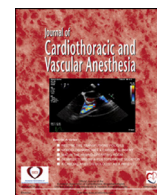


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Special Article

European Pediatric Cardiac Anesthesia Fellowship Program: A First Proof of Concept

Gabor Erdoes, MD, PhD^{*,1}, Ehrenfried Schindler, MD[†],
 Andreas Koster, MD[‡], Vera von Dossow, MD[‡],
 Ioana Maria Belciu, MD[‡], Sascha Meier, MD[§],
 Mohammed R. El-Tahan, MD^{||,¶}, Viviane G. Nasr, MD, MPH^{**}

^{*}Department of Anesthesiology and Pain Medicine, Inselspital, Bern University Hospital, University of Bern, Bern, Switzerland

[†]Department of Anesthesiology and Intensive Care Medicine, University Hospital Bonn, Bonn, Germany

[‡]Institute of Anesthesiology and Pain Therapy, Heart, and Diabetes Center, North Rhine Westphalia, Ruhr University Bochum, Bad Oeynhausen, Germany

[§]Department of Anesthesiology, University Medical Center Groningen, Groningen, The Netherlands

^{||}Cardiothoracic Anesthesia, Anesthesia, Surgical Intensive Care and Pain Medicine, College of Medicine, Mansoura University, Mansoura, Egypt

[¶]King Fahd Hospital of Imam Abdulrahman Bin Faisal University, Dammam, Saudi Arabia

^{**}Department of Anesthesiology, Critical Care and Pain Medicine, Boston Children's Hospital, Harvard Medical School, Boston, MA

The Pediatric Cardiac Anesthesia (PCA) fellowship is a demanding training program in Europe and the United States. Successful completion of the program requires years of training in anesthesiology, a thorough understanding of cardiovascular anatomy and physiology, and extensive experience in the perioperative management of neonates and children with heart disease. In the context of the first candidate to successfully complete the PCA program in Europe, this article presents excerpts from the design and structure of the European PCA program. The PCA program is evaluated critically by both external and internal reviewers, and points are highlighted that could be included in the next version of the program.

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PEDIATRIC CARDIAC ANESTHESIA (PCA) is an advanced training program that typically follows adult cardiac anesthesia training, pediatric anesthesia training, or both, depending on the certifying body and institution. Successful care of pediatric patients with congenital heart disease (CHD) requires expertise in the perioperative management of all types of heart disease. This includes a thorough understanding of cardiovascular anatomy and physiology. It also requires a mastery of patient care along the continuum, from preoperative planning through the surgical procedure and into the

postoperative recovery period. Given the broad spectrum of congenital cardiovascular anomalies and the unique considerations for each condition, the pediatric cardiac anesthesiologist must be able to develop and implement sophisticated and individualized perioperative risk scoring and anesthetic plans.¹ The latter includes the selection of appropriate medications and anesthetic agents, cardiovascular monitoring, hemodynamic management strategies, ventilator parameter settings, transfusion management, and blood conservation techniques.

In Europe and the United States, medical societies have sought to recognize the specialty of PCA. The European Association of Cardiothoracic Anesthesiology and Intensive Care (EACTAIC) and the Congenital Cardiac Anesthesia Society, in collaboration with the Accreditation Council of Graduate Medical Education, independently have developed program

¹Address reprint requests to Gabor Erdoes, MD, PhD, Director of Adult and Pediatric Cardiovascular Anesthesia, Department of Anaesthesiology and Pain Medicine, Inselspital, Bern University Hospital, University of Bern, Freiburgstrasse, INO D-207, 3010 Bern, Switzerland.

E-mail address: gabor.erdos@insel.ch (G. Erdoes).

requirements and milestones for 1 year of training.^{2–6} Despite the challenges of defining a 1-year, high-quality, standardized curriculum, the Pediatric and Congenital Subspecialty Subcommittee of EACTAIC developed a PCA curriculum in June 2021.² Since then, 4 hospitals have been accredited as hosting centers for PCA fellowship training including the University Hospital Bonn, Bonn, Germany; the Dante Pazzanese Institute of Cardiology, São Paulo, Brazil; the Heart and Diabetes Center North Rhine-Westphalia, Ruhr University Bochum, Bad Oeynhausen, Germany; and the Onassis Cardiac Surgery Center, Athens, Greece. On September 6, 2023, the first EACTAIC Fellow successfully completed the PCA program.

This article is intended to present the first practical experiences with this sophisticated program and to evaluate the program through internal and external reviews to stimulate further development.

The PCA Curriculum and Hosting Center Conditions

The EACTAIC PCA curriculum includes an age- and surgical group-specific caseload of at least 100 surgical procedures and 50 anesthetic procedures in the catheterization laboratory, as well as a 1-month rotation in the pediatric intensive care unit.² In addition to case requirements, the Fellow's progress, including number of cases performed and Union Européenne Des Médecins Spécialistes competency levels of acquired medical knowledge, didactic educational program, and technical and nontechnical skills, is evaluated quarterly by the program director. Selected topics and skills are listed in [Table 1](#). Fellows also are evaluated through 360° evaluations by the program director, surgeons, cardiologists, and intensivists. Attendance at the preoperative interdisciplinary clinical conferences and the mortality and morbidity conferences is mandatory. The Fellow also is encouraged to contribute to the interdisciplinary seminars.

The Center for Congenital Heart Disease is located in the Heart and Diabetes Center North-Rhine Westphalia, Ruhr University Bochum, Bad Oeynhausen, Germany. The center is a large, high-volume, specialized European University Heart Center. The surgical program for CHD, with approximately 400 cases/year, covers the entire spectrum of CHD from premature infants to adults, including ventricular assist device implantation and heart transplantation. In addition,

approximately 500 diagnostic and interventional cardiac catheterizations are performed annually, as well as CHD electrophysiology procedures and magnetic resonance imaging. In Germany, the administration of sedation and analgesia in the catheterization laboratory may be unique compared to centers in the United States. Approximately 50% of centers have cardiologists, and 50% have anesthesiologist teams providing anesthesia services. At the Heart and Diabetes Center, Ruhr University Bochum, anesthesiologists are responsible for the perioperative anesthesia service 3 days a week, whereas cardiologists provide sedation 2 days a week.

The first graduated EACTAIC PCA Fellow (I.B.) had basic clinical expertise in general pediatric anesthesia and advanced experience in adult cardiothoracic and vascular anesthesia. Both the EACTAIC basic and advanced adult cardiothoracic and vascular anesthesia fellowships had been completed before pursuing the PCA training.

Logbook Evaluation

In our view, the case load and distribution of cases documented in the logbook is a central quality of the curriculum. The present logbook reflects almost the entire spectrum of cardiac surgical procedures recommended in the EACTAIC PCA curriculum ([Table 2](#)). Ensuring exposure to and participation in all recommended cases is a challenging task during the 1-year training, especially when considering a 4-week intensive care unit rotation and 6 weeks of annual leave. In addition, the Fellow completed a scholarly activity with presentations on the anesthetic management of patients undergoing classic Norwood palliation, the Glenn procedure, and the Fontan procedure, based on the current literature.⁷ Seven Norwood stage 1 palliations were performed, all using the classic approach with a modified Blalock-Taussig shunt and deep hypothermic cardiac arrest with regional cerebral perfusion. Pulmonary artery banding was not performed, and the number of Blalock-Taussig shunts, coarctation repairs, and Glenn procedures performed was lower than suggested by the EACTAIC PCA curriculum. Of note, the birth rate, especially in Germany, decreased by 5% to 10% during this period, which may have influenced the number of neonatal cases.⁸ It is also important to note that center-specific programs for both surgical and interventional-based procedures influence the caseload of certain procedures. Interventional stenting of the patent ductus arteriosus partially has replaced Blalock-Taussig shunt surgery. However, less common complex procedures such as left ventricular assist device implantation, heart transplantation, and repair of the anomalous left coronary artery from the pulmonary artery (Bland-White-Garland syndrome) in infants younger than 1 year of age have been performed. It is worth noting that ABO-incompatible heart transplantation, a procedure described by Great Ormond Street Hospital (London, United Kingdom) with a closed cycle of intraoperative plasmapheresis followed by immunoadsorption and reinfusion of the separated plasma into the cardiopulmonary bypass circuit, is a highly challenging procedure. This procedure requires continuous monitoring of anti-A/B isohemagglutinin depletion to at

Table 1
List of Selected Theoretical and Clinical Skills Assessed Quarterly

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- Preoperative risk stratification
 - Transesophageal echocardiography
 - Interpretation of results of multichannel viscoelastic hemostatic assays
 - Techniques of cardiopulmonary bypass and extracorporeal life support, including advanced monitoring with regional multichannel near-infrared spectroscopy
 - Pharmacokinetics of vasoactive and inotropic drugs and the balance of systemic and pulmonary blood flow in response to pharmacologic and ventilatory interventions
 - Practical skills such as placement of catheters, difficult airway management, and lung isolation techniques
-

Table 2
Logbook of the First Fellow

	Age	N or %	Selected Complex Procedures
Cardiac surgery	<1 y	77 patients	24 neonates <ul style="list-style-type: none"> • 7 Norwood stage 1 palliations • 4 arterial switch operations
			7 Glenn procedures
			1 Left ventricular assist device implantation
			1 Heart transplantation
			1 Fallot correction + unifocalization
1-4 y	18 patients	1 Fontan procedure	
		1 ABO-incompatible heart transplantation	
		1 Correction of an anomalous left coronary artery from the pulmonary artery (Bland-White-Garland syndrome)	
4-16 y	50 patients	5 Fontan procedure	
		1 Double switch operation	
		3 Konno procedure	
Adults	16 patients	1 Glenn procedure	
		1 Hypoplastic aortic arch and coarctation revision	
		1 Tricuspid reconstruction and pulmonary conduit replacement (tetralogy of Fallot)	
		1 Fontan procedure	
		1 AV canal repair	
Interventional catheterizations	<1 y	10 patients	1 Scimitar syndrome correction
			2 Patent ductus arteriosus stenting
			2 Right ventricular outflow stenting
	>1 y	52 patients	1 Major aortopulmonary collateral artery stenting
			8 Percutaneous valve implantations
Ultra-fast-track anesthesia		35%	1 Ventricular septum device closure
			4 Coarctation stenting
Deep sedation (catheterization laboratory)		92%	Including all Glenn and Fontan procedures

Abbreviations: AV, atrioventricular; PDA, patent ductus arteriosus; RVOT, right ventricular outflow tract.

least near- complete removal (titer 1:2) before opening the transverse aortic connection.^{9,10} Thus, apart from the recommended cases required in the EACTAIC curriculum, the Fellow had the opportunity to perform more complex procedures.

An ultrafast-track concept was established to facilitate and train the Fellow in early extubation of patients undergoing Glenn and Fontan procedures. All Glenn and Fontan procedures were performed using an ultrafast-track approach, with extubation in the operating room or postoperative anesthesia care unit within 1 hour. Although such an approach may be controversial in other complex procedures, the benefit of early spontaneous breathing in these patients with passive lung perfusion is clearly established and can be considered state-of-the-art.^{11,12} This is relevant as Enhanced Recovery After Surgery programs continue to expand in cardiac surgery. Other procedures included in the ultrafast-track approach are lower-risk procedures such as atrial septal defect closure, pulmonary artery conduit replacement, subaortic stenosis, and aortic valve surgery. The fact that the vast majority of interventional procedures in the catheterization laboratory are performed under deep analgesation may reflect the unique structure at the Ruhr University Bochum. Because both disciplines (cardiology and anesthesia) perform sedation for periprocedural care, the teams, in an attempt to standardize strategies and improve data quality, have decided to preserve the natural hemodynamics under spontaneous ventilation whenever

possible, with analgesation as the preferred first-line strategy.¹³

The EACTAIC PCA fellowship curriculum does not include surgery for adult CHD as a prerequisite. This may be due to the fact that centers, especially those that have evolved from pediatric surgical centers, may not serve this patient population. The second edition of the EACTAIC PCA curriculum should consider that at least 10% of the patients in the catheterization laboratory and surgical parts of the protocol will be adults with complex CHD. Using current risk models, such as the Adult Congenital Heart Surgery score and the recently introduced Perioperative Adult Congenital Heart Disease score, 30% of these patients in the logbook were at high perioperative risk.^{1,14-16} This patient population is growing, and appropriate care of these patients is critical in cardiac surgery, as well as in the catheterization laboratory and when undergoing noncardiac procedures.¹⁷ There is convincing evidence that patients with CHD, both children and adults, are at increased risk if they are not treated in a center with a well-developed CHD infrastructure to manage all possible complications. Therefore, it is important to monitor the number of adult patients with CHD during fellowship training.

In summary, this first completed year of EACTAIC PCA training can be considered a successful achievement and a demonstration of the feasibility of the EACTAIC PCA program. Both age grouping and complexity of procedures were

well-balanced. Grouping procedures with a focus on age and complexity may be reconsidered in future versions of the EACTAIC PCA curriculum. This need can be evaluated as additional data become available when more graduates complete the program at different institutions. The inclusion of a systematic perioperative approach in the EACTAIC PCA fellowship curriculum and/or the establishment of an advanced CHD program that includes both pediatric and adult CHD patients need to be evaluated for future PCA versions.

Declaration of competing interest

None.

CRedit authorship contribution statement

Gabor Erdoes: Writing – review & editing, Writing – original draft, Conceptualization. **Ehrenfried Schindler:** Writing – review & editing, Conceptualization. **Andreas Koster:** Writing – review & editing, Writing – original draft, Conceptualization. **Vera von Dossow:** Writing – review & editing, Conceptualization. **Ioana Maria Belciu:** Writing – review & editing. **Sascha Meier:** Writing – review & editing, Conceptualization. **Mohammed R. El-Tahan:** Writing – review & editing, Conceptualization. **Viviane G. Nasr:** Writing – review & editing, Writing – original draft, Conceptualization.

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