Interventional echocardiography: Opportunities and challenges in an emerging field

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INTRODUCTION

The first transcatheter aortic valve replacement (TAVR) in 2002 set off a revolution in percutaneous transcatheter therapies for structural heart disease. The subsequent bench to bedside transition has led to rapid development of TAVR valve options, technical expertise, and widespread availability. Particularly in the past decade, there has been a frenetic pace of device development, device delivery system innovation, improvements in technical skills, and a large number of randomized clinical trials which have generated a robust evidence base. This success has led to a maturity of TAVR systems and procedural techniques. Indeed, with modern valves and delivery systems, TAVR, even in low-risk patients appear to have equipoise with surgical aortic valve replacement (SAVR). One of the keys to the dramatic success of TAVR was the creation of multidisciplinary heart teams that provided a collaborative approach to patient selection and case planning. From their inception, heart teams recognized the importance of including dedicated cardiac imagers with expertise in advanced imaging, including computed tomography angiography (CTA) and 3D echocardiography. This has allowed for a unique imaging perspective to optimal patient selection and safe planning of these high-risk procedures. It also set the stage for certain imagers to move beyond pure diagnostic echocardiography, and become active participants in structural heart disease (SHD) cases. As TEE has become ingrained in cardiac catheterization laboratories and hybrid operating rooms, it has generated a need for individuals highly skilled in specific interventional TEE (iTEE) techniques. In this article, we will focus on iTEE competencies for guidance of various SHD procedures and challenges in the practice of this burgeoning field.

EVOLUTION OF INTERVENTIONAL ECHOCARDIOGRAPHY

In the early days of TAVR, most cases were performed on intubated patients with the administration of general anesthesia. Routine intubation allowed for TEE to be used for virtually all cases. During this time, TEE imaging facilitated an understanding of potential complications such as paravalvular aortic regurgitation, valve embolization, iatrogenic ventricular septal defects, and pericardial tamponade. Furthermore, the reliance on imaging created a close partnership between proceduralists and imagers. Due to routine use of CTA for TAVR valve sizing, advancements in TAVR valve technology, and improved operator experience, complications have been significantly reduced. As the TAVR procedure became increasingly optimized, the
performance of the vast majority of cases could be performed safely under monitored anesthesia care without endotracheal intubation. This shift has made routine TEE use during TAVR more technically difficult, and in many centers, iTEE operators are now involved with TAVR guidance only for high-risk cases or when there is a need for a specialized procedure such as the use of electrocautery to reduce the risk of coronary artery obstruction (BASILICA procedure) (Figure 1). Nonetheless, imagers continue to be an integral member of TAVR heart team discussions, given their expertise in the nuances of the assessment of aortic stenosis.

While the use of iTEE during TAVR is becoming less common, there are a number of other transcatheter therapies which will continue to require experienced iTEE operators for procedural guidance. Much of the recent growth in this area has been driven by transcatheter mitral valve repair (TMVr) using the MitraClip system (Abbott Laboratories), which is an FDA approved device for the transcatheter repair of both degenerative and functional (secondary) mitral regurgitation. The MitraClip system is loosely based on the surgical technique of edge-to-edge mitral valve repair by approximating the mitral leaflets with the so-called “Alfieri stitch.” When the Alfieri stitch is applied centrally to the valve orifice, it leads to a double orifice mitral valve. Unlike TAVR, the MitraClip procedure is driven almost exclusively by iTEE guidance (Figure 2). Due to the complex nature of mitral valve anatomy and function, MitraClip implantation is an intricate and lengthy procedure in which the iTEE operator acts as the “eyes” of the implanting physician. Unlike a surgical repair, the iTEE operator can assess the degree of mitral regurgitation reduction with each grasping attempt while monitoring for issues such as iatrogenic mitral stenosis or more catastrophic complications such as leaflet tears (Figure 2).

In addition to MitraClip repair, transcatheter mitral valve replacement (TMVR) procedures are now FDA approved and are growing in frequency and in complexity. Many of the original procedures were performed by placing a TAVR valve in severe native mitral annular calcification, a prior surgical mitral annular ring, or prior mitral bioprosthesis. Numerous other mitral valve specific technologies, however, are being developed including novel anchoring techniques, leaflet control technologies, and percutaneous mitral annuloplasty rings. The greatest risks during a TMVR procedure include valve embolization and obstruction of the left ventricular outflow tract (neo-LVOT). While CTA has emerged as a primary tool for valve sizing, as well as predicting the neo-LVOT obstruction risk, TEE plays key...
FIGURE 2  Transesophageal echocardiography guidance of MitraClip Procedure. Transcatheter mitral valve repair with the MitraClip edge-to-edge repair system is heavily dependent on transesophageal echocardiography (TEE). A, 3D TEE view of the mitral valve in the “surgeon’s view” where the aortic valve is at 12 o’clock and the left atrial appendage is at 9 o’clock. B, Retroesophageal 3-chamber view with color compare mode showing severe mitral regurgitation. C, Pulse wave Doppler demonstrate pulmonary vein systolic flow reversal consistent with severe mitral regurgitation. D, Transseptal puncture performed in a standard view (yellow arrow). Left panel shows a retroesophageal short axis. Right panel shows a biplane image of a modified bicaval view. In this view, the aortic valve is defined as anterior and the superior vena cava as superior. E, 3D TEE imaging is used to monitor crossing of the guide catheter, exposure of the MitraClip (yellow arrow), and bending the catheter safely toward the mitral valve. F, 3D view used to align the open MitraClip with the mitral valve leaflets (yellow arrow). G, Retroesophageal 3-chamber “grasping view.” The anterior leaflet (yellow arrow) and posterior leaflet (red arrow) are seen lying flat on the MitraClip arms with deep insertion. H, MitraClip with closed leaflet arms and good grasp of the mitral leaflets. I, Color compare imaging showing trace residual mitral regurgitation. J, Pulse wave Doppler of pulmonary vein demonstrates normalization of systolic flow (yellow arrow). K, 3D TEE “surgeon’s view” of the final image showing a double orifice mitral valve with a central tissue bridge. L, While the procedural atrial septostomy frequently closes without intervention, sometimes 3D TEE use used to guide closure with an atrial septal defect closure device (yellow arrow). AoV = aortic valve; LA = left atrium; LAA = left atrial appendage; LV = left ventricle; RA = right atrium.
roles in the safe guidance of the TMVR procedure as well as the identification and mitigation of complications (Figure 3). Furthermore, the expertise of the interventional echocardiographer in mitral valve imaging is vital to heart team discussions on the optimal approach for each patient, whether through percutaneous options of TMVR/TMVr vs a surgical approach.

There has also been growing enthusiasm for percutaneous left atrial appendage (LAA) closure devices for stroke reduction in patients with atrial fibrillation. Although surgical left atrial appendage ligation during open heart surgery has long been performed, a minimally invasive approach has long held appeal. While several devices are in development, at this time, FDA approval exists only for the Watchman left atrial appendage occluder system (Boston Scientific).14 Percutaneous LAA closure, similar to the MitraClip procedure, requires specific iTEE skills for safe guidance and device deployment (Figure 4).

Intracardiac closure procedures such as for atrial septal defects, patent foramen ovale, and ventricular septal defects are often completed using fluoroscopy and intracardiac echocardiography (ICE), though iTEE may be used for more difficult cases. Other procedures such as LAA closure are also exploring the utilization of ICE, in place of TEE, but are currently hampered by the limitations of far-field imaging and lack of 3D capabilities.15 ICE is typically performed by the interventionalist, who may have variable experience in imaging. Therefore, the expertise of an echocardiographer may be important in establishing experience in ICE imaging and in interpreting unusual findings. As septal occluders and vascular plugs are increasingly used for novel purposes such as closure of paravalvular leaks of prosthetic valves, iTEE is finding a new role to aid in these procedures as well (Figure 5). More complex procedures, such as those with adult congenital heart disease, are also likely to increase in volume due to improvements in survival of this patient population.

The growth of transcatheter procedures is creating an unprecedented demand for individuals with specialized iTEE skills and experience in the broad range of SHD imaging.16,17 Despite this demand, it has become clear that there are specific systemic issues that may limit the pipeline of available imagers to the workforce. These include availability and adequacy of training programs; practice models and reimbursement issues; and specific occupational hazards for iTEE practitioners. While there is overlap with intraoperative TEE as performed in the surgical suite, the focus of this document will be the use of iTEE in the cardiac catheterization laboratory or hybrid operating room.

**Figure 3** Role of transesophageal echocardiography for transcatheter mitral valve replacement. Transesophageal echocardiography (TEE) aids in the performance of transcatheter mitral valve replacement (TMVR). A, 3D TEE “surgeon’s view” showing pre-existing surgical valve which will be used for anchoring. B, Biplane imaging used for transseptal crossing for valve delivery. This patient had difficult visualization due to a thick noncompliant patch from the prior surgical procedure. C, After crossing of the interatrial septum, 3D TEE is used to guide the catheter (yellow arrow) toward the mitral valve to simplify valve crossing. A small inflated balloon tip (red arrow) is used to cross the valve and ensure there is no entanglement with residual mitral chords. D, Additional balloon septostomy (yellow arrow) is often required to allow crossing of the large valve delivery sheath. E, Immediate postdeployment of TMVR valve (red arrow) with balloon inflation (yellow arrow). F, TEE used to rapidly assess for valve stability, paravalvular mitral regurgitation, and spectral Doppler identification of a gradient through the newly formed left ventricular outflow tract or “neo-LVOT”. AoV = aortic valve; LA = left atrium; LAA = left atrial appendage; MV = mitral valve; RA = right atrium; RV = right ventricle.
DEFINING THE INTERVENTIONAL ECHOCARDIOGRAPHER

The interventional echocardiographer plays an indispensable role in the preprocedural evaluation, case planning, periprocedural guidance, and postprocedural assessment of patient outcomes. As the number of operators who are experienced in interventional echocardiography has grown, there has been an identification of several specific skills and core competencies in all modalities of echocardiography, including iTEE, TTE, and ICE18–20 (Table 1). While it is important for interventional echocardiographers to be facile in all aspects of echocardiography in SHD care, further discussion will focus on the specific aspect of iTEE for procedural guidance. All iTEE practitioners should develop the skills to safely guide a transseptal puncture as well as identify and safely guide wires and catheters in the heart. iTEE operators must have a nuanced understanding of cardiac anatomy and be skilled in 3D echocardiography techniques. For any given procedure, the iTEE operator should also have a clear understanding of all procedural steps and equipment used to allow for the prospective anticipation and mitigation of complications. A highly experienced imager should be capable of providing reliable optimizations in outcomes and reductions in procedural time.

It must be stressed that given the time-sensitive nature of SHD cases, an iTEE operator must have impeccable skills with TEE probe manipulation. Not infrequently, the iTEE operator must make urgent ad hoc diagnoses and quickly recognize emergent complications such as pericardial effusions. It should be emphasized that rapid identification and detection of wire location is one of the more challenging aspects of image guidance, but one of the most critical. The inability to rapidly hone in on the location of a wire during a critical point of a procedure can directly lead to a catastrophic adverse outcome such as free wall perforation.

Beyond specific skills with probe manipulation, a skilled iTEE operator must be an effective communicator. They must be able to clearly and succinctly communicate critical and often nuanced findings in a decisive fashion. Much like belaying for the safety of a rock climber, iTEE operators must speak loudly while utilizing a commanding presence and clear closed loop communication to avoid miscommunication. Optimal patient outcomes require the iTEE operator to provide assertive and direct opinions on key procedural steps such as device positioning. As opposed to the outpatient echocardiography laboratory where there is often the luxury of time for careful deliberation, during an iTEE case, rapid decisions must be correctly made with incomplete TEE information by integrating real-time data from fluoroscopy images and hemodynamic tracings.
Much of the interest around training for transcatheter procedures has centered around the training of the interventional cardiologist. This may be related in part to the baseline requirements mandated for the creation of SHD programs. Since the 2012 advent of commercial TAVR in the United States, there have long been stringent proceduralist volume requirements set forth by the Centers for Medicare and Medicaid Services (CMS) in the National Coverage Determination (NCD) for starting and maintaining a TAVR program. With the approval of the MitraClip procedure, similar extensive proceduralist requirements were set forth in the NCD for TMVr procedures. Interestingly the TAVR NCD makes no mention of any institutional imaging requirements. For imaging intensive TMVr procedures like the MitraClip, the current NCD only has only a generic statement of the necessity of imaging expertise. It is expected that updates to this NCD will likely impose more formal minimum procedural programmatic requirements for experience and training.

Despite the growing need for well-trained iTEE operators, the system for training remains inadequate and poorly defined. While many trainees in advanced imaging programs attain exposure to SHD procedures, it is unclear how many obtain the depth of experience needed to be an independent primary iTEE operator. It is likely that very few programs provide the intensive and in-depth training required to truly master these skills with most current iTEE operators learning “on the job.” There is increasing recognition in training guidelines that at least introductory exposure to these procedures is needed for those who pursue advanced echocardiography (Level III) training. However, concrete competencies of dedicated iTEE training have not been uniformly defined and training programs remain nonstandardized.

While the best training for SHD procedures requires hands on experience, introductory experience in this field may be obtained by the use of training simulators. The American College of Cardiology COCATS 4 document makes a specific note of the growing role and potential of TEE simulators. Commercially available virtual (dry) simulators primarily focus on basic TEE image acquisition. More robust systems to simulate active procedural guidance are less available but given the growth in iTEE, it is likely development of these high level systems will appear in a matter of time. Many device vendors have more intensive “wet” simulations with cadaveric or animal hearts for device development. These types of systems are generally used for the training of iTEE operators and proceduralists on new devices for clinical trials. The expense and lack of portability of
Advancements in technology will help reduce the learning curve of this type of setup is not amenable for widespread use by trainees. Imaging quality continues to improve and advancements in 3D technology now allow imaging a larger field of view that aid in device/wire guidance. Newer machines and probes that allow for single beat color Doppler 3D imaging reduce the difficulty of challenging procedures such as paravalvular leak closures. There is also growing availability of commercial image fusion technologies which allow the TEE image to be merged with fluoroscopy images, facilitating more direct correlation between the imaging modalities.

### 5 | OCCUPATIONAL HAZARDS

Radiation exposure has long been understood as an important occupational exposure for interventional radiologists and interventional cardiologists.\(^{28,29}\) Due to the increase in the need for iTEE, radiation exposure is now being understood as a specific risk for iTEE operators. The risks of radiation exposure in cath laboratory cases have also been recognized for sonographers who are increasingly being asked to participate in cath laboratory cases.\(^{30}\) As iTEE operators are often the closest to the fluoroscopy C-arm, they may even be exposed to radiation doses at least as high as the primary device implanter, a risk which can be significantly mitigated with additional shielding.\(^{31}\) Thus, all iTEE operators must be forcefully diligent about ensuring they have adequate protection including body lead, thyroid guards, lead shielded eye protection, lead-lined cap, full coverage standing shielding, pull down lead shielding, and if possible lead-lined gloves. Radiation protection solutions will be institutional dependent, but iTEE operators should be aware of common issues such as standard equipment such as lead thyroid guards may be designed to prevent forward facing radiation; however, the iTEE operator is often standing sideways to the radiation source, leading to less protection. The iTEE operator must insist on clear communication from the implanting physicians so they may increase their distance from the fluoroscopy C-arm prior to long runs of cine angiography or high radiation digital subtraction angiography.

Other occupational hazards of the iTEE operator are likely to become clearer with time. For instance, the known higher incidence of back pain and repetitive strain injury known to the interventional cardiologists will almost certainly become an issue for the iTEE operator.\(^{32}\) Additionally, while the interventional cardiologists may be accustomed to a higher degree of morbidity and mortality directly related to catheterization laboratory-based procedures, the iTEE operators may even be asked to participate in cath laboratory cases.\(^{30}\) As iTEE operators are often the closest to the fluoroscopy C-arm, they may even be exposed to radiation doses at least as high as the primary device implanter, a risk which can be significantly mitigated with additional shielding.\(^{31}\) Thus, all iTEE operators must be forcefully diligent about ensuring they have adequate protection including body lead, thyroid guards, lead shielded eye protection, lead-lined cap, full coverage standing shielding, pull down lead shielding, and if possible lead-lined gloves. Radiation protection solutions will be institutional dependent, but iTEE operators should be aware of common issues such as standard equipment such as lead thyroid guards may be designed to prevent forward facing radiation; however, the iTEE operator is often standing sideways to the radiation source, leading to less protection. The iTEE operator must insist on clear communication from the implanting physicians so they may increase their distance from the fluoroscopy C-arm prior to long runs of cine angiography or high radiation digital subtraction angiography.

### TABLE 1  Common transcatheter procedures and essential periprocedural skillsets for interventional echocardiography operators

<table>
<thead>
<tr>
<th>Procedures</th>
<th>Essential skillset</th>
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<tbody>
<tr>
<td>TAVR</td>
<td>3D image generation including biplane imaging</td>
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<tr>
<td>MitraClip (TMVr)</td>
<td>3D dataset manipulation for sizing of valves, cardiac shunts, PVL size, etc.</td>
</tr>
<tr>
<td>TMVR</td>
<td>Guidance of transseptal puncture</td>
</tr>
<tr>
<td>Mitral Balloon Valvuloplasty</td>
<td>Wire and catheter tracking</td>
</tr>
<tr>
<td>LAA Occlusion</td>
<td>Image devices in multiple windows to avoid device shadowing</td>
</tr>
<tr>
<td>PVL Closure</td>
<td>Rapid identification of device deployment, stability, and appropriate seating</td>
</tr>
<tr>
<td>ASD/PFO Closure</td>
<td>Rapid assessment of valve pathology</td>
</tr>
<tr>
<td>VSD Closure</td>
<td>Rapid assessment of complications such as pericardial effusion, aortic root hematoma, or iatrogenic VSD</td>
</tr>
<tr>
<td>Transcatheter Tricuspid Valve Replacement/Repair</td>
<td>Rapid identification of paravalvular leak, valve migration, gradient increase for TAVR</td>
</tr>
<tr>
<td>Angiovac Guidance</td>
<td>Identification of postvalve implantation obstruction of the neo-LVOT after TMVR. Aid in identification of the apex in TMVR valve devices which require apical access.</td>
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<tr>
<td></td>
<td>Guidance of leaflet capture for transcatheter tricuspid valve repair when TEE windows suboptimal</td>
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<tr>
<td></td>
<td>Localization of echocontrast to basal septum during percutaneous ETOH septal ablation procedure</td>
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</table>

**Transthoracic echocardiography**

- TAVR
- TMVR
- Transcatheter Tricuspid Valve Replacement/Repair
- ETOH septal ablation

**Intracardiac echocardiography**

- Mitral Balloon Valvuloplasty
- LAA Occlusion
- PVL Closure
- ASD/PFO Closure
- VSD Closure

Abbreviations: ASD = atrial septal defect; ETOH = alcohol (ethanol); ICE = intracardiac echocardiography; LAA = left atrial appendage; LVOT = left ventricular outflow tract; PFO = patent foramen ovale; PVL = paravalvular leak; TAVR = transcatheter aortic valve replacement; TMVR = transcatheter mitral valve repair; TMVR = transcatheter mitral valve replacement; VSD = ventricular septal defect.
Thus, for a two clip MitraClip case, there is an 8.6-fold difference the procedure generate 7.93 work RVUs (12.32 total facility RVUs). MitraClip procedure itself generates 32.25 work RVUs for the pro-
and effort a more complex procedure may take. Furthermore, the for the entire range of iTEE procedures and the differences in time is worth 2.3 work RVUs, while the iTEE 93355 code is worth 4.66
Based on the 2020 CMS Final Rule fee schedule, the 93312 code To account for this, a separate CPT code (93355) was developed.
3D TEE technology development standpoint as well as from an ex-
operator may require additional preparation for the additional psy-
chologic distress that may arise from adverse outcomes related di-
rectly to high-pressure rapid imaging decisions.

6 | PRACTICE MODELS AND REIMBURSEMENT

Despite the many specific skills, training, and occupational hazards taken on by iTEE operators, current reimbursement often models do not adequately account for the complexity and risk undertaken. Several current models which are used across institutions in the United States are discussed below.

One common model is the use of the relative value unit (RVU) system. The RVU system assigns a specific value to services provided that is intended to reflect the complexity and time required for a procedure. These RVU’s are often tied to Current Procedural Terminology (CPT) Codes, which are used by the Centers for Medicare and Medicaid Services (CMS) for billing (Table ). Most outpatient TEE services utilize the 93312 code, which involves TEE probe placement, image acquisition, and reporting. Whereas standard TEE may take anywhere from 20 to 30 minutes to complete depending on the complexity of the case, an iTEE case such as a MitraClip procedure, may require at least 2–4 hours of direct active imaging. This is not inclusive of additional time taken to acquire baseline and completion images, and frequently more complex study interpretation involving 3D measurements and quantification. The performance and reporting of even two iTEE cases for MitraClips may take an entire day. To account for this, a separate CPT code (93355) was developed. Based on the 2020 CMS Final Rule fee schedule, the 93312 code is worth 2.3 work RVUs, while the iTEE 93355 code is worth 4.66 work RVUs. This approximately twofold increase does not account for the entire range of iTEE procedures and the differences in time and effort a more complex procedure may take. Furthermore, the MitraClip procedure itself generates 32.25 work RVUs for the proceduralist (52.16 total facility RVUs). Additional clips placed during the procedure generate 7.93 work RVUs (12.32 total facility RVUs). Thus, for a two clip MitraClip case, there is an 8.6-fold difference

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<table>
<thead>
<tr>
<th>Standard TEE Single Operator</th>
<th>93312</th>
<th>2D TEE including probe placement, image acquisition, interpretation and reporting by a single physician</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard TEE 2 Operators</td>
<td>99313</td>
<td>Code for placement of TEE probe only</td>
</tr>
<tr>
<td></td>
<td>99314</td>
<td>Code for remaining elements of TEE service</td>
</tr>
<tr>
<td>Intraoperative Monitoring</td>
<td>99318</td>
<td>Generally used for TEE during cardiac surgery, frequently not a covered service</td>
</tr>
<tr>
<td>TEE Guidance of Transcatheter Therapies</td>
<td>93355</td>
<td>Used for TEE guidance of guidance of a transcatheter therapies for structural interventions such as transcatheter valve replacement, repair, paravalvular leak closure, left atrial appendage occlusion, or cardiac septal defect closure. Includes guidance, probability manipulation, measurements, Doppler, 3D, and use of ultrasound contrast</td>
</tr>
</tbody>
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Table 2: Common Current Procedural Terminology (CPT) codes used for transesophagal echocardiography

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The low assignment of work RVUs for iTEE services means that without specific support from the practice or institution who wishes to offer these procedures, the iTEE operator becomes on paper a liability; despite performing a labor-intensive service with unique risks and work hazards. Often iTEE operators may be asked to additionally supplement their RVUs with additional clinical activities to support their time. Therefore, particularly at an institution with high SHD case volumes, a pure RVU system is not sustainable for the imager. Unfortunately, many iTEE operators are early career physicians, who may not have the knowledge, capability, or leverage to advocate for an alternative arrangement. More senior physicians may be better shielded by greater levels of protected administrative time. Forward-thinking institutions must abandon the productivity model and find alternative ways to support their iTEE imagers. This could come in the form of administrative offset days where full-time equivalent (FTE) hours are assigned by the institution. For particularly high volume iTEE operators, their time can also be more fairly compensated on a fixed salary basis. Other arrangements can be created in which the RVU’s for the entire procedure are pooled then subsequently distributed more equitably between the device implanters and the imagers. Unless advocacy efforts are successful in creating a more standardized and equitable RVU distribution, iTEE imagers must be proactive in negotiating sustainable local solutions for their time.

7 | FUTURE DIRECTIONS

The future of iTEE will undoubtedly continue to mature from both a 3D TEE technology development standpoint as well as from an expanding pool of operators with adequate skills and experience. For this field to advance and stay sustainable, it cannot ride on the sweat and unbridled enthusiasm of the newly minted early career graduates. As the multitude of devices currently in development reaches maturity, for a sustainable career, most large institutions will likely
require 2–3 fully supported iTEE operators to allow for load leveling and skillset redundancy.

Additionally, as the field of iTEE continues to develop, we are slowly but steadily approaching a phase where iTEE skills should and must be carefully taught under supervision. Given the high-pressure nature of these cases and growing number of experienced iTEE operators to serve as mentors, within a generation, “on the job” training should no longer be the accepted standard. To ensure patient safety and quality care, iTEE operators should be required to document an adequate number of supervised cases to demonstrated competency prior to independent iTEE practice. To aid this, a coordinated effort should be undertaken by high volume SHD programs to train dedicated iTEE specialists and develop the data that supports the unique and challenging nature of this field. Hopefully, the learning curve of the future will also be improved with newer technologies such as fusion imaging and novel simulation technologies.

Current iTEE practitioners must also be diligent in continuing to expand their skillset and embrace multimodality imaging. As there are developments and advancements in 3D ICE technology, the iTEE provider of the future may find a new role in the operation of 3D ICE catheters.15

Finally, given the advancement and increasing complexity of transcatheter therapies, the interventional imager has become an indispensable and critically important member of the heart team. It is important for those who practice iTEE to actively discuss the current challenges of practicing under current reimbursement structures, and partner with hospital systems as well as major cardiovascular and imaging societies to advocate for and foster the development of this nascent field.

DATA AVAILABILITY STATEMENT
Data sharing is not applicable to this article as no new data were created or analyzed in this study.

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