*Cardiology in the Young*

**cambridge.org/cty**

## Guidelines

**Cite this article:** Krasemann T, Butera G, Thomson J, Chessa M, and Bokenkamp R (2023) AEPC recommendations for training in interventional catheterisation for CHD. *Cardiology in the Young* **33**: 854–861. doi: 10.1017/S1047951123000823

Received: 14 December 2022
Revised: 22 February 2023
Accepted: 26 March 2023
First published online: 22 May 2023

**Keywords:**
Training guidelines; interventional catheterisation; CHD; AEPC

**Corresponding author:** Dr T. Krasemann, Head of service, Department of Paediatric Cardiology, Sophia Children's Hospital, Erasmus Medical Center, Rotterdam, Wytemaweg 803015 CN, Rotterdam, Netherlands.
Email: t.krasemann@erasmusmc.nl

© The Author(s), 2023. Published by Cambridge University Press. This is an Open Access article, distributed under the terms of the Creative Commons Attribution licence (http://creativecommons.org/licenses/by/4.0/), which permits unrestricted re-use, distribution and reproduction, provided the original article is properly cited.

# AEPC recommendations for training in interventional catheterisation for CHD

Thomas Krasemann[1], Gianfranco Butera[2,3], John Thomson[4], Massimo Chessa[3,5,6] and Regina Bokenkamp[7]

[1]Department of Paediatric Cardiology, Sophia Children's Hospital, Erasmus MC, Rotterdam, The Netherlands; [2]Department of Paediatric Cardiology, Cardiac Surgery and Heart Lung Transplantation - Bambino Gesù Hospital and Research Institute, IRCCS, Rome, Italy; [3]European Reference Network for Rare and Low Prevalence Complex Diseases of the Heart: ERN GUARD-Heart, Amsterdam, The Netherlands; [4]Department of Paediatric Cardiology, Leeds Congenital Heart Unit, Leeds, UK; [5]ACHD UNIT, Pediatric and Adult Congenital Heart Centre, IRCCS – Policlinico San Donato, San Donato M.se, Milan, Italy; [6]Vita Salute San Raffaele University, Milan, Italy and [7]Department of Paediatric Cardiology, Leiden University Medical Center, Leiden, The Netherlands

**Abstract**

To reflect new developments in imaging, indications, and techniques in catheterisation of patients with CHD, the training recommendations of the Association for European Paediatric and Congenital Cardiology (AEPC) for the training in interventional catheterisation for CHD have been reviewed and updated after more than 7 years. They include detailed information about knowledge, skills, and approach to clinical practice expected from trainees at basic, intermediate, and advanced level.

In 2015, the Interventional Working Group of the Association for European Paediatric and Congenital Cardiology (AEPC) published guidelines regarding the training of paediatric cardiologist wishing to further specialise in invasive catheterisation in CHD.[1] As the population of adults with CHD grows and their treatment frequently requires catheter intervention,[2,3] the guidelines have been extended to include those cardiologists treating this group of patients.

The majority of cardiac catheterisation procedures in CHD are performed with the intention of intervening on specific lesions or problems. Invasive diagnostic procedures are performed less frequently, mainly because current non-invasive options such as echocardiography, MRI, and CT provide very accurate anatomic and functional information. Paediatric and adult cardiologists specialising in invasive catheterisation need to be able to interpret other imaging modalities and have a good working knowledge of the limitations of other imaging modalities in order to adequately plan and carry out procedures.[4] Diagnostic catheterisation remains an important tool particularly for direct pressure measurements but also because of the high spatial resolution that angiography offers.

New developments also include catheterisations carried out not only in the classical catheter laboratory or at the bedside but also radiation-free interventions guided by echocardiography or MRI[7–9] Basic knowledge about the possibility to perform catheterisation studies without the use of radiation is expected from an advanced trainee.

The collaboration of cardiac surgeons and catheter interventionalists in the catheter laboratory or cardiac theatre in the form of hybrid procedures is a reality, and awareness of the application (and limitations) of the hybrid approach is important for intermediate and advanced trainees.[10,11]

As in previous versions,[1] all of the recommendations in this document must be considered in the context of local, national, and international regulations, and clinical governance structures and are not intended to override these.

## Training in transcatheter intervention in adult CHD

Multi-societal training guidelines relating to transcatheter intervention in adult CHD patients have recently been published.[12]

This document should be viewed as complimenting these training guidelines and can be applied for the training of both paediatric and adult congenital interventionalists. Settings described for paediatrics are applicable for adult congenital programmes, too.

Models of practice and therefore to an extent training reflect differences in local circumstances, and there is no perfect model of interventional care. We would emphasise that opportunities for training and practice in adult CHD interventional practice should not confined to trainees coming from an adult background but are useful for paediatric cardiologists, too. However, it is essential that an adult CHD interventionalist has deep knowledge and experience of congenital

cardiac problems, and it is important that interventionalists functioning in this field should do so as part of an expert multidisciplinary team.

## Settings

Most cardiac catheterisations for CHD are carried out electively, but acute and emergency procedures occur, mainly in children. It is important that trainees are exposed to procedures in both situations. As indications vary, any cathlab programme undertaking training of paediatric or congenital cardiologists must be within an institution where inpatient and outpatient facilities, intensive care, anaesthesiology, and a cardiac surgical programme for these patients are present. The latter is especially important, as paediatric and congenital cardiac catheterisation, especially interventional procedures, carry risks. Hence, these should be carried out only in departments where congenital cardiac surgery is carried out, too, in case of potential emergencies arising from the catheterisation itself.[13] Lines of communication between the catheterising cardiologist and the cardiac surgeon should be well established and should begin during multidisciplinary meetings for the discussion of procedures. Any trainee involved in catheterisation should also be involved in case planning as well as in early post-catheterisation care.[1,14,15] Although the level of involvement will vary dependent on the level of training, this is important even for beginners.

Regular case reviews and morbidity and mortality meetings should be held to discuss technical, conceptual, and ethical aspects of procedures. Local results should be regularly compared with accepted "standards of care" – usually national audit data or international data published in the literature. The trainee should become more and more involved in all of these aspects. Trained nurses, cardiac physiologists, and radiographers should contribute to procedural planning where appropriate relating to their areas of expertise through consideration of equipment, radiation settings, etc. Their special knowledge will also help the trainee to better understand the complexity of procedures.

The unit lead is responsible for directing the programme and specifically managing the case load, the procedures undertaken in the laboratory as well as offering direction and support for other interventional cardiologists within the team.[1] A named substantive interventional cardiologist should undertake primary responsibility for each trainee or fellow within the programme. This individual should provide support, guidance, and mentorship as well as working with the trainee on paperwork/logbook requirements.

### *Facilities and equipment*

Ideally, a catheterisation laboratory in a training institution should be equipped in accordance with the recommendations of the AEPC, last updated in 2018. As these recommendations were updated recently, we do not include a summary here but refer to the guidelines themselves.[13]

### *Training programme curriculum*

Any training programme for paediatric and adult congenital interventionists should include consideration of knowledge, skills, and attitudes. Understanding of the concepts of CHD including natural history and treatment options are a prerequisite for training. In this area, dexterity and the ability to learn and repeat procedures to a high standard are an essential requirement. Finally, ethical considerations need to be taken into account when considering complex interventions in complex patients. Obtaining this overall skill set is a major undertaking which requires dedication, insight, the ability to self-reflect, and the ability to work constructively within a team. In some trainees, manual skills may come easily, but the attitude towards other aspects of care for patients requiring catheterisation such as communication and the acceptance of own shortfalls may not be as well developed. These trainees need special attention and guidance.

### *Conduct of training*

Trainees should be supported to interpret clinical information in context of the patient history, non-invasive findings, and the pre-procedural evaluation and planning of procedures. These should include a consideration of risks, benefits, advantages, and disadvantages of interventional procedure versus alternatives. The trainee should be encouraged to present these data appropriately, for example, during multidisciplinary meetings.[16]

The trainee should discuss her/his preliminary plan of treatment with supervising senior staff and obtain informed consent initially under supervision, but later independently. Adequate documentation, including aims of the intervention, technical considerations, potential risks, and complications is important.

During catheter procedures, the trainee needs to understand the use of radiation and its risks adhering to the "as-low-as-reasonably achievable" (ALARA) principles.[17,18] Attending a radiation protection course is mandatory ideally before or early in training.

The trainee will initially mainly observe, but then become increasingly involved in cases, starting with patient positioning, equipment preparation, setting up an aseptic scrub table (initially under supervision, i.e., by a qualified cath scrub nurse) and planning of procedures as well as gaining knowledge of the catheter material. In addition, trainees need to learn to assist the primary operator in a reasonable and then anticipatory way. The next step is obtaining skills in vascular access and then subsequently guiding catheters. Interpretation of the obtained catheter data should be assessed regularly by the supervisor.

After the procedure, the trainee with the aid of the trainer needs to critically appraise the procedure and interpret and discuss data obtained.

Post-procedural patient care is an essential part of training. This includes training in and subsequently direct care for a patient after a procedure under general anaesthesia, communicating with anaesthesists, managing the access sites, monitoring for post-procedural complications, ordering and interpretation of post-procedural investigations and discharge planning. Communication with patients and/or parents as well as caregivers should also be done by the trainee, initially under supervision, but over time independently. There should be an opportunity for regular debriefing with the trainer assuming a mentorship role both formally as a route to documenting achievements and milestones in training, but also informally to develop a constructive trainer–trainee relationship.

## Training for paediatric and congenital cardiologists in training (basic level)

Interventional congenital catheterisation is usually carried out as part of a programme consisting of paediatric cardiology, general paediatrics, and acute subspecialties, including neonatology and cardiac surgery. Hence, knowledge of these fields is essential to understand and discuss indications and results of these procedures with these subspecialties. The guidelines of the AEPC regarding

https://doi.org/10.1017/S1047951123000823 Published online by Cambridge University Press

training including all these domains are updated regularly.[19] For adult congenital heart programmes carrying out catheterisations, understanding of the patients history and interventions (both surgical and in the catheter laboratory) in the past is essential.

Carrying out cardiac catheterisations as first operator at this level of training is not mandatory.

During core training in Paediatric Cardiology, trainees should at the relevant time in training be exposed, under supervision, to cardiac catheterisation (see training recommendations for Paediatric Cardiology from the AEPC on the AEPC website.[19]). Each trainee should be exposed to 50 catheterisations, including the pre- and post-procedural care and the interpretation of the obtained catheter data and how it relates to other investigations.

A basic level of training for paediatric and adult congenital interventions should provide the trainee with introductory knowledge of haemodynamics, angiography, radiation safety, indications, risks, limitations, and benefits of catheter procedures in patients with CHD. This includes knowledge of the use of ionising radiation and the ALARA principle.[17,18] Ideally, the trainee should also be involved in emergency procedures like balloon atrial septostomies and pericardiocentesis. If direct opportunities are limited, then a thorough understanding of emergency procedures-indications, techniques, and complications should be obtained.

A summary of the required knowledge, skills, and attitudes is shown in Table 1.

## Training for paediatric and congenital cardiologists specialising in catheterisation techniques (intermediate and advanced level)

After successfully completing training at a basic level, including adequate assessments of competence the trainee, in conjunction a trainer may decide to move to training at the next level.

### *Intermediate level*

At intermediate level, a trainee congenital cardiologist specialising in catheterisation should plan and in some cases perform diagnostic cardiac catheterisation as first operator, including single-ventricle evaluation and selected pulmonary hypertension studies. The trainee should work towards performing 100 interventional procedures, of which approximately 50 should be (at least in part) as first operator, under supervision. Direct participation in any part of a catheter study counts towards total numbers.

Usually, to achieve the number of procedures, this level of training will require at least 12 months.

Increasing depth of knowledge in the planning of procedures and interpretation of the acquired data is expected, and the trainee should be responsible for the presentation of catheter information during multidisciplinary meetings.

A summary of the required knowledge, skills, and attitudes is shown in Table 1.

### *Advanced level*

This level of training requires at least 12 months in a dedicated fellow position. Training is summative and at advanced level, the trainee should look to build on knowledge and skills learned in the intermediate stage. In addition to more "simple" interventions and diagnostic catheterisations, the trainee should actively plan and take part in more complex interventions eventually progressing to the point that they can take the lead in selected cases. Eventually, the trainee should demonstrate the skills required to perform these complex cases as the main operator, although still under support by an experienced substative interventionalist. Progress needs to be monitored and documented regularly.

Integration of different imaging modalities during catheterisation procedures, that is, transoesophageal echocardiography, image overlay from previously acquired cross-sectional imaging like MRI or CT, including strengths and weaknesses should be recognised and understood by the trainee.[4–6] The potential role of rotational angiography in certain clinical situations should be considered.[7] Trainees need to know about the use of additional advanced imaging but also about the limitations of the different techniques applied.

Since around 15 years, MRI-guided interventions have been performed.[7] MRI-guided catheterisation of both diagnostic and interventional allow catheterisation without the use of radiation.[8,9] The trainee should be aware of the possibility to perform radiation-free cardiac catheterisation studies. However, this must be put within the local context and the local availability of such facilities.

Depending on institutional practice, the trainee should be involved in hybrid procedures from the planning stage to procedural execution.

To achieve an adequate level, it is possible that the trainee may need to spent time in a larger institution where a (near) full-time focus on catheterisation is a reasonable prospect and advanced techniques are regularly in use. At this level of training, the trainee should perform at least 150 catheter interventions on the top of intermediate training level as first operator. A higher number of procedures is desirable and will contribute to developing the trainees skills to further depth.

An advanced trainee should have exposure to intervention in patients of all ages and in order to achieve this special provision may need to be made, for example, time within an adult CHD lab for a paediatric cardiologist based in a children's hospital, and in a paediatric cath lab for an adult congenital interventional trainee.

Experience at this level should include angioplasty and stenting of aortic coarctation and branch pulmonary arteries, embolisation and retrieval techniques, and ideally percutaneous valve insertion and VSD closure. Consideration of potential complications related to catheterisation, use of stents or devices, need to be discussed in advance with more senior colleagues, and bail-out plans should be made by the trainee.

A summary of the required knowledge, skills, and attitudes is shown in Table 1.

At any level of training, simulation training, the use of augmented reality, and also training on decision making can be important for the progress of the trainee.

## Assessment

As already stated, training is summative and progress will be different for each individual. It is important to assess the trainee regularly to document progress, identify deficiencies, and plan further training needs. Ideally, regular formative and summative assessments should be performed and form part of documentation of training in line with local and national regulations and practices.

Mandatory courses (radiation protection and morphology) should be documented, as well as any other courses or conferences relevant to the field of catheter interventions the trainee

https://doi.org/10.1017/S1047951123000823 Published online by Cambridge University Press

**Table 1.** Knowledge, skills, and attitude at different levels of training.

| Level | Basic | Intermediate | Advanced |
|---|---|---|---|
| **Knowledge** | • Anatomy of CHD<br>• Indications for emergency catheterisations<br>• Indications, limitations of diagnostic procedures, potential complications, and management strategies<br>• Indications, limitations of interventional procedures, potential complications, and management strategies<br>• Potential complications in the early post-procedural course and follow-up<br>• Basic knowledge of radiation and ALARA principle | • Detailed anatomy of CHD – morphology course<br>• Equipment used in the catheterisation laboratory, including pressure transducers, physiological recorders, blood gas analysers, image intensifiers, and digital image acquisition systems<br>• Catheters, guidewires, devices, and stents used frequently in congenital cardiac disease for diagnostic cardiac catheterisation and a limited range of interventions<br>• An understanding of medico-legal and ethical issues related to interventions | • Knowledge about interventional options in CHD in all age groups, including age-specific limitations and risks<br>• How to interpret a wide range of imaging modalities to support interventional work (e.g., transoesophageal echocardiography guidance, intracardiac echocardiography, and MRI three-dimensional imaging) and how to use them for planning and during the procedure<br>• Knowledge about advantages/disadvantages of image overlay techniques and rotational angiography<br>• Basic knowledge about MRI-guided interventions<br>• A detailed understanding of the materials and specialised equipment required for interventional procedures in CHD<br>• Technical understanding of of X-ray delivery, radioprotection, and how to reduce exposure<br>• Technical details of all interventional procedures used in CHD<br>• Potential problems associated with specific interventions and their solutions<br>• Technical details about different vascular accesses and use of vascular ultrasound<br>• A wide knowledge of literature and studies relevant to catheterisation and intervention, including recent innovations |
| **Skills** | • Pre-procedural evaluation and care, understanding of previously acquired imaging, and data<br>• Venous and arterial access under supervision<br>• Participation in 50 diagnostic or interventional catheterisations<br>• Interpretation of haemodynamics and oximetry, including calculation of blood flow, shunts, and resistances<br>• Interpretation of angiography<br>• Reporting of catheter data, interpretation of catheter data, relationships with non-invasive evaluation, and indication to interventions/surgery<br>• Integrate transoesophageal and intracardiac echocardiography monitoring during interventional procedures<br>• Management of post-procedural care and choice of adequate investigations to check procedural success | • Obtain informed consent for most routine procedures, including an explanation of the benefits and potential risks of the procedure<br>• Plan and supervise management before and after catheterisation<br>• Planning of catheterisation including access, materials to be used, which information needs to be obtained when and how during the procedure<br>• Acquire vascular access in all age groups and use of ultrasound guidance for access<br>• Manage anticoagulation during the procedure<br>• To perform > 100 diagnostic or interventional catheterisations, of which > 50 as first operator (on the top of basic-level training)<br>• Choose appropriate catheters and wires and manipulate them successfully and safely<br>• Acquire appropriate pressure and oximetry data in a logical sequence and deviate from previously made plan if necessary<br>• Perform angiography, including catheter type, size, and position, contrast volume, rate of delivery, selecting image intensifier angles, magnification, and coning<br>• Perform diagnostic cardiac catheterisation independently<br>• Perform a limited range of interventions as first operator under supervision (occlusion of patent arterial duct, balloon dilation of pulmonary and aortic valves, pulmonary artery angioplasty, recoarctation angioplasty, and myocardial biopsy) | • Select intervention cases on the basis of comparing risk and outcome against surgical or medical alternatives<br>• Select the best interventional solution to the patient's problem based on literature and local skills<br>• Detailed planning of catheter interventions, including strategies and equipment to deal with difficulties<br>• Demonstrate a high level of procedural judgement<br>• Anticipate/organise unusual vascular access (e.g., transhepatic access with collaboration of radiologists, carotid access with participation of surgeons, etc.)<br>• To perform > 150 diagnostic or interventional catheterisations, of which > 75 as first operator (on the top of intermediate-level training)<br>• Perform the following interventions independently in all age groups: occlusion of simple patent arterial duct, balloon dilation of pulmonary and aortic valves, pulmonary artery angioplasty, coarctation/recoarctation angioplasty, and myocardial biopsy<br>• Perform the following interventions in all age groups as first operator under supervision: device occlusion of atrial septal defect, device occlusion of complex patent arterial ducts, primary coarctation angioplasty or stenting, pulmonary artery stenting, stent redilation, embolisation of collateral vessels, and retrieval of foreign bodies<br>• Collaborate with experts in performing complex interventions such as: transseptal puncture, blade septostomy, stenting of the atrial septum, radiofrequency perforation of pulmonary atresia, ductal stenting, stenting of venous pathways after Senning and Mustard operations, bilateral pulmonary artery stenting, transcatheter ventricular septal defect closure, closure of complex patent ductus arteriosus, occlusion of coronary artery fistula, percutaneous valve insertion in pulmonary or other positions, and hybrid procedures such as |

(*Continued*)

https://doi.org/10.1017/S1047951123000823 Published online by Cambridge University Press

**Table 1.** (*Continued*)

| Level | Basic | Intermediate | Advanced |
|---|---|---|---|
| | | • React quickly and appropriately to adverse changes in rhythm or haemodynamics<br>• Manage intraprocedural complications such as tamponade (pericardiocentesis), haemothorax (chest drain insertion), and arrhythmias (drug treatment, cardioversion, and temporary pacing)<br>• Manage post-procedural vascular complications, including thrombolytic treatment<br>• Participate in the audit of activity in the catheterisation laboratory<br>• Teach other staff such as nurses, technicians, and junior medical staff in the catheter laboratory | perventricular ventricular septal defect closure, ductal stenting, or more complex hybrid interventions<br>• Perform with experts catheterisations under critical settings (e.g., in the acute post-operative period, in a child under extracorporeal membrane oxygenation, etc) knowing the benefits, but also risks and limitations of the procedures in those settings<br>• Carry out long-term follow-up of patients after interventional procedures<br>• Undertake research activity related to cardiac catheterisation and intervention and participate in multi-centre research activity related to cardiac catheterisation and intervention<br>• Have at least two "peer-reviewed" articles published or in press, studying techniques, or results in congenital heart catheterisation<br>• Teach cardiac catheterisation to junior trainees and faculty<br>• Teach other staff such as nurses, technicians, and junior medical staff in the catheter laboratory<br>• Participate in regular mortality/morbidity conferences with surgical and non-surgical colleagues to discuss adverse outcomes and decide best institutional approach<br>• Be able to critically review and analyse your institutional approach in comparison with other institutions |
| **Attitude** | • Appreciate the anxiety and concerns of patients and relatives undergoing interventional procedures<br>• Be able to discuss the advantages and disadvantages of medical versus interventional and surgical management in a way that patients can understand<br>• Be able to discuss the advantages and disadvantages/risks of different devices used in different clinical situations with patients<br>• Appreciate the importance of radiation protection<br>• Appropriate self-confidence and recognition of limitations<br>• Appreciate the importance of cooperation with cardiac surgeons already during planning<br>• Have a multidisciplinary approach to pre-operative assessment, involving other specialists if indicated | • Understand international and local processes and concepts for consent. Consent patients sensitively with an objective assessment of risks<br>• Liaise and discuss cases with cardiac surgeons directly and present cases during multidisciplinary meetings adequately detailed<br>• Appreciate and discuss the technical potential and limitations of surgery compared with intervention and vice versa<br>• Appreciate the importance of effective working with non-medical staff during invasive procedures<br>• Display and develop a caring approach to the high-risk patient and patients with important complications<br>• Keep calm when adverse events occur | • Involve other members of the multidisciplinary team in the strategy for complex cases<br>• To maintain a responsible attitude to the selection and application of intervention in complex lesions and patient subgroups<br>• Appreciate and develop the concept of working directly with surgeons during complex hybrid cases.<br>• Be prepared to be involved in properly planned and executed multi-centre research to assess the benefit of complex intervention<br>• Be self-critical regarding own limitations and ask for support if necessary at any time of the training<br>• Present data on international conferences |

attended. The content should be reflected on during assessment meetings.

## Comprehensive logbook

The trainee should keep a comprehensive logbook of all activities related to cardiac catheterisation as outlined in Table 1. At each level of training, the logbook will be a central piece of evidence of training. The logbook should contain a list of all procedures carried out and that should include technical details, complications and their management, and personal reflections. During regular training meetings, the logbook will form an important tool for discussion of achievements and needs between the trainer and trainee. It is essential that not only technicalities are discussed during training meetings but also the time for reflection is given.

In addition, regular direct observation of skills should be carried out in a structured way to allow the trainee to self-reflect on comments received.[20] Also, the trainee should receive advice and recommendations on how to improve skills. An example of a form for

https://doi.org/10.1017/S1047951123000823 Published online by Cambridge University Press

**Assessment of Procedural Skills in Cardiac Catheterisation (Direct Observation of Practical Skills)**

Trainees Name: Programme Director/ Supervisor:

Name of Assessor: Assessors Job Title:

Date of Procedure:_____/_____/_____ Date of Assessment: _____/_____/_____

**Brief Title/ Description of Case:**

Please Circle: **Emergency** **Urgent** **Elective** **1st Operator** **2nd Operator** **3rd Operator**

| | Below Level expected for stage in training | Appropriate level for stage in training | Above level expected for stage in training |
|---|---|---|---|
| Demonstrates understanding of the indications, anatomy and physiology and technique of the procedure | ☐ | ☐ | ☐ |
| Participation in obtaining informed consent | ☐ | ☐ | ☐ |
| Demonstrated appropriate pre-procedure planning and preparation | ☐ | ☐ | ☐ |
| Participation in pre-procedure team briefing | ☐ | ☐ | ☐ |
| Technical Ability (hand skills/ hand-eye coordination etc.) | ☐ | ☐ | ☐ |
| Aseptic technique and equipment preparation | ☐ | ☐ | ☐ |
| Seeks help appropriately | ☐ | ☐ | ☐ |
| Communication with team members during case | ☐ | ☐ | ☐ |
| Post-procedure management | ☐ | ☐ | ☐ |

**Overall Ability to perform this procedure**

| | |
|---|---|
| Able to perform this procedure independently and manage potential complications | ☐ |
| Able to perform this procedure with minimal supervision/ assistance | ☐ |
| Able to perform this procedure with significant assistance | ☐ |
| Unable to perform procedure even with significant assistance | ☐ |

**Comments, including plans for skills development.**

Trainees signature: _____ Date:_____

Assessors signature: _____ Date:_____

AEPC Interventional working group Cardiac catheterisation skills assessment form December 2013

**Figure 1.** Direct observation of practical skills form for use to assess procedural planning and skills in the congenital cardiac catheterisation laboratory.

https://doi.org/10.1017/S1047951123000823 Published online by Cambridge University Press

**Table 2.** Example of logbook.

| No. | Date | Weight (kg) | Age | Consent (y/n) | Emergency (y/n) | Diagnosis | Procedure performed | Operator | Notes | Reflective summary (y/n) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 27/7/2020 | 4,2 | 2 days | N | Y | Transposition of the great arteries (TGA) | Rashkind | First | Transumbilical, straightforward | Y |
| 2 | 27/7/2020 | 38 | 11 years | Y | N | Coarctation of the aorta (CoA) | Covered stent | Second | Cave: left subclavian artery | N |
| 3 | 29/7/2020 | 12 | 16 months | Y | N | Persistant ductus arteriosus (PDA) | Device occlusion | First | Device choice (manufacturer, type) | y |

such structured assessment is shown in Figure 1 (which has not changed since the last recommendations were published in 2015).

An example of a structured procedure log is shown in Table 2.

Whilst feedback from the trainer is important for the trainee regarding the three domains of knowledge, skills, and attitude, these can also be assessed formally by other team members, that is, by a multi-source feedback. This allows an assessment not only on the specific skills and knowledge necessary in the catheterisation laboratory itself but also on attitude and performance within the broader team.[21,22] In most instances, these will be carried out in the form of anonymised structured questionnaires which can be distributed, collected, and collated before feeding back the results to the trainee.[21]

For every level of the training, a documented personal development plan based on the requirements as described above is useful and provides a framework for a discussion of achievements and expectations. Short-term and medium-term goals should be written down, signed by both the trainer and the trainee, and be used at appraisal meetings to evaluate the progress of the trainee against these previously agreed aims. Such appraisal meetings should be held at least annually. These yearly reviews may also be useful for local statutory and academic training bodies.

## The trainee in difficulty

Documentation of assessment is important, especially if previously agreed goals have not been reached. Shortcomings and weaknesses should be identified, and potential solutions or remedies for the trainee must then be agreed. In the unfortunate situation where the trainee repeatedly fails to meet objectives, despite adequate support and guidance the trainee may be deemed unsuitable to become an independently working congenital interventionalist. To reach this conclusion, it is essential that deficiencies in knowledge, skills, or an attitude incompatible with teamworking/high-quality patient care should be accurately documented and discussed with the trainee. A trainee in this situation will require discussion within the wider local medical training infrastructure (e.g., the overarching training "Deanery") where formal advice and support for both the trainee and the training programme can and should be obtained.

Where it is clear that a trainee will not progress within the interventional field but has attributes that are compatible with substantive practice in congenital cardiology adequate support should be given in developing other career options within the specialty.

## Conclusions

Training in interventional congenital cardiology is complex because it requires not only manual skills and dexterity but also a thorough knowledge of pathology and haemodynamics across a great variety of patients, and of materials and devices. To obtain adequate exposure requires extensive training which may be long and arduous.

Also, once a trainee successfully reaches advanced level of training, he/she can get a role as junior interventionalist in a team. Learning never stops, and mentoring may be ongoing even after the training has formally been finished. Working in teams will allow any interventionalist to develop further independent of his/her level of experience.

The responsibility of the trainers cannot be overestimated. Leading by example and in a constructive manner is hugely important for a trainees development. Ultimately, training should provide opportunities for the trainee to grow into the role of an interventionalist who, at the end of the training, can confidently consider indications, carry out standard procedures safely and independently, and appraise himself and the institutional approaches critically, thus contributing to the development of the specialty in a collaborative manner. In many cases, this will require a trainee to need to move between units and even countries to seek and obtain the experience required. The success of mentorship has been shown for cardiac surgery and in the catheterisation laboratory.[23–25]

**Supplementary material.** To view supplementary material for this article, please visit https://doi.org/10.1017/S1047951123000823.

**Financial support.** This research received no specific grant from any funding agency, commercial, or not-for-profit sectors.

**Competing interest.** None.

## References

1. Butera G, Morgan GJ, Ovaert C, Anjos R, Spadoni I. Recommendations from the association of european paediatric cardiology for training in diagnostic and interventional cardiac catheterisation. Cardiol Young 2015; 25: 438–446.
2. Aboulhosn JA, Hijazi ZM, Kavinsky CJ, et al. SCAI position statement on adult congenital cardiac interventional training, competencies and organizational recommendations. Catheter Cardiovasc Interv 2020; 96: 643–650. DOI 10.1002/ccd.28885.
3. Brida M, Diller GP, Nashat H, et al. Cardiac catheter intervention complexity and safety outcomes in adult congenital heart disease. Heart 2020; 106: 1432–1437. DOI 10.1136/heartjnl-2019-316148.

4. Pushparajah K, Duong P, Mathur S, Babu-Narayan S. Educational series in congenital heart disease: cardiovascular MRI and CT in congenital heart disease. Echo Res Pract 2019; 6: R121–138.
5. Goreczny S, Dryzek P, Morgan GJ, Lukaszewski M, Moll JA, Moszura T. Novel three-dimensional image fusion software to facilitate guidance of complex cardiac catheterization : 3D image fusion for interventions in CHD. Pediatr Cardiol 2017; 38: 1133–1142.
6. Kang SL, Armstrong A, Krings G, Benson L. Three-dimensional rotational angiography in congenital heart disease: present status and evolving future. Congenit Heart Dis 2019; 14: 1046–1057.
7. Tzifa A, Krombach GA, Krämer N, et al. Magnetic resonance-guided cardiac interventions using magnetic resonance-compatible devices: a preclinical study and first-in-man congenital interventions. Circ Cardiovasc Interv 2010; 3: 585–592.
8. Veeram Reddy SR, Arar Y, Zahr RA, et al. Invasive cardiovascular magnetic resonance (iCMR) for diagnostic right and left heart catheterization using an MR-conditional guidewire and passive visualization in congenital heart disease. J Cardiovasc Magn Reson 2020; 22: 20.
9. Pushparajah K, Wong JK, Bellsham-Revell HR, et al. Magnetic resonance imaging catheter stress haemodynamics post-fontan in hypoplastic left heart syndrome. Eur Heart J Cardiovasc Imaging 2016; 17: 644–651.
10. Kalfa D, Torres AJ. Indications and results for hybrid interventions in patients with congenital heart disease. Arch Cardiovasc Dis 2020; 113: 96–103.
11. Bearl DW, Fleming GA. Utilizing hybrid techniques to maximize clinical outcomes in congenital heart disease. Curr Cardiol Rep 2017; 19: 72.
12. Chessa Massimo, Baumgartner Helmut, Michel-Behnke Ina, et al. ESC working group position paper: transcatheter adult congenital heart disease interventions: organization of care – recommendations from a joint working group of the european society of cardiology (ESC), european association of pediatric and congenital cardiology (AEPC), and the european association of percutaneous cardiac intervention (EAPCI). Eur Heart J 2019; 40: 1043–1048.
13. Krasemann T, Berger F, Liuba P, Thomson J. Recommendations for the configuration of a cardiac catheterisation laboratory for the treatment of children with CHD. Cardiol Young 2018; 28: 791–794.
14. Thomson etal. Recommendations of the british congenital cardiac association for therapeutic cardiac catheterisaotion in paediatric heart disease. December 2012. *Available at:* http://www.bcs.com/documents/BCCA_Guidelines_for_interventional_catheterisation_in_children_-_December_2012_FINAL.pdf.
15. Chessa M, Baumgartner H, Michel-Behnke I, et al. ESC working group position paper. transcatheter adult congenital heart disease interventions: organization of care – recommendations from a joint working group of the european society of cardiology (ESC), european association of pediatric and congenital cardiology (AEPC) and the european association of percutaneous cardiac intervention (EAPCI). Eur Heart J 2019; 40: 1043–1048.
16. Abu-Zidan FM, Premadasa IG. The surgical morbidity and mortality meeting as an educational tool. Med J Malaysia 2001; 56: 441–445.
17. Osei FA, Hayman J, Sutton NJ, Pass RH. Radiation dosage during pediatric diagnostic or interventional cardiac catheterizations using the "air gap technique" and an aggressive "as low as reasonably achievable" radiation reduction protocol in patients weighing <20 kg. Ann Pediatr Cardiol 2016; 9: 16–21.
18. Justino H. The ALARA concept in pediatric cardiac catheterisation: techniques and tactics for managing radiation dose. Pediatr Radiol 2006; 36: 146–153.
19. Professional advisory committee and council of the Association for European Paediatric Cardiology. Recommendations for training in Paediatric Cardiology., https://www.aepc.org/uploads/page/doc/66/AEPC%20Recommendations%20for%20training%20in%20paediatric%20cardiology%20(2005).pdf.
20. Bindal N, Goodyear H, Bindal T, Wall D. DOPS assessment: a study to evaluate the experience and opinions of trainees and assessors. Med Teach 2013; 35: e1230–e1234.
21. Stevens S, Read J, Baines R, Chatterjee A, Archer J. Validation of multisource feedback in assessing medical performance: a systematic review. J Contin Educ Health Prof 2018; 38: 262–268.
22. St John M, Tong B, Li E, Wilbur K. Competency-based education frameworks across Canadian health professions and implications for multisource feedback. J Allied Health 2020; 49: e1–e11.
23. Nassour I, Balentine C, Boland GM, et al. Committee on academic advancement of the association for academic surgery. Successful mentor-mentee relationship. J Surg Res 2020; 247: 332–334.
24. Odell DD, Edwards M, Fuller S, et al. Society of thoracic surgeons workforce on career development. The art and science of mentorship in cardiothoracic surgery: a systematic review of the literature. Ann Thorac Surg 2022; 113(4): 1093–1100.
25. Bagai A, O'Brien S, Al Lawati H, et al. Mentored simulation training improves procedural skills in cardiac catheterization: a randomized, controlled pilot study. Circ Cardiovasc Interv 2012; 5(5): 672–679.


https://doi.org/10.1017/S1047951123000823 Published online by Cambridge University Press