

Status of Pediatric Perfusion Education: 2000 Survey

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Abstract: In recent years, studies have raised questions about pediatric perfusion training, minimum proficiency requirements, and specialization. To understand these questions better, a survey was undertaken to investigate the status of pediatric/neonatal perfusion training in the United States. Three groups were surveyed: program directors (PD), recent graduates of perfusion programs (RG), and pediatric cardiac anesthesiologists (PCA). Program directors and recent graduates were queried about didactic curriculum and clinical experiences. All three groups were asked core questions regarding minimum proficiency, specialization, and need for a postgraduate style program. Didactically, 65% of program directors believed that perfusion programs provided a solid introductory knowledge base in infant perfusion. Clinically, students performed an average of 124 ± 42.5 adult and 17 ± 12.9 pediatric cases during their education. Program directors cited numerous limitations to clinical pediatric education, including access to pediatric cases and allocation of resources. The PD (69%) and RG (96%) both believed

graduates were less prepared to perform infant/pediatric cardiopulmonary bypass (CPB) at graduation as compared to adult CPB. The opinions of all three groups were divided when asked whether the essentials and guidelines requirement for minimum pediatric caseload is too low (yes response: PD 52%, RG 73%, PCA 47%). The PD and RG were against pediatric subspecialization/certification (87%, 57% respectively); whereas, the PCA were unanimously in favor (100%) of pediatric subspecialization/certification for perfusionist. All three groups felt a postgraduate-style program in infant perfusion would benefit the community (78%, 82%, 100%). Finally, 64% of RG said that, if available, they would have considered entering a training program in pediatric/neonatal perfusion after graduation. Our results indicate that there are still limitations to pediatric perfusion education. A postgraduate-style program in infant perfusion is one possible solution to this problem. **Keywords:** perfusion education, pediatric, cardiopulmonary bypass, training, specialization, survey. *JECT. 2001;33:233–238*

For more than a decade, the perfusion community has debated issues surrounding pediatric training, proficiency requirements, subspecialization, and separate acknowledgment of pediatric perfusion competence (1–5). At the heart of the debate is the challenging environment in which clinical pediatric cardiopulmonary bypass (CPB) is practiced, which is arguably quite different from adult CPB (6). With this, we must also consider the volume and distribution of pediatric open-heart surgery in the United States. For example, less than 3% (19,000) of the approximately 700,000 open-heart procedures performed each year can be categorized as pediatric/neonatal CPB (7, 8). If these procedures were allocated to perfusionists at the same average rate as adult CPB (140 cases/year) it could be extrapolated that only 135 perfusionists nationwide would be necessary to perform 100% of all pediatric/neonatal CPB in the United States (9). It is estimated, however, that there are 900 clinical perfusionists in the

USA who are performing pediatric/neonatal CPB (10). In a recent pediatric perfusion survey of 68 centers performing pediatric/neonatal perfusion, Olshove et al. reported that perfusionists in mixed centers (centers performing both adult and pediatric cases, but predominately adult CPB) performed an average of only 49 pediatric/neonatal CPB cases per year (5). Compounding the limited opportunity for clinical practice of pediatric/neonatal CPB are the diversity of the patient population, technical complexity, and rapidly evolving perfusion techniques (11).

In light of this, we have evaluated the role of accredited perfusion programs in the United States in the preparation of entry level clinical perfusionists with skills and knowledge in pediatric/neonatal CPB in an attempt to determine if a postgraduate-style program in neonatal perfusion is warranted.

METHODS

In the fall of 2000, a survey questionnaire designed to assess current pediatric perfusion education was administered to three different groups: Program directors (PD), recent graduates of perfusion programs (RG), and pediatric cardiac anesthesiologists (PCA).

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Program Directors

Program directors of accredited perfusion programs were contacted directly via telephone. Participating directors were then interviewed with regard to the objective facts surrounding the didactic coursework and clinical activity of their students. In addition, each director was asked to provide feedback regarding their subjective views and perceptions on global issues relating to pediatric perfusion training.

Recent Graduates

Individuals who have graduated from accredited North American perfusion programs during the years of 1998–2000 were surveyed. The data were collected by telephone or mail. The recent graduate survey also consisted of an objective and a subjective section. In the objective portion, information on clinical activity during their perfusion training was obtained. In the subjective portion, the recent graduates were asked to rate their didactic education on a scale of 1–5, with 1 = not comprehensive, 5 = very comprehensive.

Pediatric Cardiac Anesthesiology

Fifty pediatric cardiac anesthesiologists from different pediatric open-heart programs were mailed a packet consisting of the following: an instructional cover letter, the section of the Essentials and Guidelines that refers to the minimal clinical exposure, a survey consisting of the core questions listed below, and a return envelope.

Core Questions Asked to all Groups

The following core questions (questions common to all groups) were asked:

- Are the Essentials and Guidelines requirements for pediatric clinical activity too low?
- Should there be subspecialization and/or certification in pediatric perfusion?
- Would a postgraduate program in infant perfusion be a benefit to the community?

Statistical Analysis

Data are expressed as mean \pm standard deviation.

RESULTS

Group Response Rates

Program Directors: Directors from 21 (95%) of the 22 currently active perfusion programs were surveyed, as well as two directors of recently inactive programs ($n = 23$).

Recent Graduates: The number of recent graduate perfusionists surveyed was 61. This represents approximately

18% of all the graduates in the last 3 years (based on an estimate of 145 graduates/year). Included in the sample were responses from graduates of 20 of the 22 accredited programs. The number of recent graduates per program was 3.1 ± 2.0 individuals, with a range of 1 to 10.

Pediatric Cardiac Anesthesiologists: Of the 50 questionnaires sent, 16 responses were returned for a response rate of 32%.

Didactic Content in Accredited Perfusion Education Programs

Program Directors' Responses: Programs offered didactic pediatric perfusion education via a dedicated stand-alone course (35%) or, more commonly, by bundling pediatric instruction into other courses (65%) where appropriate (Figure 1). In addition, two (9%) of the program directors reported having a separate course in extracorporeal membrane oxygenation (ECMO). Fourteen program directors (61%) have made significant changes to their didactic pediatric curriculum within the past 5 years (Figure 2). The most common changes include updating scientific articles, the addition of ultrafiltration techniques, and the recruitment of expert lecturers. The majority of program directors (65%) agreed that perfusion programs collectively provide a solid introductory knowledge base in infant perfusion (Figure 3).

Recent Graduates Responses: Recent graduates were asked to give their opinions regarding the didactic portion of their pediatric perfusion education on a scale of 1–5. They were asked to give an over-all rating and then further rate specific aspects of their pediatric perfusion education (Table 1). Of the 20 programs responding, 15 received an average rating above 3.0.

Clinical Training in Accredited Perfusion Education Programs

While program directors were asked to estimate the average pediatric/neonatal caseload for all their graduates,

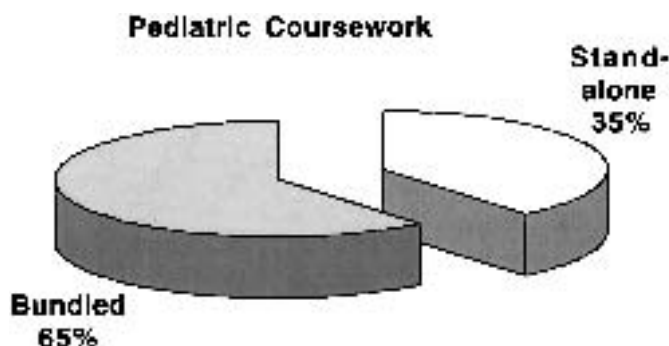


Figure 1. Didactic pediatric perfusion education strategies at accredited programs: "Stand alone" pediatric course versus pediatric material "bundled" into other courses.

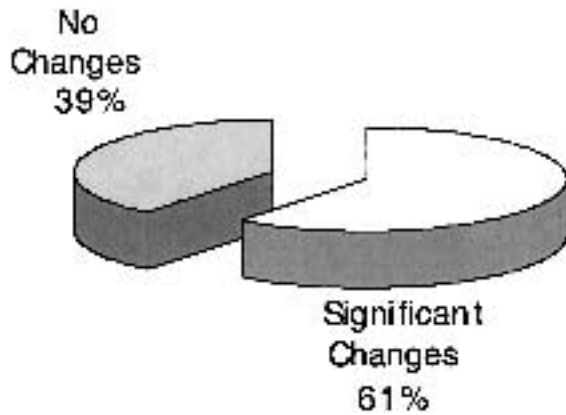


Figure 2. Program directors responses on whether there have been significant changes in their programs didactic pediatric curriculum over the previous 5 years.

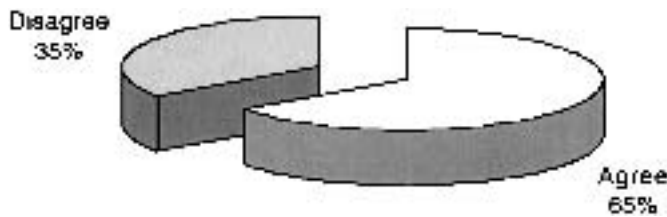


Figure 3. Program directors responses to the statement, "Overall, perfusion education programs provide a solid, introductory knowledge base in infant perfusion."

Table 1. Recent graduate rating of didactic pediatric education.

Didactic Instruction	Rank (avg.)
Overall	3.7 ± 0.91
Embryology/anatomy	3.5 ± 1.1
Blood gas strategies (pH-stat, alpha stat)	3.9 ± 1.0
Circulatory arrest, low-flow	3.7 ± 1.1
Pediatric ultrafiltration (MUF, Z-BUF)	3.6 ± 1.2
Pediatric equipment/circuitry	3.5 ± 1.1

Range for each category was 1-5.

the recent graduates were asked about their individual experience with pediatric/neonatal CPB while in school (Table 2). Recent graduates reported performing 17.0 ± 12.9 pediatric cases, of which 10 ± 9.4 were on patients less than 10 kg, as a perfusion student. Recent graduates (69%) and program directors (96%) both believed that perfusion graduates were less prepared to perform pediatric/infant CPB as they were to perform adult CPB at graduation. The vast majority of program directors (96%) agreed that most clinical skill acquisition of pediatric/neonatal perfusion was accomplished after graduation on the job. Program directors were asked what they believed to be the limitations in the delivery of pediatric perfusion education. Responses were organized into four main cat-

Table 2. Clinical cases as reported by program directors and recent graduates.

	Program Directors	Recent Graduates
Adult cases performed (range)	133 ± 37.2 (75-230)	124 ± 42.5 (54-219)
Pediatric cases performed (range)	22 ± 13.5 (0-58)	17 ± 12.9 (0-50)
Pediatric (<10 kg.) performed (range)	8 ± 7.4 (0-26)	10 ± 9.4 (0-35)

Values expressed as mean ± SD.

egories shown in Table 3. The access to pediatric cases was reported as a limitation by 70% of the centers. The protective environment that surrounds pediatric open-heart surgery and the low comfort level for students participating was reported by 43% of the program directors. Resource allocation was a third category of perceived limitation reported by 30% of the program directors.

Recent graduates reported that, if available, 64% would have considered some form of postgraduate training in infant perfusion education.

Core Questions

Responses to the core questions were compared in the three survey groups and are listed in Table 4. Differences between group responses could be seen in each core question. The majority (73%) of the recent graduates felt that the essentials and guidelines requirements of 10 pediatric cases observed or performed was too low; whereas, 52% and 47% of the program directors and pediatric cardiac anesthesiologists believed this to be true. The question of subspecialization and/or certification was supported by PD 13%, RG 43%, and PCA 100%. The majority of respondents from all groups (PD 78%, RG 82%, PCA 100%) agreed that a postgraduate-style program in infant perfusion would be a benefit to the community.

DISCUSSION

Didactic Education

Pediatric perfusion knowledge was provided in one of two ways, either through a stand-alone pediatric course or by bundling pediatric topics into other courses. It was beyond the scope of this work to determine if either strategy offers any particular advantage over the other. Significantly, nearly 40% of the program directors said that their pediatric curriculum has not been updated in the last 5 years. In light of the many recent developments in circuitry and perfusion techniques this may be of concern. In defense of the perfusion programs, there is the difficult question of how much time and resources should be expended in pediatric perfusion education. The allocation of these resources to pediatric training must be balanced with the reality that (because pediatric open-heart procedures

Table 3. Program directors categorized responses to: "What do you see as the current limitations of pediatric perfusion education?"

Limitation #1	ACCESS TO CASES	#of PD responding 16/23 (70%)
Actual responses:		
<ul style="list-style-type: none"> · "There are limited clinical rotation sites." · "Unable to provide adequate amount of cases and experience" · "It is hard to get the students behind the pumps because of limited cases." · "Access to the pediatric cases" · "Clinical experience is hard to get; there are a finite number of cases." · "Low case availability limits student opportunity." · "Over-all exposure is low because of disproportionate overall case load." · "Limited by case availability." · "Case numbers do not provide a reasonable experience." · "Ability to get students into pediatric settings is a limitation." · "Limited by the few clinical sites." · "Clinical pediatric sites willing to train students are few." · "Limited number of pediatric cases a student may participate in." · "Clinical affiliates and case numbers." · "Lack of good pediatric clinical affiliates." · "The best you can do is expose students because of the low volume." 		
Limitation #2	PROTECTIVE ENVIRONMENT	10/23 (43%)
Actual Responses:		
<ul style="list-style-type: none"> · "Very protective environment, unwilling to allow students to do more than observe" · "Pediatrics is getting so specialized that surgeons aren't comfortable with even staff perfusionists." · "Pediatric perfusionists are very protective of cases." · "Clinicians are very protective of cases." · "Observation guidelines loophole means nobody lets students do kids." · "Pediatric perfusionists are not comfortable with students doing cases." · "Pediatric open-heart team is very picky about who participates." · "Instructors are very protective, which limits hands-on experience." · "Surgeons do not want student doing neonatal CPB." · "Unwillingness of pediatric surgeons to allow students to participate." 		
Limitation #3	RESOURCE ALLOCATION	7/23 (30%)
Actual Responses:		
<ul style="list-style-type: none"> · "Cannot invest the time concentrating on an area that most students will never do after graduation." · "Logistically hard to justify to much emphasis when 95% of graduates will be doing adult CPB." · "Resources have to be balanced. Adults CPB must be predominant." · "Time factor; pediatrics is a small sector of market." · "Job market for pediatric is limited." · "Pediatric CPB is a small slice of the total market. Adults must be emphasized." 		
Limitation #4	OTHER	5/23 (22%)
Actual responses:		
<ul style="list-style-type: none"> · "Variability of cases makes training difficult." · "Pediatric cases are the most surgeon specific." · "Invasive cardiology has taken away the chip shots that made good student cases." · "Polarization in the perfusion community." · "Lack of qualified clinical instructors." 		

represent a very small portion of the national caseload) most new graduates will not be practicing pediatric perfusion. Therefore, an overemphasis on pediatric perfusion, both didactically and clinically, could in a larger sense be counterproductive to producing competent and skilled adult perfusionists.

Two-thirds of the program directors believed that perfusion education programs provide a solid introductory knowledge base in infant perfusion. This was substantiated by the responses gathered from the recent graduates

who gave favorable responses concerning their didactic pediatric perfusion education (Table 1). It must be noted however, that only 6 of the 61 (10%) recent graduates who participated were actually performing pediatric/neonatal CPB. Greater input on this question from a greater number of recent graduates who are performing pediatric/neonatal CPB may have had more value. We were unable to correlate our data with such objective benchmarks as the certification exam. Unfortunately, the American Board of Cardiovascular Perfusion does not track a pedi-

Table 4. Comparison of responses to core questions.

Core Questions	Program Directors	Recent Graduate	Ped Card Anesth
Are the essentials and guidelines requirements for pediatric clinical activity too low?	Yes-52%	Yes-73%	Yes-47%
Should there be subspecialization and/or certification in pediatric perfusion?	Yes-13%	Yes-43%	Yes-100%
Would a postgraduate program in infant perfusion be a benefit to the community?	Yes-78%	Yes-82%	Yes-100%

atric perfusion category in the certification exams per se, so it is difficult to determine how many questions relate to pediatric/neonatal perfusion and how well these questions are answered.

Clinical Education

Clinical exposure to pediatric procedures is vital in becoming proficient in pediatric/neonatal CPB. Experience has been cited as a highly important component of perfusion safety, especially with regard to pediatric perfusion (12). The lower volume and higher complexity of pediatric/neonatal CPB may amplify the potential for bypass-related incidents. A recent study, in fact, reports that CPB incidents occur at a higher rate in pediatric open-heart centers when compared to adult-only centers (13). For the perfusion student, The Essentials and Guidelines for an Accredited Educational Program for the Perfusionist requires that "a minimum of 10 clinical pediatric cases requiring cardiopulmonary bypass must be observed or performed prior to graduation" (Section I, E, 10). This standard was reported by one program director, "... to be so low, that it is too high," implying that the value of observing 10 pediatric cases is so limited that the time could be spent in more constructive ways. Overall, program directors were split in regard to the minimum standards, with 52% believing that it was too low. Nearly, three-quarters of the recent graduates believed that the standards were too low. Recent graduates were asked to provide the number of pediatric cases they performed as students. The term "pediatric" perfusion is broad (1 day-18 years), so we asked students to categorize a subgroup of patients less than 10 kg. It is in this smaller patient population that the more specialized equipment, circuitry, and perfusion techniques are utilized. Currently, the average graduating perfusion student exceeds this minimal standard and will have performed approximately 20 pediatric cases (nine of which are on patients under 10 kg). However, the pediatric clinical experience reported by the recent graduates ranged widely (0-58 cases), with 42% performing 10 or less cases and 21% having only observational exposure.

Nearly all program directors (96%) conceded that the clinical skills necessary for pediatric/neonatal CPB would be learned on the job.

Problems and Solutions

The difficulties and problems perfusion programs face are highlighted in the program directors' responses to what they saw as limitations in the delivery of pediatric perfusion training (Table 4). Not only must perfusion schools balance the use of time and resources during the brief ~2 years of training, but they also must handle the logistical problems of getting perfusion students behind the pump in pediatric procedures. Access to pediatric cases in combination with the low comfort level and/or exclusion of students by perfusionists and surgeons were cited as a major limitation by program directors. The guarded environment of pediatric/neonatal perfusion is understandable in light of other survey data, which indicate that many practicing pediatric perfusionists have themselves difficulty attaining the clinical activity felt to be required for maintenance of proficiency (3, 5). However, if the perfusion community desires a higher level of pediatric experience in the newly graduated perfusion students, then these impediments to case access must be addressed.

A recent report by the AmSECT Pediatric Committee showed that nearly three-quarters of the 105 practicing pediatric perfusionists believe that additional training is necessary before performing pediatric CPB (10). The same report raised questions as to the role of perfusion schools in addressing this concern. Suggestions to remedy the problems have come in many forms. In this study, several program directors stated that they attempt to provide a "pediatric tract" for individual students who express strong interest and aptitude in pediatric perfusion. Previously, Lawson et al. suggested the option of ACPE endorsed pediatric perfusion internship (8). Others have suggested that Masters degree programs could provide the specialized training required in pediatric perfusion (9).

The critical role of specialized anesthesia for pediatric cardiac surgery has been recognized (14). By examining the path that pediatric cardiac anesthesiology has taken, we can explore the idea of additional training in pediatric/neonatal perfusion. Pediatric cardiac anesthesiology is similar to perfusion, because there is no formal credentialing for its practice beyond the board exam for anesthesiology. However, it has become generally accepted that individuals working in pediatric cardiac anesthesiology have attended some additional training in the form of a fellowship. The pediatric cardiac anesthesiologists as well as all other groups surveyed, indicated overwhelming support for the development of a postgraduate-style infant perfusion training program. Although separate certification for pediatric perfusion is neither popular nor practi-

cal, the model used by pediatric cardiac anesthesiology may represent a mechanism to balance the limitations currently faced by perfusion education programs. In the future, it would be beneficial to survey the pediatric cardiac surgeons on these issues as well.

Since 1963, when the first formal perfusion program was organized, perfusion education programs have undergone numerous developmental changes in response to the natural growth and professionalization of perfusion (15). This report shows that perfusion schools are challenged to provide adequate pediatric and infant perfusion training especially in the area of clinical case exposure and hands on experiences. These challenges are magnified with the trend in the perfusion community toward subspecialization in pediatric perfusion. According to James P. Dearing, a pioneer in perfusion education, "There is a need for diversity in academic options for extracorporeal circulation technologists in order for the profession to evolve in a viable manner" (16). Perhaps, the establishment of specialty training opportunities in pediatric/neonatal perfusion is part of that evolution.

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