical analysis.

23 Quality assurance/improvement.

24 Ethical and legal issues.

25 Practice management.

Cardiothoracic anesthesia subspecialty conferences, including lectures, interactive conferences, hands-on workshops, morbidity and mortality conferences, cardiac catheterization and echocardiography conferences, cardiothoracic surgery case review conferences, journal reviews, and research seminars should be regularly attended. Active participation of the cardiothoracic anesthesia resident in the planning and production of these conferences is essential. However, the faculty should be the conference leaders in the majority of the sessions. Attendance by subspecialty residents at multidisciplinary conferences especially in cardiovascular medicine, pulmonary medicine, cardiothoracic surgery, vascular surgery, and pediatrics relevant to cardiothoracic anesthesia is encouraged.

The resident must complete a minimum of one academic assignment. Academic projects may include grand rounds presentations, preparation and publication of review articles, book chapters, and manuals for teaching or clinical practice, clinical research investigation or similar scholarly activities. A faculty supervisor must be in charge of each project."

The clinical cardiac and pediatric anesthesiology fellowship programs are customarily 1 year in duration. A significant portion of the 1-year fellowship (e.g. 6 months) can be devoted to education focused on anesthesia for patients with CHD and provide a broad exposure to the clinical experiences outlined above coupled with the didactic program that systematically covers the listed topical areas. The sequencing of the clinical experiences is less important than the inclusion of enough variety so that patients with CHD are cared for.

Dedicated time is ideally set aside for other experiences that amplify the clinical anesthesia experience, e.g. rotations through the cardiac catheterization and the pulmonary function testing laboratories. Time devoted to the perfusion team will greatly enhance the fellow’s mastery of the principles and practice of CPB and its related topics such as management of the intra-aortic balloon pump.

Every fellow learning cardiac and/or pediatric anesthesiology should be provided education about education.6 The fellow can serve as “junior faculty” when supervising a core
resident caring for a patient with CHD. The fellow should be expected to conduct teaching conferences, present lecture topics, and teach in other appropriate settings. Only in this way will the quality of the future teachers of anesthesiology for patients with congenital cardiac lesions be assured.

If research experience is added to the subspecialty training of a cardiac and/or pediatric anesthesiology fellow, a variable additional time period, over and above the 1-year clinical experience, will be defined based upon the research project requirements. Every subspecialty trainee should be expected to complete an academic project as defined in the proposal cited above.

**How to learn: The principles of education**

From a teaching perspective, there are three areas of learning: (i) cognitive, (ii) psychomotor, and (iii) affective. It is very useful to conceptualize teaching and learning cardiac anesthesia using this type of classification.

Cognitive learning centers on the knowledge base. The content learning that this represents is usually well defined by educators. Textbook after textbook has been written to provide the learner with what the teachers deem essential content for cognitive learning. Content learning, however, entails more than just memorizing facts. Cognitive learning has been defined by Bloom in his well-accepted taxonomy. Cognitive learning entails more than just memorizing facts. Cognitive learning has been defined by Bloom in his well-accepted taxonomy.7 Learning and teaching in the cognitive domain follows a hierarchy of six increasingly more complex levels:

1. Knowledge—recall.
2. Comprehension—understanding.
3. Application—use of abstractions.
4. Analysis—break down; seeing the relationship of parts.
5. Synthesis—put together; creating a new entity.

Knowing facts about pressures and oxygen saturations within the cardiac chambers, for example, is basic content necessary for understanding the physiology of congenital cardiac lesions. It is the higher levels of cognitive learning that are needed to develop a differential diagnosis and safe anesthetic plan. Understanding the cardiac chamber pressure and oxygen saturation data, application of it to a specific anatomic and clinical situation, and analysis of the physiological data for a particular patient allows the creation of an anesthetic prescription, for example, that does not result in a specific patient developing ventricular failure or systemic hypoxia.

The fundamentals of a knowledge base for pediatric cardiac anesthesia exist within the Content Outline of the Joint Council on In-Training Examinations of the ABA and American Society of Anesthesiologists (ASA). The full outline is divided into sections on physiological, physical and clinical sciences. Within each of these sections are specific subsections directly related to cardiac anesthesia for patients with CHD. In the section on physiological sciences, for example, determinants and regulation of cardiac output and pharmacology of cardiovascular drugs are outlined. In the section on physical sciences, topics such as cardiovascular anatomy and physics of monitoring methods are included. The section on clinical sciences covers topics such as CHD and circulatory arrest. The Appendix to this chapter is an abridged form of the ABA/ASA Outline listing the topical areas that define the content of cardiothoracic anesthesia.9

As in many educational endeavors, knowledge is well defined. Agreement on what constitutes the psychomotor domain of learning, however, is often poorly defined or non-existent. A clear, written definition of the psychomotor skills that must be mastered when learning cardiothoracic anesthesia is not available. Many psychomotor skills that are essential for learning cardiothoracic anesthesia are obvious. Intra-arterial and pulmonary artery monitoring, for example, are techniques that must be learned by the student of cardiothoracic anesthesia. When these techniques should be mastered during the education of the anesthesiologist, however, is not agreed upon.

It would be of educational benefit if all of the psychomotor skills that encompass cardiothoracic anesthesia were catalogued. Once the full scope of the skills is defined, the next appropriate step would be to decide what must be included in the core anesthesia residency training program and what should be deferred for the more advanced educational program for those electing training as subspecialists in cardiac and pediatric anesthesia.

The last category for learning is the affective domain. Affective refers to the “emotional” aspect of education. Specifically, the affective domain covers those aspects of learning that enable the student to interact with others and understand relationships. The goal is to enable the learner to understand their own personal values and those of others in order to develop interactions that will be most efficient and effective. While psychological sciences in general are well defined, this is a specific psychological area of learning that is not as well developed. A taxonomy of the affective learning domain exists in general form. The taxonomy defines the following levels of affective learning and teaching:

1. Receiving.
2. Responding.
4. Organizing.
5. Value complexing.

As students and educators, we are usually quite good at learning and teaching knowledge and skills. As pupils and professors, we are much less adept at the educational process for affective learning and teaching. Organized curricula exist for content and, in some instances, skill learning. Rarely does a curriculum exist for affective learning. Teachers most often do not set out to teach affective topics like they do knowledge and skill lessons. Affective learning most often takes place not from a curriculum, but rather, when the student observes
the teacher’s behavior. An enormous amount of passive teaching and learning takes place in the affective arena, in ways much more subtle than for content and psychomotor skills. By just being themselves, teachers role model “good, bad, and ugly” behaviors and students learn them all, quite well.

By not consciously planning the teaching of affective topics, i.e. behavior, the student of cardiothoracic anesthesiology is deprived of the opportunity to learn such essentials as how best to relate to a surgeon, cardiologist, nurse, and patient. Effective relationships between physician professionals that are not passive, passive–aggressive or aggressive, but rather open, forthright, and communicative need to be more formally taught and will intuitively benefit patient care. Think, for example, how different the affective learning situation (ACGME). The surgical case volume and mix must be available. The pediatric cardiology and pulmonary medicine departments may be equipped to meet many of the imaging and isotope needs. It is less important which service provides the imaging than that it be fully available.

A very important aspect of having the pediatric and adult cardiology services available and their equipment needs met is that this will then allow collaboration between these departments and the cardiothoracic surgeons and anesthesiologists. Joint clinical care and teaching conferences, educational programs and research projects will enhance the residency training programs for all of the services and most certainly the subspecialty fellowships in cardiac and pediatric anesthesiology.

When anesthesiology fellows complete their training in cardiac or pediatric anesthesiology many will enter clinical practice settings. In these environments they will undoubtedly interact with or even hire paraprofessionals. It is inevitable that cardiac and pediatric anesthesiologists will work side-by-side with perfusionists, cardiothoracic nurse practitioners, respiratory therapists, surgical physician’s assistants and the many other categories of paraprofessionals that care for this patient population. While it may never have been considered an important part of the educational experience for cardiac and pediatric anesthesiology trainees in the past, all residencies should give serious consideration to this issue. Patient care settings will present physician–paraprofessional interactions. Better that these relationships be understood and made part of the education of the residents and fellows than not. If “taught,” patient care will benefit and these relationships will most likely be more positive than if ignored.

**Essential/desirable educational resource needs and paraprofessional relationships**

In order to have cardiac and/or pediatric anesthesiology fellowship training that is of adequate quality, a number of specific institutional resources are essential. There must be a cardiothoracic surgical program that cares for patients with CHD. Ideally this will include a training program accredited by the Accreditation Council for Graduate Medical Education (ACGME). The surgical case volume and mix must include all of the areas listed in the curriculum section above.

In addition to the surgical program, accredited general pediatrics and pediatric subspecialty programs are essential and an adult CHD division is desirable. To fully support the diagnostic and therapeutic needs of patients with CHD, clinical laboratory facilities must exist in the institution. Cardiothoracic and pulmonary non-invasive laboratories and a cardiac catheterization suite are essential. Consultation from general pediatric and all other appropriate pediatric subspecialties as well as an adult cardiology service with expertise in the management of adult CHD patients must be readily available for cardiothoracic surgeons and anesthesiologists.

Imaging is a very important part of the diagnostic and therapeutic needs of those caring for patients with CHD. A full service radiology department with radioisotope capability.

**Who learns and who teaches: Cardiac and pediatric anesthesiology fellowship education in the USA**

**The programs and the learners**

There are 132 accredited “core” residency programs in anesthesiology in the USA educating 4296 trainees. A core residency is defined as a program that provides 3 years of clinical anesthesia training broadly defined in the “Program Requirements for Residency Education in Anesthesiology.”

The Program Requirements are published by the Anesthesiology RRC of the ACGME. The RRC is comprised of representatives from the ABA, ASA and American Medical Association (AMA). A program is accredited when it voluntarily elects to be reviewed by the RRC and is determined to be in compliance with the published Program Requirements. Cardiothoracic and pediatric anesthesiology education as a part of the core residency is conducted in all 132 ACGME accredited programs. This education undergoes quality review as part of the entire accreditation/reaccreditation process for anesthesiology residencies.
The Program Requirements for residency education during the first 2 years of the core clinical anesthesiology training program call for a balance of clinical experiences and didactic presentations that include all aspects of peri-anesthetic care in basic anesthesia and subspecialty disciplines. Cardiac and pediatric anesthesiology are included in the list of subspecialties for which “...identifiable 1-month rotations...” must be provided. An additional requirement for “...a 2-month rotation in critical care” provides the trainee with an opportunity for learning many of the principles of cardiac anesthesiology, especially as they apply to patients in the critical care unit setting.

“The program must provide 12 months of experience in advanced and complex anesthesia assignments in the CA-3 year.” The Anesthesiology RRC has recently implemented new Program Requirements that blend advanced and subspecialty clinical experiences for the CA-3 year into one 12-month experience in advanced anesthesia case management during which no subspecialty training may be more than 6 months in length. This precludes most core residents from gaining sufficient subspecialty expertise to be fully educated in cardiac and/or pediatric anesthesiology for patients with CHD.

There are currently 41 accredited pediatric anesthesiology specialty programs educating 61 trainees. Program requirements for pediatric anesthesiology fellowship education have been defined by the Anesthesiology RRC. Cardiothoracic anesthesiology is not an RRC accredited program, hence standardized program requirements do not exist. Program reporting of cardiothoracic anesthesiology programs by the AMA does not occur. Cardiothoracic anesthesiology subspecialty education as a CA-4 program is offered in 70 institutions. These programs have been identified by the SCA Education Committee through their questionnaire about training opportunities in this subspecialty. Utilizing the responses, an SCA booklet, Training Opportunities in Cardiovascular Anesthesia has been published on a periodic basis to make this information available for prospective trainees.

The ASA (Committee on Anesthesia Subspecialties, Park Ridge, IL 60068), under the guidance of JG Reves, MD, has collected information on the numbers of trainees who have elected to “specialize” during the last 12 months (CA-3 year) of the 36-month core residency and who have elected to gain subspecialty training in an additional non-required year of education after the completion of the core residency. The most recent data is from the 2000–01 academic year and represents responses to questionnaires mailed to 151 institutions. The information represents an 86.7% response rate (130 completed questionnaires).

Figure 2.1 displays the total number of CA-3 residents training in core anesthesiology programs in the USA from 1989 to 2001. Figure 2.2 displays the number of individuals who have elected to complete an additional non-required year of training (CA-4) after completing the core residency program from 1989 to 2001. Figures 2.3 and 2.4 depict the distribution of subspecialties for CA-3 and CA-4 residents in 2000–01. There has been a relatively steady increase in the number of individuals who have elected additional CA-4 subspecialty training. Many trainees believe that additional education and the resultant “credential” will make them more competitive when obtaining practice positions. Table 2.1 summarizes the percentage of core residents since the 1989–90 academic year that selected subspecialty education.
and 8% of the CA-3 and 18% and 17% of the CA-4 sub-specialty trainees in 2000–01 (Figs 2.9 & 2.10). The popularity of pain management has resulted in erosion in the total number of residents selecting training in cardiothoracic and pediatric anesthesiology. This is documented by the fact that in 2000–01, 171 CA-4 residents (CA-4 n = 383 in 2000–01) selected a 12-month subspecialty training program in pain management (Figs 2.9 & 2.10).

The teachers

The faculty who teach cardiac and pediatric anesthesiology are anesthesiologists who have vast clinical experience in the...
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It is fair to state that cardiac and pediatric anesthesiology is taught by physicians who are primarily clinicians, not teachers. These individuals, like the overwhelming majority of physician educators, have had little to no education about being an educator. As such, clinical anesthesiologists who teach anesthesiology in general and cardiac and/or pediatric anesthesiology in particular are often the least adept at the teaching tasks they have prime responsibility for effecting.

Table 2.2  Percentage of anesthesiology residents in subspecialty education for 6 or more months during an elective CA-4 (PGY 5) training period.

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Excerpted from Committee Work of the ASA Committee on Anesthesia Subspecialties. CA-3 and CA-4 Subspecialty Education Data for the 2000–2001 Academic Year, of the American Society of Anesthesiologists (ASA). A copy of the full text can be obtained from ASA, 520 N. Northwest Highway, Park Ridge, IL 60068-2573. Reproduced with permission, ASA Committee on Subspecialties.

Fig. 2.5  Number of CA-3 and CA-4 residents in anesthesiology training programs participating in a 12-month cardiac subspecialty education in the USA from 1989/90 to 2000/01. Excerpted from Committee Work of the ASA Committee on Anesthesia Subspecialties. CA-3 and CA-4 Subspecialty Education Data for the 2000–2001 Academic Year, of the American Society of Anesthesiologists (ASA). A copy of the full text can be obtained from ASA, 520 N. Northwest Highway, Park Ridge, IL 60068-2573. Reproduced with permission, ASA Committee on Subspecialties.

Fig. 2.6  Percentage of CA-3 and CA-4 residents in anesthesiology training programs participating in a 12-month cardiac subspecialty education in the USA from 1989/90 to 2000/01. Excerpted from Committee Work of the ASA Committee on Anesthesia Subspecialties. CA-3 and CA-4 Subspecialty Education Data for the 2000–2001 Academic Year, of the American Society of Anesthesiologists (ASA). A copy of the full text can be obtained from ASA, 520 N. Northwest Highway, Park Ridge, IL 60068-2573. Reproduced with permission, ASA Committee on Subspecialties.

care of these patients. Within this group are faculty members who have completed specialized training in cardiac, pediatric or both subspecialties of anesthesiology. There is no requirement for a teacher of cardiac or pediatric anesthesiology to have completed a subspecialty training program in the discipline. The RRC Program Requirements comment on subspecialty teachers in the following way: “The faculty should have varying interests, capabilities, and backgrounds, and must include individuals who have specialized expertise in a significant majority of the recognized subspecialties... Fellowship training; several years practice, primarily within a subspecialty; and membership and active participation in national organizations related to the subspecialty may signify expertise.”

It is fair to state that cardiac and pediatric anesthesiology is taught by physicians who are primarily clinicians, not teachers. These individuals, like the overwhelming majority of physician educators, have had little to no education about being an educator. As such, clinical anesthesiologists who teach anesthesiology in general and cardiac and/or pediatric anesthesiology in particular are often the least adept at the teaching tasks they have prime responsibility for effecting.
Fig. 2.7 Number of CA-3 and CA-4 residents in anesthesiology training programs participating in a 12-month pediatric subspecialty education in the USA from 1989/90 to 2000/01. Excerpted from Committee Work of the ASA Committee on Anesthesia Subspecialties. CA-3 and CA-4 Subspecialty Education Data for the 2000–2001 Academic Year, of the American Society of Anesthesiologists (ASA). A copy of the full text can be obtained from ASA, 520 N. Northwest Highway, Park Ridge, IL 60068-2573. Reproduced with permission, ASA Committee on Subspecialties.

Fig. 2.8 Percentage of CA-3 and CA-4 residents in anesthesiology training programs participating in a 12-month pediatric subspecialty education in the USA from 1989/90 to 2000/01. Excerpted from Committee Work of the ASA Committee on Anesthesia Subspecialties. CA-3 and CA-4 Subspecialty Education Data for the 2000–2001 Academic Year, of the American Society of Anesthesiologists (ASA). A copy of the full text can be obtained from ASA, 520 N. Northwest Highway, Park Ridge, IL 60068-2573. Reproduced with permission, ASA Committee on Subspecialties.

Fig. 2.9 Number of CA-3 and CA-4 residents in 12-month cardiac, pediatric and pain anesthesiology subspecialty residency programs in 1989–90 and 2000–01. Excerpted from Committee Work of the ASA Committee on Anesthesia Subspecialties. CA-3 and CA-4 Subspecialty Education Data for the 2000–2001 Academic Year, of the American Society of Anesthesiologists (ASA). A copy of the full text can be obtained from ASA, 520 N. Northwest Highway, Park Ridge, IL 60068-2573. Reproduced with permission, ASA Committee on Subspecialties.

Fig. 2.10 Percentage of CA-3 and CA-4 residents in 12-month cardiac, pediatric and pain anesthesiology subspecialty residency programs in 1989–90 and 2000–01. Excerpted from Committee Work of the ASA Committee on Anesthesia Subspecialties. CA-3 and CA-4 Subspecialty Education Data for the 2000–2001 Academic Year, of the American Society of Anesthesiologists (ASA). A copy of the full text can be obtained from ASA, 520 N. Northwest Highway, Park Ridge, IL 60068-2573. Reproduced with permission, ASA Committee on Subspecialties.
Information is available that points out what constitutes effective teaching traits and how to become a better physician educator.6,13–16 Exposure to and adoption of these principles and techniques will markedly improve the entire educational process and outcome for anesthesiology education.

**Program evaluation—educational analysis**

Analysis of the educational program is the logical and essential outgrowth of the teaching process. The teaching process consists of: (i) identifying a target (student) population, i.e. the core anesthesiology and subspecialty cardiac and pediatric anesthesiology resident trainees; (ii) agreeing upon program goals and objectives; (iii) developing a curriculum, i.e. knowledge, skills, and attitudes, based upon the goals and objectives; and (iv) facilitating the activity of teachers who implement the curriculum using various clinical and didactic instructional methods.

Evaluation of the success of this process is accomplished in a variety of ways. The faculty evaluate the students to assure that they have learned the content, skills and attitudes. The trainees and program are evaluated by the ability of the residents to pass certifying exams (when they exist) and secure professional positions in which they become credentialed to provide specific medical care. Patient outcome statistics can be analyzed to demonstrate that the educational program does not result in unacceptable morbidity and mortality and in fact may improve these parameters. An institution’s CQI (continuous quality improvement) program serves as an effective method for continuing medical education and evaluation of the success of the educational program as well as the clinical care provided to patients. The resident trainees assess the faculty’s effectiveness and accomplishments as educators and role models. The RRC evaluates the core anesthesiology and pediatric anesthesiology subspecialty residency programs based upon their ability to meet the published Program Requirements. If an accreditation mechanism is established for subspecialty education in cardiothoracic anesthesiology, a similar RRC evaluation will assess these programs. Until formal accreditation of cardiothoracic anesthesiology residencies becomes a reality, informal evaluation must take place via internal institutional reviews and by peers from involved professional organizations like the SCA.

Analysis of all of the evaluation data mentioned allows reaffirmation or modification of the program goals and objectives, curriculum, faculty, and teaching methods. In this way, the educational loop is completed, quality education is provided, and public trust assured.

**Practical advice on learning anesthesia for the care of patients with congenital heart disease—pearls to consider**

Education is a change in behavior based upon experiences. The first and foremost perspective that the resident/fellow must have is to fully engage in experiences related to this subspecialty.

**Pearl I** To gain experiences, immerse yourself in every conceivable clinical and didactic activity related to anesthesia for patients with CHD.

Enhance every experience by raising its cognitive level. Full understanding of anesthesia for patients with CHD can only come from questioning each scenario.

**Pearl II** Seek the answer to the most important question related to your learning, i.e. why?

In order to assure that the resident/fellow has had sufficient experiences from which to learn and has asked “why” to fully understand, insist that the resident becomes a teacher.

**Pearl III** Learn how to teach cardiothoracic anesthesiology to others and you will assure that you have learned it!

**Acknowledgements**

I wish to thank George E. Miller, MD, for the insight on Socrates.

Sections of this chapter have been reproduced, modified or abridged from the following:


**References**


PART 1 History, education, and science


Suggested additional readings


Appendix—Content outline [abridged—to include cardiothoracic and pediatric anesthesia topics]

Joint Council on In-training Examinations

American Board of Anesthesiology
American Society of Anesthesiologists

Revised January, 1996

I. Physiological sciences

A. Physiology

1 Respiration

Lung volumes

Lung mechanics

Ventilation–perfusion

Diffusion

Blood gas transport

Regulation of ventilation

Non-respiratory functions of lungs

2 Cardiovascular

Cardiac cycle

Ventricular function

Venous return

Blood pressure

Micro-circulation

Organ perfusion

Regulation of circulation and blood volume

3 Central and peripheral nervous system

4 Hepatic function

5 Renal function

6 Endocrine function

7 Temperature regulation

B. Pharmacology

1 General concepts

2 Anesthetics

a gases and vapors

3 Anesthetics

a intravenous

4 Anesthetics

a local

5 Muscle relaxants

6 Autonomic drugs

7 Cardiovascular drugs

8 Diuretics

9 Drug interactions

II. Physical sciences

A. Anatomy

1 Topographical anatomy as landmarks

2 Radiologic anatomy

3 Respiratory system

4 Cardiovascular system

B. Biochemistry

1 Normal body metabolism

2 Acid-base regulation

3 Water and electrolytes

C. Physics

1 Mechanics

2 Flow velocity

3 Uptake and distribution of inhalation anesthetics

4 Physics of breathing systems

5 Monitoring methods

6 Instrumentation

7 Ventilators

8 Defibrillators

9 Pacemakers

III. Anesthesia procedures, methods, and techniques

1 Evaluation of the patient and preoperative preparation
CHAPTER 2 Teaching and learning in congenital cardiac anesthesia

2 General anesthesia
3 Intravenous fluid therapy during anesthesia
4 Complications
   Trauma
   Temperature
   Bronchospasm, laryngospasm
5 Special techniques
   Controlled hypotension
   Controlled hypothermia
B. Disease states—clinical problems and their management
   1 Respiratory
      Obstructive disease
      Restrictive disease
      Management of the patient with respiratory disease
   2 Cardiovascular
      Ischemic heart disease
      Valvular heart disease
      Rhythm disorders and conduction defects
      Heart failure and cardiomyopathy
      Cardiac tamponade and constrictive pericarditis

Circulatory assist
Myocardial preservation
Pulmonary embolism
Hypertension
Peripheral circulatory failure
Vascular diseases
Cardiopulmonary resuscitation
3 Other entities
   Pediatric anesthesia
   Neonatal physiology
   Congenital heart disease
   Emergencies in the newborn
4 Special problems in
   Laparoscopic surgery
   Thoracoscopy

Based on ABA–ASA. Content Outline. Joint Council on In-Training Examinations. American Board of Anesthesiology–American Society of Anesthesiologists (ASA), 1996. A copy of the full text can be obtained from ASA, 520 N. Northwest Highway, Park Ridge, IL 60068-2573.