SCAI Position Statement on Adult Congenital Cardiac Interventional Training, Competencies and Organizational Recommendations

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Background:

Congenital heart disease (CHD) is the most common congenital anomaly and occurs in ~ 0.8% of all live births. Medical and surgical advancements over the past 80 years have resulted in markedly improved survival, and the majority of CHD patients are now surviving to reach adulthood. The number of adults with CHD (ACHD) in the United States now exceeds the number of pediatric patients. This changing demographic trend towards adulthood was first recognized in the early 1970’s, and several clinics specializing in ACHD were developed in the 1980’s. Over the past 40 years, there has been an incremental increase in the number of ACHD clinics and specialty centers, mostly based at large academic medical centers, and often staffed by both adult and pediatric cardiology specialists. Along with the rise in the number of ACHD patients, there has been a parallel increase in the volume and variety of transcatheter interventional procedures applicable to ACHD patients.

The definition of ACHD can be somewhat arbitrary depending on the various stakeholders managing CHD patients and the institutional culture and expertise. Most agree that age 18 years is the typical cutoff that separates pediatric from adult patients. However, some Children’s hospitals will accept CHD patients as old as 26 years or even older, especially if they have been cared for all of their lives in the same institution. Often, during the college age years (18-22 yrs), patients and their parents may prefer continued care with their pediatric cardiologist. Meanwhile, there are also adult cardiologists and hospitals willing to manage late adolescent CHD patients, especially those with adult weight ranges and those with comorbidities such as diabetes, hypertension and dyslipidemia. Issues of contraception, pregnancy planning and pregnancy management in young women with ACHD require special consideration and teams experienced in this area of ACHD, be they pediatric or adult specialists, are best suited to care for these patients. Models of “expert ACHD centers” that exist currently vary widely from collaboration between a free-standing children’s hospital that collaborates with a partner adult hospital/s, to a children’s hospital embedded within an adult medical center to adult hospitals with no affiliation with a Children’s hospital but that have collaborative arrangements with pediatric cardiology. While diversity of ACHD centers exists, it is clear that a team approach involving both pediatric and adult CHD experts and multi-specialty collaborators is optimal for the best care of ACHD patients from adolescence through older adulthood.

The rapid rise in the number and complexity of transcatheter interventional procedures performed in this population has prompted the publication of consensus recommendations from stakeholder organizations regarding the delivery of ACHD interventional care, including recommendations within the ACC/AHA guidelines explicitly stating that interventional procedures should be performed at regional ACHD centers by qualified specialists with training and experience in ACHD interventional care and in laboratories with appropriate staffing and experience to fulfill this task. The Adult Congenital Heart Association (ACHA) was founded as a national organization in the United States that includes patients and medical professionals and helps educate and empower ACHD patients and their families. In 2014, the ACHA developed an ACHD center accreditation process that includes a comprehensive list of staffing and care process requirements (https://www.achaheart.org/provider-support/accreditation-program/). The ACHA’s accreditation steering committee attempted to establish certain well-defined quality measures for the delivery of ACHD care in the United States. This accreditation program has become a
cornerstone for ensuring that comprehensive care centers for ACHD meet pre-specified acceptable thresholds, including recommendations for the delivery of transcatheter interventional care. The ACHA Comprehensive Care Center requirements state that ACHD interventions should be performed by trained and experienced specialists at centers with adequate facilities and expertise to deliver such care. The availability of around the clock interventional and surgical coverage is critical, as is the participation of the ACHD team in the peri-procedural care as well as long-term anticipatory planning of these patients.

Specialized training in ACHD has taken place at pioneering ACHD programs in the United States for over three decades. The early training programs did not include a uniform curriculum but relied on the age-old technique of a master clinician accepting to tutor and train willing apprentices who would then go on to establish grow new and established ACHD programs. These specialists came from both adult and pediatric cardiology backgrounds, hence, the majority of established ACHD programs in the United States currently include adult and pediatric cardiac specialists working collaboratively. Interventional ACHD procedures are currently performed by both pediatric and adult specialists at pediatric, adult, and combined hospital settings ⁴. ACHD was certified as a unique sub-specialty by the American Board of Medical Specialties in 2012 and the American Board of Internal Medicine instituted a certifying examination that, thus far, has been given in 2015 and 2017; there are now over 300 physicians from pediatric and adult cardiology backgrounds certified as ACHD specialists in the United States. The Accreditation Council for Graduate Medical Education (ACGME) now certifies ACHD training programs for a 2-year fellowship in ACHD that can be offered after successful completion of fellowship training in adult or pediatric cardiology. Within the 2-year ACHD fellowship curriculum is a requirement for a minimum of 2 months of catheterization training and there are an additional 6 months that can be utilized for research and/or elective rotations.

In recognition of the need for specific recommendations regarding interventional training, an expert consensus statement from the Society for Cardiovascular Angiography and Interventions (SCAI) was published in 2010⁵,⁶. The authors appropriately highlighted that “training needs to be aligned with the goals and priorities of a “basic” or “advanced” level; moreover the training should be categorized into either “acquired” or “congenital” interventional cardiology. Moreover, the experts concluded that fellowship training in structural and congenital interventions is but “a foundation for a lifetime of learning and maturation, and very few trainees will master more than either the basics of a very select number of complex procedures during a 1- or even 2-year program.” The experts recommended a minimum fellowship duration of one year but strongly encouraged ongoing mentorship and continued learning thereafter. This consensus document also highlighted the importance of integrated multi-disciplinary care in partnership with established centers of excellence in ACHD. An additional expert consensus document from SCAI was published in 2014 focusing on interventional training in pediatric (and congenital) interventional cardiology ⁷. This document was not specific to ACHD and was primarily focused on pediatric interventional training. The experts proposed case numbers of specific procedures and encouraged the utilization of a performance evaluation tool for ongoing trainee assessment. The duration of training can vary but the experts recommended at least 250 total cases be performed, 150
of which should be interventional procedures. ACHD-specific case numbers and case types were not stated.

Methodology:

Multi-disciplinary stakeholders from the interventional and ACHD communities were invited to attend a roundtable meeting organized by SCAI at the 2018 SCAI Scientific Sessions. Attendees included pediatric interventionalists, adult structural interventionalists, ACHD specialists, and observers representing industry stakeholders. Three fellow trainees were also present in the role of scribes and charged with documenting the discussions. Meeting participants are listed in Supplemental Table 1. The attendees were evenly split into three groups, each led by a meeting co-chair and focused on the following priorities: 1) ACHD interventional training, 2) competency for physicians already in practice, and 3) institutional and team requirements for the delivery of ACHD interventional care. Following a brief overview and instructions by the meeting chairman, the experts proceeded to debate and discuss their group mandates for 90 minutes. Each group reported on their conclusions, concerns, and recommendations at the end of the meeting.

SCAI received financial support for the roundtable from Abbott Laboratories, Edwards Lifesciences, and Medtronic Inc. Industry supporters did not participate in planning, content development, or tactical execution of the meeting. Meeting attendees received honoraria for their participation.

This position statement summarizes the key judgements and recommendations that were drafted at the roundtable and refined in subsequent discussions among members of the writing group. The resulting document has been developed according to SCAI Publications Committee policies for writing group composition, disclosure and management of relationships with industry (RWI), internal and external review, and organizational approval. The writing group has been organized to ensure diversity of perspectives and demographics, multi-stakeholder representation, and appropriate balance of RWI. Relevant author disclosures are included in Supplemental Table 2. Before appointment, members of the writing group were asked to disclose all relevant financial relationships with industry (>$25,000) from the 12 months prior to their nomination. A majority of the writing group disclosed no relevant financial relationships. Disclosures were periodically reviewed during document development and updated as needed. SCAI policy requires that writing group members with a current financial interest are recused from participating in discussions or voting on relevant recommendations. The work of the writing group was supported exclusively by SCAI, a nonprofit medical specialty society, without commercial support. Writing group members contributed to this effort on a volunteer basis and did not receive payment from SCAI.

Recommendations were discussed by the full writing group on a series of teleconferences and during two additional in-person meetings until all group members agreed on the text and qualifying remarks. All recommendations are supported by a short summary of the evidence or specific rationale. Additionally, the writing group conducted a survey of ACHA-accredited ACHD programs to ascertain diagnostic and interventional case volumes and practice setting(s) from the prior year. This information
was used to inform recommendations on optimal procedural volumes. Survey results are presented in Supplemental Table 3.

The draft manuscript was posted for public comment in December 2019 and the document was revised to address pertinent comments. The writing group [unanimously] approved the final version of the document. The SCAI Publications Committee and Executive Committee endorsed the document as official society guidance in [MONTH, YEAR].

ACHD Interventional Training Recommendations:

The objective was to determine recommendations for the following parameters:

1. Eligibility for training
2. Training environment and duration of training
3. Procedural volume

Key Background Points:

There are both cognitive and procedural skillsets that are necessary in order to perform interventional ACHD catheterization. Individuals seeking to be competent in ACHD interventional care should have a deep understanding of congenital heart disease, in addition to demonstrating the technical/procedural skills necessary to perform interventions. The recommendations provided herein are intended to ensure that trainees who seek to perform ACHD interventions possess training in both realms (the cognitive tools and the procedural skillset) to become competent. Recommendations are not intended to be a mandate, but rather to help ensure that the training of ACHD interventionalists will include both cognitive and procedural aspects of ACHD. Moreover, it is important to recognize that trainees may come from diverse educational backgrounds, including pediatric cardiology, adult interventional cardiology, and adult congenital cardiology; it is imperative that logical pathways be available for individuals from these diverse backgrounds. The experts recognize that some invasive or interventional training in ACHD may have taken place during general pediatric cardiology fellowship, ACHD fellowship, or adult structural or coronary interventional fellowship. However, in general, this does not constitute an adequate amount of training in ACHD interventions and additional focused training is necessary.

Eligibility for ACHD Training:

Trainees may come from diverse educational backgrounds with varying levels of ACHD knowledge and procedural skills. Four main training backgrounds were identified from which individual candidates desiring to train in ACHD interventions may emerge:
1. A trainee who has completed a general pediatrics residency followed by a general pediatric cardiology fellowship and additional pediatric interventional cardiology training. It should be noted that accredited fellowships in pediatric interventional cardiology do not yet exist.

   a. **Strength**: This fellow already possesses an understanding of the anatomy/pathology central to congenital heart disease and technical/procedural skillsets required for interventional cardiology.

   b. **Weakness**: This fellow lacks specific training in adult co-morbidities, pregnancy and their treatments and adult cardiovascular processes which may be superimposed on the underlying congenital disease and affect procedural care and outcomes.

2. A trainee who has completed an internal medicine residency followed by a general adult cardiology fellowship and adult interventional cardiology fellowship (with a primary focus on coronary interventions).

   a. **Strength**: This fellow has demonstrated the procedural skillset to be an interventionalist and is already trained to obtain access, the use of a variety of catheter and wires, understands radiation dosing, and can use select equipment, and understands the anatomy/pathology central to coronary and other cardiovascular diseases associated with aging.

   b. **Weakness**: This fellow lacks the specific CHD training that provides the cognitive skillset and understanding gathered during focused ACHD fellowship. Additionally, equipment not routinely used during coronary interventions may limit the procedural skillset of this type of fellow.

3. A trainee who has completed an internal medicine residency, adult cardiology fellowship, followed by a 12-month adult interventional cardiology fellowship and a separate 12-month adult structural fellowship (with the latter focused on procedures for acquired structural diseases, such as transcatheter aortic valve replacement, transcatheter mitral valve repairs, etc.). These trainees may have had limited exposure to complex congenital interventions but may have participated in atrial septal occlusion procedures and other “simple” CHD interventions.

   a. **Strength**: This trainee possesses the procedural and technical skillsets to perform structural procedures.

   b. **Weakness**: This trainee lacks the specific CHD training that provides the cognitive skillset and understanding gathered during focused ACHD fellowship. Moreover, this trainee has typically had very limited exposure to complex ACHD interventions (e.g. in single ventricle patients, complex RVOT interventions, etc).
4. A trainee who has completed a pediatric or adult cardiology fellowship and thereafter has completed or is enrolled in an ACHD fellowship and desires to train further in ACHD interventions.

   a. **Strength**: This trainee possesses a clear interest in ACHD. As such, the ACHD fellowship may be geared towards the specific interventional interest without extraneous years of non-ACHD interventional care.

   b. **Weakness**: This trainee does not possess interventional technical/procedural skillsets and has not undergone focused interventional training.

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**Duration of Training and Training Environment**

Completion of an interventional training program does not ensure that physicians are fully capable of independently performing all ACHD interventional procedures. Competency goes beyond training, and should be thought of as an ongoing process. At the conclusion of any fellowship program, the physician has only achieved the minimum level of competency to go on to the next stage. Lifelong learning and multi-disciplinary collaboration are the overarching principles in this field. Thereafter, an emerging ACHD interventionalist is best served both by continued mentorship and interactions with the other stakeholders in this field. The duration and depth of such mentorship may vary from individual to individual but is certainly worthwhile to have in the first five years out of training. The congenital heart team remains critical in providing both the mentorship as well as the collaboration for the maturation process.

The duration of ACHD interventional training is highly dependent on the procedural volume and the achievement of competence by the trainee. The procedural volume recommendations made in the next section should serve as the primary determinant of training duration and in a busy ACHD interventional program should be achievable over a 12-24 month period. It is imperative that the training also include appropriate risk stratification for interventional procedures, potential complications, and the appropriate management of said complications.

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**Procedural Volume**

Although case volumes tend to be somewhat arbitrary, the advanced ACHD interventional trainee should develop technical skills (as a primary operator or first assistant) on a sufficient volume and variety of procedures in order to achieve competence and comfort with all aspects of the procedure. For trainees with a pediatric interventional background it is recommended that all cases are performed in adults in order to achieve competence in ACHD patients. For trainees with an ACHD or adult interventional background it is recommended that at least 10% (and no more than 25%) of cases are performed in children. It is important for adult providers to engage with and work along-side their
pediatric interventional counterparts and in so doing gain knowledge and experience in the
management of children with CHD. There are certain interventional procedures that are uncommon in
the ACHD population (e.g. VSD closure) but are more frequently performed in the pediatric population,
therefore, the adult trainee may gain more exposure to such procedures in the pediatric population.

During the ACHD interventional training curriculum the trainee should participate as primary operator or
first assistant in at least 150 ACHD catheterization cases, of which, a minimum of 100 of these should be
interventional procedures. In addition to procedural performance, it is imperative that the trainee
develops in depth understanding of the indications/contraindications, techniques, equipment choices,
complications, limitations, maneuvers and procedural expectations associated with these procedures.
The interventional procedures should be varied and include a minimum number of procedures in the
following areas:

- **Device closures:**
  - Atrial septal defect (ASD) ≥15
  - Patent foramen ovale (PFO) ≥12
  - Intra-cardiac echocardiography (ICE) to guide septal closure ≥ 20 cases. This
    requirement is optional and can be replaced by transesophageal guidance of
    closure procedures.
  - Ventricular septal defect (VSD) ≥2
  - Patent ductus arteriosus (PDA) ≥8

- **Angioplasty/stenting procedures**
  - Coarctation with stent ≥8
  - Pulmonary valve implant ≥12
  - RVOT or branch pulmonary artery stents ≥5
  - Aortic valvuloplasty ≥3
  - Pulmonary valvuloplasty ≥5
  - Stent implantation in venous vessels ≥5
  - Stents conduits/baffles ≥5
  - Pulmonary vein stents?
  - Fontan baffle fenestrations?

- **Balloon septostomy ≥2** (can be with other LA procedures)
- Aortic valve implant ≥5
- Mitral valve interventions (valvuloplasty/valve in valve implant/mitral clip) ≥ 5
- Transeptal catheterization ≥10
- Perivalvular leak closure ≥5
- Ultrasound guided access ≥100
- Large vessel vascular closure techniques ≥ 30
- Radial artery access ≥20
- Coronary angiography ≥40
In addition to the above procedural volume recommendations the trainee must demonstrate knowledge of angiographic projections to support interventions in a variety of CHD subtypes such as coarctation of the aorta, branch pulmonary artery stenting, pulmonary valve implantation, intracardiac baffles and selective coronary angiography.

There is a growing trend towards the performance of hybrid interventions and the trainee should develop experience in working collaboratively with congenital heart surgeons around complex cases requiring surgical access. Understanding surgical capabilities, techniques, approaches, and potential complications is required for appropriate patient selection and sound decision making.

The ACHD interventional program training director is responsible supervising the trainee and for signing off on individual procedural volumes. There must be demonstrated competence not only in the technical maneuvers required to conduct an intervention but also in an in depth knowledge of procedural complications and bail out strategies. It is the responsibility of the program director to ensure that the requisite knowledge base has been achieved prior to certifying a trainee.

Appropriate ACHD case exposure and volume are clearly needed in order to ensure adequate training. It is imperative that training centers have sufficient ACHD interventional case volume and variety to facilitate such training. ACHD interventional training programs should have an annual case volume that exceeds 150 with a minimum of 100 interventional procedures. Physicians performing training should be experienced in ACHD interventions and are expected to commit sufficient time and effort into the procedural training, didactic education and mentorship of the trainee/s. Mentors/trainers and lab directors should confirm that the trainee/s have performed the sufficient number of procedures as defined above and that the trainee/s are in good standing and have the technical skills and knowledge base to perform ACHD interventions. It should be noted however that no trainees will master the variety of ACHD interventions during the training period and ongoing learning and mentorship are strongly recommended.

**ACHD interventional competency for physicians in practice**

**Determination of competency**

Determination of competency for physicians that are no longer in a training program is challenging given the heterogeneity of practice types, operator volume, case complexity and practice location. It would be unrealistic to expect proceduralists who have been performing interventional cardiology on adult congenital patients for many years to sit for an examination or to go back to fulfill additional training requirements. Thus, we propose simple guidelines to guide interventionalists already in practice to allow for self-assessment, self-improvement and for definition of minimum acceptable procedural volumes.
Rather than enforcing strict guidelines, it is suggested that all ACHD interventionalists should track their case volume, case complexity and complication rates. Procedural competency is very difficult to determine and must, at least in part, be based on case volume. Case complexity must also be considered and cases could be divided into simple vs. complex (Table 1). A high case volume at an ACHA-accredited comprehensive care center that performs the breadth of complex ACHD procedures is ideal for the development and maintenance of procedural competency. These procedures are often performed by an interventional team that may consist of pediatric and adult interventional specialists working together. This model provides a pathway to develop and maintain the competence of more than one individual of the multidisciplinary team. In general, ACHD interventional competency should require an average case volume of at least 50 ACHD cases per year with over 30 ACHD interventions.

Tracking procedural numbers and outcomes is essential and registries such as the NCDR-IMPACT or the Congenital Cardiovascular Interventional Study Consortium (CCISC) registries should be used by all ACHD interventionalists. Determination of competency by on-going self-assessment of cognitive knowledge, procedural volume and procedural complexity is critical and should be performed by allinterventionalists. A coordinated effort by the various societies and stakeholders, including SCAI, ACC and ACHA would be ideal in the future. Societies could aid ACHD interventionalists by developing self-assessment modules to maintain general knowledge and to track procedural volumes and complexity.

**Ongoing procedural training**

The last two decades have witnessed an explosion of interventional procedures in the field of congenitl cardiology. The number and variety of wires, catheters, occlusion devices, balloons, stents, and transcatheter valves and other devices has increased dramatically. The expansion of new devices and techniques is likely to continue to grow exponentially. It is imperative that physicians stay abreast of innovative developments and learn to utilize the available tools by participating in ongoing procedural training and proctorship; most often provided by industry partners.

Because ACHD interventionalists can not be expected to maintain adequate volume in all the potential ACHD procedures and devices, liberal use of proctors provided by the manufacturers of devices should be utilized. Ideally, our industry partners would outline minimal procedural volumes and provide proctors as needed. ACHD interventionalists should be expected to utilize proctors for procedures performed less than 2-5 times/year.

**Ongoing education**

It is imperative that physicians in practice stay abreast of developments in the field of ACHD and ACHD interventions. Attendance at educational conferences held regularly in the United States and throughout the world are helpful in this regard. There are online resources that can be utilized to maintain and increase cognitive knowledge of ACHD such as the CHIP network and ACHD learning center (https://www.newachdlearningcenter.org/). Documentation of continuing education is an integral part.
of the ongoing assessment of competence. ACHD interventionalists already in practice should attempt to accrue at least 30 hours of CME credits per year focused on congenital interventions.

Role of adult structural/congenital partnership

Collaboration between adult and pediatric interventional specialists is ideal for the provision of comprehensive ACHD care. As an example, adult interventional specialists often have expertise in coronary interventions and certain structural interventions (e.g. transcatheter aortic valve replacement and mitral valve clip placement), while pediatric interventionalists may have expertise in peripheral pulmonary artery interventions and postoperative right ventricular interventions. Therefore, a collaborative relationship between adult and pediatric interventionalists is most desirable for adult patients with CHD. It is imperative that individual providers, institutions, and payers commit to this collaborative care model in order to provide the highest quality care to these patients. Many of the common ACHD procedures are performed routinely in the pediatric population. A collaboration between a pediatric-trained interventionalist and an adult-trained congenital interventionalist can allow both physicians to gain exposure to additional procedural volume and techniques outside of the scope of their usual cases.

Institutional and team requirements

The delivery of high quality care is dependent on a multi-disciplinary team with expertise in ACHD. An institution with a comprehensive ACHD program is the ideal setting for such a multi-disciplinary care model. Care can be effectively delivered at both adult and children’s hospitals as long as essential components are in place. Children’s hospitals should have 24/7 access to adult sub-specialists. Many children’s hospitals have an age limit on patients and therefore it is important that such institutions also have well defined transfer processes in place with partner adult hospitals staffed with qualified ACHD specialists. Given the heterogeneity of care models across the United States, there should be some flexibility to allow for regional and institutional variations. The currently established requirements for ACHA comprehensive care center accreditation clearly delineate the institutional needs for provision of ACHD care, and the expert consensus is that these be adopted by institutions that desire to perform ACHD interventions. Institutional accreditation by the ACHA is dependent on demonstration of institutional commitment to the delivery of high-quality ACHD care across the board and the presence of a qualified multi-disciplinary team. Moreover, this accreditation also establishes that processes and procedures are in place for the delivery of ACHD care at both children’s and adult hospitals. The ACHD care team should include a variety of specialists to support the most qualified interventional specialist/s in successfully planning for and performing ACHD interventional procedures. Adverse event simulation can be useful in training the team to handle complications and emergencies. Moreover, advanced cardiac life support (ACLS) certification is essential when treating ACHD patients and is an additional requirement for ACHA comprehensive care center accreditation. The ACHD multi-disciplinary team should consist of the following team members:
• ACHD board-certified cardiologist
• ACHD interventionalist
• ACHD Fellow/ACHD interventional fellow
• Cath lab nursing with expertise and comfort in the care of ACHD patients
• Cardiac anesthesiology with ACHD expertise
• ACHD imaging – MRI/CT/ECHO – with expertise in pre- and intra-procedural imaging
• CHD cardiothoracic surgery
• Cardiac critical care cardiologists with ACHD experience
• 24/7 ACHD call for coverage
• For children’s hospitals: adult subspecialists available for pre-, intra-, and post-procedural care. Internal medicine hospitalists should be available 24/7.
• Social services and ethicists to aid in complex decision making

The ACHD medical team plays a central role in the care of such patients and should be involved in all aspects of the care of these patients:

a. Pre-procedural care:
   i. Complete ACHD and internal medicine evaluation performed by the ACHD cardiologist, consisting of detailed medical, surgical, and interventional history, non-invasive imaging, arrhythmia evaluation, results of exercise testing, and optimization of medical therapy
   ii. Cardiac anesthesia consultation
   iii. Care presentation and discussion in multidisciplinary conference with presence of ACHD medical, interventional, surgical, and anesthesiology teams
   iv. ACHD team, anesthesiologist, and ACHD interventionalist should confirm that there has been no change in clinical status upon arrival of the patient for the procedure

b. Peri-procedural care:
   Review of procedure plan with all involved including nurses, technicians, including discussion of anesthesia plan, interventional plan, review of laboratory study result, post-procedure care, potential need for mechanical circulatory support, surgical back-up, bail out options.
   i. Qualified ACHD interventional team to perform procedure
   ii. Cardiac anesthesia team
   iii. Imaging support (transesophageal or intracardiac echocardiography, congenital heart MRI or CTA)

c. Post-procedural care:
i. Communicate with floor or intensive care unit (physician-to-physician and nurse-to-nurse) to clarify post-procedure care and follow-up testing

ii. Post-procedural care providers
   1. ACHD team
   2. Cardiac intensive care unit team
   3. If the patient is on a pediatric cardiology service, recommend ACHD consultation
   4. If the patient is on an adult cardiology team, recommend ACHD consultation

iii. Depending on co-morbidities, internal medicine subspecialists may need to be involved. For children’s hospitals consider internal medicine consult for all with complex medical issues.

iv. ACHD imaging post-procedure and prior to discharge

v. 24/7 ACHD coverage available

vi. Schedule follow-up – ACHD interventional vs ACHD providers (cardiologist or advanced practice provider) or both

Institutional Issues

a. For both adult and children’s hospitals:
   a. Proper catheterization lab equipment and set up; biplane imaging is desirable
   b. Cardiac anesthesia support
   c. Equipment, devices, catheters fully stocked
   d. Cardiothoracic surgical expertise in CHD available
   e. ACHD program
   f. ACLS for all staff involved
   g. Fully operational clinical research infrastructure to support innovation

b. Specific to children’s hospitals:
   a. ACLS for involved staff
   b. Internal medicine hospitalists and/or subspecialists available
   c. Adult equipment available in catheterization lab and on all units where ACHD patients will be cared for
   d. Emergency and less urgent transfer plan to adult hospital

c. Specific to adult hospitals:
   a. CHD specific
      i. Sonographers with congenital certification/training
      ii. Imagers with ACHD expertise
      iii. Cath lab staff with ACHD expertise
      iv. Equipment/Lab/supplies/stock
   b. If the interventionalist travels from a children’s hospital to an adult hospital to perform procedures, appropriate privileging should be in place and staff with CHD experience should be available
Conclusions

The growing number and complexity of ACHD interventional procedures necessitate the development of ACHD-specific plans and processes for the delivery of high-quality comprehensive interventional care. Adequate training of future specialists is key and should be inclusive of both adult and pediatric specialists. Moreover, it is imperative that care for this population be delivered by multi-disciplinary teams that combine adult and pediatric expertise in a symbiotic and collaborative manner. ACHD board certification and comprehensive care center accreditation are important recent additions that serve to standardize the delivery of care to this population. Ongoing training and education are essential as is institutional commitment to the delivery of safe and efficacious care. Further planning and multi-society stakeholder collaboration is necessary to establish and help maintain competency standards for physicians in practice.
REFERENCES:


Table 1. Simple vs complex ACHD interventional procedures.

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<th>Simple ACHD Interventional Procedures</th>
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<th>Simple ASD closure</th>
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<td>Pulmonary venous angioplasty/stenting</td>
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<tr>
<td></td>
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<td></td>
<td></td>
<td>Mitral valvuloplasty/TMVR</td>
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<td>Surgical conduit/baffle angioplasty/stenting</td>
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<td></td>
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<td></td>
<td></td>
<td>Transcatheter pulmonary valve replacement</td>
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<td>Transcatheter tricuspid valve replacement</td>
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<tr>
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<td>Fontan fenestration/stenting</td>
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<tr>
<td></td>
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<td></td>
<td></td>
<td>Atrial septal fenestration/stenting</td>
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</tbody>
</table>

PFO= patent foramen ovale, ASD= atrial septal defect, PDA= patent ductus arteriosus, VSD= ventricular septal defect, TAVR= transcatheter aortic valve replacement, TMVR= transcatheter mitral valve replacement.
 Supplemental Table 1. 2018 SCAI ACHD Training & Competencies Roundtable Participants

**Chair:**
Jamil Aboulhosn, MD, FSCAI  
UCLA Adult Congenital Heart Disease Center  
Los Angeles, CA

**Co-Chairs:**
Ziyad M. Hijazi, MD, MSCAI  
Sidra Heart Center at Sidra Medicine  
Doha, Qatar  
Clifford Kavinsky, MD, PhD, MSCAI  
Rush University Medical Center  
Chicago, IL  
Doff B. McElhinney, MD, FSCAI  
Stanford University, Lucile Packard Children's Hospital  
Palo Alto, CA

**Scribes:**
Daniel McLennan, MBBS  
Children's Hospital Colorado  
Aurora, CO  
Sanjay Sinha, MD  
UCLA, Division of Pediatric Cardiology  
Los Angeles, CA  
Subeer Wadia, MD  
Rush University Medical Center  
Chicago, IL

**Expert Stakeholder Participants:**
Anita W. Asgar, MD  
Institut de Cardiologie de Montreal  
Montreal, Quebec  
Steven R. Bailey, MD, MSCAI  
LSU Health Sciences Center  
New Orleans, LA  
Lee N. Benson, MD, MSCAI  
The Hospital for Sick Children  
Toronto, Ontario  
Curt Daniels, MD  
Nationwide Children's Hospital  
Columbus, OH  
Payam Dehghani, MD, FSCAI  
Prairie Vascular Research Network  
Regina, Saskatchewan  
Ted E. Feldman, MD, MSCAI  
Edwards Lifesciences  
Irvine, California  
Joanna Ghobrial, MD  
Cleveland Clinic  
Cleveland, OH  
Matthew J. Gillespie, MD, FSCAI  
The Children's Hospital of Philadelphia  
Philadelphia, PA  
James B. Hermiller, MD, MSCAI  
The St. Vincent Medical Group at The Heart Center  
Indianapolis, IN  
Eric Horlick, MD, FSCAI  
Toronto General Hospital  
Toronto, Ontario  
Frank F. Ing, MD, MSCAI  
UC Davis Medical Center  
Sacramento, CA  
Ignacio Inglessis, MD, FSCAI  
Massachusetts General Hospital  
Boston, MA  
Thomas K. Jones, MD, FSCAI  
Seattle Children's Hospital  
Seattle, WA  
Saibal Kar, MD, FSCAI  
Los Robles Hospital  
Los Angeles, CA  
Daniel S. Levi, MD, FSCAI  
UCLA Medical Center  
Los Angeles, CA  
John Moore, MD, MPH, FSCAI  
UCSD Rady Children's Hospital  
San Diego, CA  
Evan Zahn, MD, MSCAI  
Cedars-Sinai Medical Center  
Los Angeles, CA
### Supplemental Table 2. Writing Group Disclosures of Relationships with Industry (RWI)

<table>
<thead>
<tr>
<th>Group Member</th>
<th>Date</th>
<th>Consultant</th>
<th>Speaker's Bureau</th>
<th>Ownership/Stock/Shareholder</th>
<th>Grant or Research Support</th>
<th>Institutional or Organizational Relationship</th>
<th>Expert Witness</th>
<th>Advisory Board</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jamil A. Aboulhosn, MD, FSCAI (Chair)</td>
<td>11/20/2018</td>
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<tr>
<td>Clifford J. Kavinsky, MD, PhD, MSCI (Co-chair)</td>
<td>11/3/2018</td>
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<tr>
<td>Doff B. McElhinney, MD, FSCAI (Co-chair)</td>
<td>11/12/2018</td>
<td>Medtronic ($35,000)</td>
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<tr>
<td>Ziyad M. Hijazi, MD, MSCI (Co-chair)</td>
<td>11/4/2018</td>
<td>Occlutech ($60,000)</td>
<td>NuMED ($30,000)</td>
<td>Venus Medtech</td>
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<tr>
<td>Frank F. Ing, MD, MSCI</td>
<td>11/12/2018</td>
<td>Abbott</td>
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<tr>
<td>Lee N. Benson, MD, MSCI</td>
<td>11/12/2018</td>
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<tr>
<td>Anita W. Asgar, MD</td>
<td>11/2/2018</td>
<td>Abbott</td>
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<tr>
<td>Daniel S. Levi, MD, FSCAI</td>
<td>11/12/2018</td>
<td>Edwards Lifesciences ($38,000), PFM Medical ($39,000), Medtronic ($10,000), Inceptus Medical ($75,000)</td>
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<tr>
<td>Eric Horlick, MD, FSCAI</td>
<td>11/6/2018</td>
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<tr>
<td>Ignacio Inglessis, MD, FSCAI</td>
<td>11/5/2018</td>
<td>Edwards Medical ($250,000), Medtronic ($250,000), St. Jude/Abbott ($200,000), Gore Medical ($150,000)</td>
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<tr>
<td>Joanna Ghabrial, MD</td>
<td>11/13/2018</td>
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<tr>
<td>Curt J. Daniels, MD</td>
<td>11/21/2018</td>
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</tr>
<tr>
<td>Joseph Kay, MD</td>
<td>11/25/2018</td>
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</tbody>
</table>
Supplemental table 3. Results of survey emailed to 30 Adult Congenital Heart Association accredited comprehensive care centers, 26 program directors responded to the questionnaire.

<table>
<thead>
<tr>
<th>Program</th>
<th>1. Indicate which setting ACHD cardiac catheterizations are performed at your institution</th>
<th>2. Estimate how many DIAGNOSTIC ACHD catheterizations were performed at your institution/s in 2018</th>
<th>3. Estimate how many INTERVENTIONAL ACHD catheterizations were performed at your institution/s in 2018</th>
<th>4. How many ACHD invasive/interventional faculty members work at your institution/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Center 1</td>
<td>Children’s Hospital within an Adult Hospital</td>
<td>61-120</td>
<td>&gt;120</td>
<td>3</td>
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<tr>
<td>Center 2</td>
<td>Both at the separate Children’s and Adult Hospitals</td>
<td>61-120</td>
<td>61-120</td>
<td>≥4</td>
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<tr>
<td>Center 3</td>
<td>Both at the separate Children’s and Adult Hospitals</td>
<td>61-120</td>
<td>31-60</td>
<td>3</td>
</tr>
<tr>
<td>Center 4</td>
<td>Both at the separate Children’s and Adult Hospitals (the hospitals are connected)</td>
<td>31-60</td>
<td>61-120</td>
<td>2</td>
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<tr>
<td>Center 5</td>
<td>Both at the separate Children’s and Adult Hospitals</td>
<td>31-60</td>
<td>31-60</td>
<td>2</td>
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<tr>
<td>Center 6</td>
<td>Children’s Hospital</td>
<td>31-60</td>
<td>31-60</td>
<td>3</td>
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<tr>
<td>Center 7</td>
<td>Both at the separate Children’s and Adult Hospitals. All Interventional procedures at Childrens. Diagnostic at Adult and Childrens</td>
<td>&gt;120</td>
<td>61-120</td>
<td>&gt;4</td>
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<tr>
<td>Center 8</td>
<td>Both at the separate Children’s and Adult Hospitals</td>
<td>61-120</td>
<td>31-60</td>
<td>≥4</td>
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<tr>
<td>Center 9</td>
<td>Children’s Hospital within an Adult Hospital</td>
<td>61-120</td>
<td>&lt; 30</td>
<td>1</td>
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<tr>
<td>Center 10</td>
<td>Children’s Hospital within an Adult Hospital</td>
<td>31-60</td>
<td>31-60</td>
<td>2</td>
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<tr>
<td>Center 11</td>
<td>Adult Hospital</td>
<td>&lt; 30</td>
<td>&lt; 30</td>
<td>3</td>
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<tr>
<td>Center 12</td>
<td>Both at the separate Children’s and Adult Hospitals</td>
<td>31-60</td>
<td>&lt; 30</td>
<td>3</td>
</tr>
<tr>
<td>Center 13</td>
<td>Children’s Hospital</td>
<td>31-60</td>
<td>&lt; 30</td>
<td>1</td>
</tr>
<tr>
<td>Center</td>
<td>Description</td>
<td>CHD Providers</td>
<td>Structural Attendings</td>
<td>Notes</td>
</tr>
<tr>
<td>--------</td>
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</tr>
<tr>
<td>14</td>
<td>Both hospitals; Both at the separate Children’s and Adult Hospitals</td>
<td>61-120</td>
<td>31-60</td>
<td>2 CHD trained providers at Children’s; 1 CHD trained provider at adult hospital. There are numerous structural attendings at the adult hospital.</td>
</tr>
<tr>
<td>15</td>
<td>Both at the separate Children’s and Adult Hospitals</td>
<td>61-120</td>
<td>31-60</td>
<td>3</td>
</tr>
<tr>
<td>16</td>
<td>Children’s Hospital within an Adult Hospital- 2 separate hospitals in the same location</td>
<td>61-120</td>
<td>31-60</td>
<td>3</td>
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<tr>
<td>17</td>
<td>Both at the separate Children’s and Adult Hospitals</td>
<td>61-120</td>
<td>61-120</td>
<td>3</td>
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<tr>
<td>18 *</td>
<td>Does not include TAVRs</td>
<td>Both at the separate Children’s and Adult Hospitals</td>
<td>31-60</td>
<td>&lt; 30</td>
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<tr>
<td>19</td>
<td>Children’s Hospital (with very occasional diagnostic case at neighboring adult hospital)</td>
<td>&gt;120</td>
<td>&gt;120</td>
<td>&gt;/ 4</td>
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<tr>
<td>20</td>
<td>Most ACHD caths are done in the children’s hospital. Some selective ones are done in the adult hospital (coronaries only etc)</td>
<td>31-60</td>
<td>31-60</td>
<td>3</td>
</tr>
<tr>
<td>21</td>
<td>Children’s Hospital within an Adult Hospital</td>
<td>31-60</td>
<td>&lt; 30</td>
<td>2</td>
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<tr>
<td>22</td>
<td>Both at the separate Children’s and Adult Hospitals</td>
<td>61-120</td>
<td>31-60</td>
<td>3</td>
</tr>
<tr>
<td>23</td>
<td>Children’s Hospital within an Adult Hospital</td>
<td>31-60</td>
<td>31-60</td>
<td>&gt;4</td>
</tr>
<tr>
<td>24</td>
<td>Both at the separate Children’s and Adult Hospitals</td>
<td>61-120</td>
<td>31-60</td>
<td>&gt;4</td>
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<tr>
<td>25</td>
<td>Both at the separate Children’s and Adult Hospitals</td>
<td>31-60</td>
<td>&lt; 30</td>
<td>&gt;4</td>
</tr>
<tr>
<td>26</td>
<td>Both at the separate Children’s and Adult Hospitals</td>
<td>&gt;120: (total 132)</td>
<td>&lt; 30: (total 49)</td>
<td>&gt;4</td>
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</tbody>
</table>