GUIDELINES AND STANDARDS

Recommendations for Echocardiography Laboratories Participating in Cardiac Point of Care Cardiac Ultrasound (POCUS) and Critical Care Echocardiography Training: Report from the American Society of Echocardiography

James N. Kirkpatrick, MD, FASE, Richard Grimm, DO, FASE, Amer M. Johri, MD, FASE, Bruce J. Kimura, MD, Smadar Kort, MD, FASE, Arthur J. Labovitz, MD, FASE, Michael Lanspa, MD, FASE, Sue Phillip, RCS, FASE, Samreen Raza, MD, Kelly Thorson, MSRS, ACS, RDCS, RCCS, FASE, and Joel Turner, MD, FRCP, *Seattle, Washington; Cleveland, Ohio; Kingston, Ontario and Montreal, Quebec, Canada; San Diego and Palo Alto, California; Stony Brook, New York, Tampa and Naples, Florida; Salt Lake City, Utah; Baltimore, Maryland; Plano, Texas*

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From University of Washington Medical Center, Seattle, Washington (J.N.K.); Cleveland Clinic, Cleveland, Ohio (R.G.); Queen's University, Kingston, Ontario, Canada (A.M.J.); Scripps Mercy Hospital, San Diego, California (B.J.K.); Stony Brook University, Stony Brook, New York (S.K.); Tampa General Hospital and Naples Heart and Vascular Center, Tampa and Naples, Florida (A.J.L.); Intermountain Medical Center and University of Utah, Salt Lake City, Utah (M.L.); Johns Hopkins Medicine, Baltimore, Maryland (S.P.); Baylor Scott & White Heart Hospital, Plano, Texas (S.R.); Lucile Packard Children's Hospital Stanford, Palo Alto, California (K.T.); and Jewish General Hospital, Montreal, Quebec, Canada (J.T.).

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Reprint requests: American Society of Echocardiography, Meridian Corporate Center, 2530 Meridian Parkway, Suite 450, Durham, NC 27713 (E-mail: ase@asecho.org).

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Abbreviations
2D = Two-dimensional
3D = Three-dimensional
CCE = critical care echocardiography
LV = Left ventricle
POCUS = point of care ultrasound
TEE = Transesophageal echocardiography
UAPE = ultrasound assisted physical examination

SUMMARY

Cardiac point of care ultrasound provides rapid bedside diagnosis of important cardiovascular pathology and is performed by a growing number of users in a variety of clinical settings. Echocardiographers and sonographers may be asked to play a role in training practitioners in cardiac ultrasound who come from disciplines outside of the cardiovascular field. These trainees' backgrounds, needs, objectives, and available time can create challenges and opportunities for echocardiography laboratories. Furthermore, the presence of additional learners in the echocardiography laboratory will require additional resources. This document is the product of an American Society of Echocardiography writing group composed of representatives from cardiology, critical care medicine, emergency medicine, and cardiac anesthesiology and others, assembled to provide expert guidance. The following recommendations are intended as practical resource to assist echocardiography laboratories to train partners in the provision of high quality cardiac ultrasound: 1: **Identify Trainee Needs**; 2: **Employ Educational Resources**; 3: **In General, Avoid Certifying Global Competency**; 4: **Count the Cost in Echocardiography Laboratory Resources**; 5. **Advocate for Resources to Meet Extra Needs**.

I. INTRODUCTION

The application of ultrasound for the purpose of imaging the heart represents a remarkably versatile and incredibly useful diagnostic tool. Advances in sophistication are matched by advances in miniaturization, allowing high quality, relatively low-cost imaging systems to proliferate as point of care tools. Cardiac Point-of-Care Ultrasound (cardiac POCUS) leverages these developments to provide rapid bedside diagnosis of important cardiovascular pathology when performed by a large variety of users. Practitioners outside the confines of cardiovascular medicine have adopted cardiac POCUS, and its use is now standard in many adult and pediatric emergency departments, critical care settings, and outpatient clinics, often as part of a broader examination involving other organ systems. Hospitalists on general wards and anesthesiologists in pre-operative clinics are increasingly using cardiac POCUS.

There are longstanding training programs in emergency medicine and critical care. On-line and in-person academic and commercial training courses serve a growing number of practitioners in and outside of academic settings all over the world. Many academic institutions include training for medical students, medical residents and others.[1] A number of different organizations administer POCUS certification pathways for physicians, advanced practice providers, and students.[2] In January 2019, the National Board of Echocardiography offered a special certification for practitioners of echocardiography in critical care settings for the first time.

Echocardiographers and sonographers may be asked to play a role in training practitioners in cardiac ultrasound who come from disciplines outside of the cardiovascular field. In particular, echocardiography labs will likely play an expanded role in training many individuals seeking certification in critical care echocardiography. These trainees' backgrounds, needs, objectives, and available time do not necessarily fit into the standard pathways for training cardiology fellows and sonographers. The presence of additional learners in the echocardiography laboratory will require additional resources, including compensation for echocardiographer and sonographer time, and the use of reading stations and echo machines.

One of the goals of the American Society of Echocardiography (ASE) is to provide education and training for all users of cardiac ultrasound, as well as to serve its members who participate in education and training of learners from all disciplines. This document is the product of an ASE writing group composed of representatives from cardiology, critical care medicine, emergency medicine, and cardiac anesthesiology and others, assembled to provide expert guidance in the form of practical recommendations. This document does not address all training issues in ultrasound education, particularly those in medically underserved areas, nor does this paper address billing for cardiac ultrasound services, performance of transesophageal echocardiography (TEE) during resuscitation, or the expectation that cardiac ultrasound should be standard of care in settings like the emergency department or intensive care unit.

The writing group operated under the assumption that, if provided with adequate resources, echocardiographers and sonographers should welcome opportunities to participate constructively in the education and training of users of cardiac ultrasound, promoting quality in the service of patients and integrating all forms of bedside cardiac ultrasound with standard echocardiography. In short, the goal should be to train **partners** in the provision of high quality care.

Johri, *et al.* recently summarized the state of cardiac ultrasound in medical school education.[3] The current paper complements that work by focusing specifically on the role of the echocardiography laboratory, especially in light of the new critical care echocardiography certification pathway. Our writing group provides the following recommendations as a resource for echocardiography laboratories: 1: **Identify Trainee Needs**; 2: **Employ Educational Resources**; 3: **In General, Avoid Certifying Global Competency**; 4: **Count the Cost in Echocardiography Laboratory Resources**; 5. **Advocate for Resources to Meet Extra Needs**.

A. Definitions

In this document, we define and address four main forms of transthoracic cardiac ultrasound, recognizing there are different ways to categorize the practice. (Table 1) **Ultrasound assisted physical examination (UAPE)**, **Cardiac POCUS**, **critical care echocardiography (CCE)**, and **standard transthoracic echocardiography** (TTE–including limited transthoracic echocardiography and comprehensive echocardiography performed by echocardiography laboratory staff) have sufficient differences in philosophy, scope, and training so as to co-exist as separate and complementary techniques within the field of cardiac ultrasound. Regardless of where, how and by whom cardiac ultrasound is performed, all practitioners should be aware that employing it beyond one's capacity, and inadvertently recording but not recognizing important findings, can have serious clinical consequences and may even subject the

Table 1 Definitions of cardiac ultrasound categories

	UAPE	Cardiac POCUS	CCE	Limited echo	Comprehensive echo
Diagnostic expectations	"Routine" performance of a single imaging protocol to augment bedside examination	Focused exams with specific imaging protocols based upon suspicion of a specific disease (e.g., rule out tamponade)	Focused on a collection of specific views/findings pertinent to the care of the critically ill (e.g., cardiac output, fluid responsive)	Focused on previously delineated findings as a follow-up exam; limited imaging protocol applied to answer a specific question	Comprehensive, all findings, quantification; increasingly use advanced techniques
Application frequency	Frequent, daily, multiple physicians	Usually once, per disease, but more frequently if change in clinical status	On admission or change in clinical status, potentially frequently	As follow up to comprehensive echo; potentially multiple times over weeks to months	Once (per admission, change in clinical status)
Interpretation of findings	Presence or absence of ultrasound "signs" indicative of cardiac abnormality	Findings related to the diagnosis sought in protocol	Primary and incidental findings recorded in views	All findings, primary and incidental, recorded in limited views	All findings, primary and incidental recorded in comprehensive imaging
Quantification	Usually Absent	Optional	Typically	Typically	Mandatory
Indication	Physical exam	Clinical suspicion	Medical necessity	Medical necessity	Medical necessity
Documentation	Images not recorded (except for QA), findings reported in physical exam	Image archiving and formal reporting controversial	Images archived, formal report	Images archived on PACS, formal report	Images archived on PACS, formal report
Teaching required	Introductory and modest (weeks)	Modest (weeks to months)	Advanced (months)	Advanced (years)	Advanced (years)
Notes	Used "in the manner and intent" of cardiac physical examination	Similar to UAPE, but disease specific	Imaging protocols specific to issues in the critically ill; comparison to available prior studies as indicated	Reading all findings increases training burden. Comparison to available prior studies is standard practice. Must be able to convert to comprehensive at bedside	Completely evaluates all findings, regardless of referral question or incidental nature. Comparison to available prior studies is standard practice.

CCE, critical care echocardiography; *PACS*, Picture Archival and Communication System; *POCUS*, point of card ultrasound; *UAPE*, ultrasound assisted physical examination.
Adapted from: Kimura BJ. Point-of-care cardiac ultrasound techniques in the physical examination: better at the bedside. Heart 2017;103:987-994. https://doi.org/10.1136/heartjnl-2016-309915.

practitioner to legal liability. Therefore, training, assessment, and continuous quality improvement are crucial components for all forms of cardiac ultrasound, from the most limited bedside exam to the most advanced comprehensive echocardiogram.

"Point of care" can technically refer to all examinations performed at the patient's bedside, but here we employ its use in a more specific fashion. The writing group employs the terms "Ultrasound Augmented Physical Examination (UAPE)" and "cardiac POCUS" to mean a limited imaging protocol employed to detect or characterize a subscribed list of generally readily apparent pathological findings or to facilitate serial assessments of specific anatomic or physiological parameters. UAPE and cardiac POCUS employ specific views to meet the expediency required of rapid bedside examination in the clinical arena.[1,4-7] Rapid diagnosis allowing initiation of therapies constitutes a clear benefit, particularly in settings where delay of even a few minutes impacts morbidity and mortality. The potential for non-invasive, facile, and frequent repeat imaging (e.g., to monitor volume status) and focused screening (e.g., pre-participation sports physicals) constitute other uses. The protocols employed in UAPE and cardiac POCUS can vary widely, as noted in Table 1. The writing group differentiates UAPE from cardiac POCUS in that UAPE is employed as an "ultrasonographic stethoscope", meant to improve diagnosis of cardiovascular findings beyond what is possible with standard physical examination techniques. UAPE images are often not recorded, and findings are documented in a progress note (similar to physical examination findings) rather than in a formal report. Although value exists in recording cardiac POCUS exams in regards to patient care and quality assurance, the writing committee recognizes the reluctance of some cardiac POCUS users to archive undiagnosed incidental findings and manage and review a large volume of patient data.

This document considers CCE to include critical care, advanced emergency medicine and pre-operative imaging protocols. CCE usually employs an expanded protocol and a list of diagnoses pertinent to the critical care setting but shares with cardiac POCUS the advantages of rapid bedside diagnosis and frequent, non-invasive monitoring. Doppler assessments may be included. Report generation, image archiving, comparison to previous studies, notification, quality assurance, and maintenance of training standards (credentialing) of operators are all important aspects of CCE (Table 1).

TTE is a formal diagnostic test involving a comprehensive and standardized protocol and more advanced analysis and interpretation than CCE, though some CCE examinations may employ many modalities common to comprehensive echocardiography. All cardiac findings in the imaging views should be reported.[8] Importantly, although a majority of TTEs performed are comprehensive studies, limited TTE plays a role in follow-up studies or in focused studies examining specific indications. A crucial distinction between CCE and a limited TTE performed by the echocardiography laboratory is that a limited TTE can be converted to a comprehensive study, including advanced modalities, as needed. It may be necessary to perform a TTE to delineate/characterize/quantify or revise findings identified on UAPE, cardiac POCUS and CCE, and especially in cases when suspicion for a cardiac cause of a patient's clinical situation remains despite negative findings.

TTE increasingly involves techniques such as advanced valvular and hemodynamic quantification, 3D imaging, ultrasound enhancing agent (UEA) imaging, agitated saline contrast administration and speckle tracking that are beyond the scope of UAPE, cardiac POCUS and many CCE protocols. Conversely, UAPE, cardiac POCUS and CCE protocols often involve imaging that is not currently part of the standard TTE examination (e.g., lung windows, deep vein imaging). In this way, cardiac POCUS and CCE work in collaboration with TTE to leverage the strengths of each.

Key Points

- Ultrasound Assisted Physical Examination (UAPE) and Cardiac POCUS involve a limited imaging protocol to detect or characterize specific findings or to facilitate serial assessments in a timely fashion. Findings should be documented in the medical record. This writing committee recommends that cardiac POCUS images be recorded with a formal report generated, but acknowledges this is a controversial point.
- CCE employs an expanded protocol and a list of diagnoses pertinent to the critical care setting. Doppler assessments may be included, and assessments not part of standard transthoracic echocardiography are common (e.g., lung windows). Report generation, image archiving, comparison to previous studies, notification, quality assurance, and maintenance of training standards (credentialing) of operators are all important aspects of CCE.
- Standard transthoracic echocardiography (TTE) employs a comprehensive and standardized protocol and more advanced analysis and interpretation. When clinically indicated, a limited standard TTE can be converted to a comprehensive study, including advanced modalities (3D, strain, comprehensive Doppler).
- No clinician should employ any form of cardiac ultrasound beyond his or her capacity. Training, assessment and continuous quality improvement are crucial components for all forms of cardiac ultrasound.

II. RECOMMENDATION 1: IDENTIFY TRAINEE NEEDS

Point-of-care ultrasound is a multispecialty field with broad applications.[9-16] The spectrum of POCUS, even when restricted to cardiac imaging, is often defined by the user's practice (e.g., general examination vs indication-based), patient mix (e.g., outpatient screening vs inpatient), or subspecialty (e.g., focused exams by general medicine hospitalists, or practitioners in emergency medicine, anesthesiology or critical care). The trainee's professional position also determines training needs. Medical students and residents on rotation in the echocardiography laboratory may be fulfilling a curricular requirement for basic training in UAPE or as an elective to learn about echocardiography, whereas practicing physicians may be honing their skills to serve patients. In light of these important differences, before a trainee begins a rotation in the echocardiography laboratory, there should be some identification of the needs (objectives of training). Figure 1 depicts a stepwise approach that will help to craft a useful training experience.

Often, the formal requirements of a curriculum drive the training of cardiac POCUS and CCE users, and sometimes of UAPE learners.

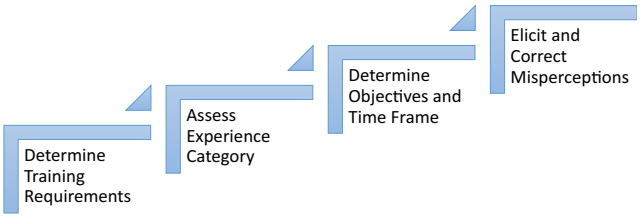

Figure 1 Framework for planning the training experience.

Various specialty societies have published curricular recommendations that outline the specific needs of trainees from specific specialties.[17-20] For example, the World Interactive Network Focused On Critical Ultrasound (WINFOCUS) provides a general guide to training requirements for cardiac POCUS in critical care,[21,22] and an expert roundtable on echocardiography in the intensive care unit generated an international consensus statement on training standards for advanced critical care echocardiography in 2014.[17] The content outline for the Examination of Special Competence in Critical Care Echocardiography, which built on these prior documents, is provided in Appendix 1. Even for trainees who are not part of a program with formal requirements, individualizing training by discussing the training experience is preferable to providing a uniform experience to everyone.

The large range of experience that trainees have prior to pursuing cardiac ultrasound education creates challenges at all levels of training.[23] Trainees may be complete novices to ultrasound, or they may have had some informal or formal training, including prior completion of a cardiac POCUS, emergency medicine, anesthesiology, or critical care-specific curriculum. While the complete novice may require a training program that starts with basic concepts, other trainees may already have mastered them. Our writing group recommends attempting to categorize trainees into different experience categories (Figure 2).

Importantly, trainees' competency level may be below or above their category of experience, and it is possible that a trainee may be quite competent in one aspect while simultaneously deficient in another. Specifically, the trainee may be at very different stages in content knowledge, scanning skills and interpretive skills. There are various methods to assess competency, and this is an evolving area in ultrasound education (Appendix 2).[11,12,19,20,22] At present, there is insufficient evidence to recommend one assessment over another.

Trainees must make clear to their teachers/trainers in the echocardiography laboratory what they require and work with the echocardiography laboratory to determine whether the training the lab can provide meets the trainee's objectives. A written outline of objectives will help focus the training on the aspects of cardiac ultrasound that are most useful and will prove most efficient, in addition to setting reasonable expectations for the scope of training. Table 2 provides sample objectives for a cardiac POCUS trainee.

Many trainees, particularly in academic settings, will be seeking training in the echocardiography laboratory as part of a training program. Echocardiography trainers should consult with the directors or experts in trainee's program to develop objectives and in order to contribute optimally to a coordinated training experience. For example, a trainee's critical care program may seek refinement of skills during its trainees' echocardiography laboratory rotations, building on basic scanning and interpretation instruction already provided. This trainee may then receieve further focused training and complete a required number of scans in the critical care setting. The trainee may return to the echocardiography laboratory at a later date for a concentrated "refresher" experience.

A. Generic Trainee Categories

Despite the need for individualization, training experiences can be categorized into a simplified framework. Figure 3 proposes sample training categories with suggested curricular elements. "**Observer**" experiences—consisting of exposure to the workings of the echocardiography laboratory—can help clinicians better understand the indication and limitations of echocardiography and get a first-hand glimpse into what their patients undergo during an echocardiogram test. Learners may spend time shadowing echo lab staff and observing the processes of transthoracic, stress and transesophageal echocardiography, from acquisition of images to interpretation. They should learn appropriate use criteria, indications and risks of stress and transesophageal echocardiography and report nomenclature.

Training in cardiac ultrasound **scanning** can be implemented in several forms including 1) shadowing and observation of a sonographer, 2)"holding-the-hand" scanning, 3) acquiring "extra views" after the sonographer has completed a scan and 4) adjudication of saved, independently-performed scans. Cardiac ultrasound **interpretation** training can involve several methods including 1) reading with experts, 2) reading independently with subsequent expert review, and 3) independently generating preliminary reports with expert feedback. Repetition and experience are crucial in both scanning and interpretation for all trainees. Thus cardiac UAPE, POCUS and CCE trainees should focus their efforts to gain as much repetition and experience as possible in appropriate contexts. Training may include blended educational experiences using e-learning and self-assessment in addition to formal face-to-face interaction and didactics.[10]

Time frame for learning also plays a significant role. Trainees generally are allotted a limited amount of time for cardiac ultrasound training, and echocardiography laboratory personnel may need to adjust the curriculum to the available training time. For example, observational experiences can last any amount of time, but a 2-day exposure to echocardiography may not be sufficient to view all of the different echocardiography modalities. UAPE rotations are similarly variable, but our writing group recommends that trainees spend at least 2 weeks in training. Cardiac POCUS training time frame should depend significantly on prior experience. Trainees who have learned "the basics" in the emergency department may benefit from one or more weeks in the echocardiography laboratory to hone skills, while we recommend a least a month-long rotation for novice users. The optimal time for CCE trainees also depends on prior experience, but total training time involving concentrated emphasis on CCE should last at least 2-3 months. The echocardiography lab may also participate in "refresher" courses, particularly for trainees and practitioners who do not use cardiac ultrasound at the bedside on a regular basis. The duration of these courses can be quite variable and tailored to individual needs and experience. Importantly, echocardiography personnel who participate in training of UAPE, cardiac POCUS and CCE practitioners should emphasize the importance of participation in quality assurance and quality improvement processes. Many institutions and training programs have developed robust processes, some of which may be integrated into refresher courses. It is beyond the scope of this document to recommend specific elements for a quality assurance/quality improvement program.

Untrained	Informal Training	Limited Formal Training	Formal Training, Experience
• Observer • Novice scanner	• Some non-systematic exposure	• Course or rotation in medical school or post-graduate course or conference	• Typically part of a training program (Emergency Medicine, Critical Care, Anesthesiology, etc.)

Figure 2 Experience categories of cardiac POCUS/CCE trainees.

Table 2 Sample objectives for cardiac POCUS

1) List the views that should be acquired as part of the cardiac POCUS examination.
2) Obtain all of the views that should be acquired as part of the cardiac POCUS examination.
3) Perform an interpretation of a cardiac POCUS examination to include interpretation of left and right ventricular function, left ventricular wall thickness, left atrial size, presence of pleural and/or pericardial effusion, IVC size and collapsibility.
4) Describe tamponade physiology findings as they will appear on cardiac POCUS.
5) Describe cardiac POCUS examination findings associated with pulmonary embolism.
6) Describe cardiac POCUS examination findings associated with heart failure with reduced ejection fraction.
7) Describe cardiac POCUS examination findings associated with heart failure with preserved ejection fraction.

IVC, inferior vena cava; *POCUS*, point of care ultrasound.

B. Cautions and Caveats

Most importantly, training should include correction of unrealistic expectations, such as expectation of mastery over a short time period, expectations of privileging upon completion of training, or certification of competency, if these are not going to be provided. Some trainees may harbor misconceptions regarding utility of ultrasound in clinical scenarios where it would not be useful (Figure 4). Such misconceptions should be corrected prior to undertaking training, though they may not surface until later.

A significant danger is the production of overconfident practitioners who go on to make errors that harm patients. Trainees should understand the limitations of cardiac ultrasound in general, and the particular limitations of their scanning protocol and of the devices they are using. While certain diagnoses may seem "easy" to make, the key for every practitioner is to recognize one's limitations in diagnostic skill. Errors of interpretive omission (e.g., not recognizing a wall motion abnormality) or exclusion (e.g., failing to image an aortic dissection) may result in withholding of potentially lifesaving therapies if UAPE, cardiac POCUS or CCE is considered sufficient to "rule out" significant pathology. Misinterpretation can lead to unnecessary invasive procedures with a risk of complications (e.g., mistaking a pleural for a pericardial effusion, leading to complications during a bedside pericardiocentesis).

In one study by Wilkinson *et al.*, cardiac POCUS training increased the rate of false-positive diagnoses, despite the fact that the subjects demonstrated increasing confidence in their inaccurate findings.[23] Trainees must know when to order a standard echocardiogram to confirm their findings or to make a diagnosis that is not apparent from UAPE, cardiac POCUS or CCE views. In addition to contextual discussion of these important issues, trainees should be reminded that their scans must be placed into the clinical context as one data point among many. The data obtained from cardiac POCUS, in particular, should be used to clarify a particular chief complaint or symptom, not, in most cases, as a definitive diagnostic test. Furthermore, trainees must understand the clinical implications of the findings they uncover and the next diagnostic or therapeutic steps. Trainees should understand institutional protocols that address these issues.

UAPE, cardiac POCUS and CCE trainings are not the same as the training of cardiology fellows and sonographers. They are more circumscribed, with the goal of learning utilization of cardiac ultrasound in specific environments for indications that are generally less broad than those encountered by cardiologists and sonographers. Advanced echocardiography techniques are fast becoming standard components of comprehensive echocardiography (3-dimensional imaging, strain imaging, advanced Doppler interrogation, use of ultrasound enhancement agents, advanced great vessel imaging) and should be part of the standard education of cardiology fellows and sonographers but are generally outside the scope of training for UAPE, cardiac POCUS and CCE. The total amount of concentrated time spent learning cardiac ultrasound is also significantly different. Cardiology fellows are required to spend 6 months on rotation in the echocardiography laboratory, in addition to training in cardiovascular physiology and pathology. Critical care and emergency medicine training programs generally cannot spare their trainees that amount of time for elective rotations in the echocardiography laboratory, and while these trainees may gain significant practice in scanning and interpretation while on their other clinical rotations, these experiences lack the same degree of concentrated focus on cardiac ultrasound, cardiac physiology and cardiac pathology. Additional fellowship training in emergency or critical care ultrasound may augment these experiences.

Finally, an echocardiography laboratory is not required or expected to provide training in areas outside of its expertise. CCE and many emergency medicine ultrasound curricula cover multiple non-cardiac findings that lie outside the expertise of most echocardiography laboratories, in particular lung B-lines, pleural effusions, carotid and femoral plaques, fatty liver, abdominal aortic aneurysms, venous imaging for cannulation, deep vein thrombosis, hydronephrosis and bladder volume. Echocardiography laboratories should partner with experts from these departments to provide training.

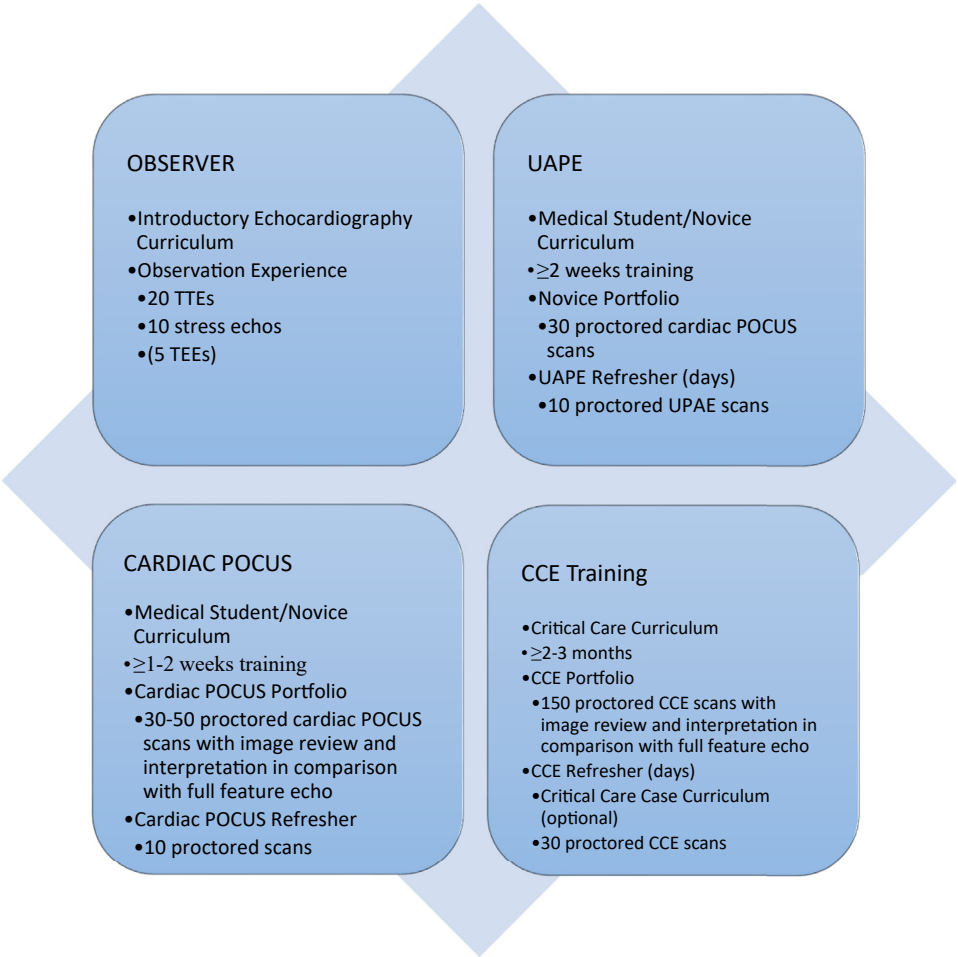

Figure 3 Sample plan categories for the trainee. Introductory Echocardiography Curriculum: range of echo services, appropriate use criteria, definitions and limitations of cardiac ultrasound, how to understand and apply echocardiogram reports. A helpful set of training videos is available through Clinical Key (https://www.clinicalkey.com/#!/search/Procedures%2520Consult%253EEchocardiography/%7B%22facetquery%22:%5B%22+contenttype:PC%22%5D%7D). Medical Student/Novice Curriculum: basic physics, anatomy, UAPE or cardiac POCUS exam (basic scanning views), pathology seen in UAPE or cardiac POCUS views. Critical Care Case Curriculum: multi-image case examples with demonstration of critical care disease findings in different views; review of imaging and interpretive pitfalls. Portfolio: Case mix examples (Appendix 2).

Key Points

- Individualizing training by discussing the trainees' needs and prior experience is preferable to providing a uniform experience to everyone.
- Echocardiography laboratory personnel may need to adjust the curriculum to the available training time.
- UAPE rotations should last at least 2 weeks.
- Cardiac POCUS trainees without prior experience should spend a month in the echo lab, while those with prior experience may benefit from one or more weeks to hone skills.
- Experienced CCE trainees should have a concentrated emphasis on the elements of critical care echocardiography lasting at least 2-3 months.
- The echocardiography laboratory may participate in "refresher" experiences for trainees.
- Echocardiography laboratory personnel should encourage trainees to participate in ongoing quality assurance/quality improvement processes.
- Training should include correction of unrealistic expectations, such as mastery over a short time period, privileging upon completion of training, or certification of competency, if these are not going to be provided.
- Trainees should understand the limitations of cardiac ultrasound in general, and the particular limitations of their scanning protocols and of the devices they are using.
- Trainees must understand the clinical implications of the findings they uncover and the next diagnostic or therapeutic steps.

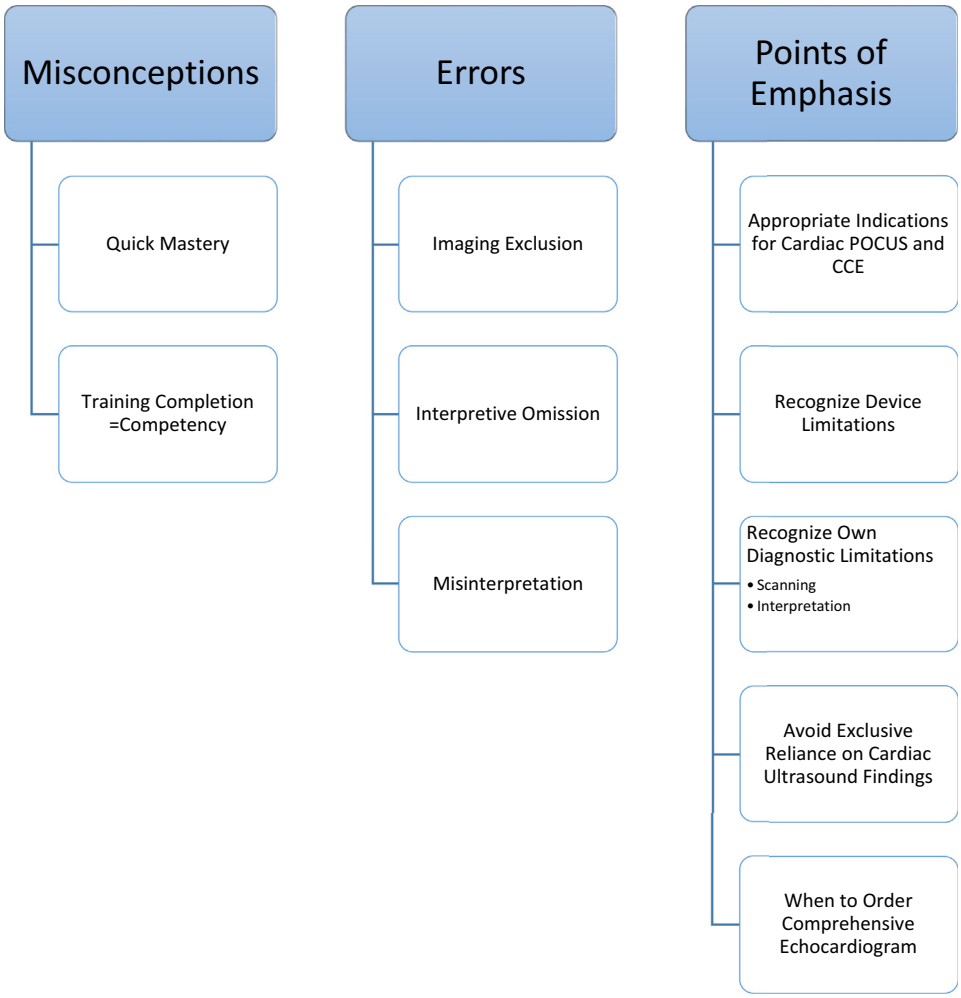

Figure 4 Possible misconceptions, types of errors and points of emphasis prior to training.

III. RECOMMENDATION 2: EMPLOY EDUCATIONAL RESOURCES

Most beginners and many advanced trainees will benefit from accessing online educational materials. Our writing group recommends the use of online resources in general, particularly for novice users, as introductory didactics can reduce the reliance on echocardiography laboratory resources to teach basic concepts. There are a large number of such programs. Both industry and academic institutions have developed training courses of variable length, scope, intensity and cost. Some of the online didactic modules are designed as a prerequisite to in-person, hands-on scanning training and others are "standalone." In many cases, the cardiac ultrasound is one part of a larger point-of-care ultrasound training course, while others focus only on the cardiac examination. It is beyond the scope of this article to provide a comprehensive review of each online course that may be used by individual echocardiography laboratories to teach cardiac ultrasound. It should be noted that the appropriate teaching modules may vary, according to the trainee's background and needs.

The recently published ASE online curriculum for medical students includes many helpful components for beginners and novice users of cardiac POCUS: https://aseuniversity.org/ase/lessons/47 Specific modules of interest to echocardiography laboratories from this curriculum include Introduction, Basic Anatomy Correlating to Cardiac POCUS Views, Complete Cardiac POCUS Scan, Pathology I and II, Teach the Teacher, and Standards and Testing. Part of the mandate of the writing group is to develop curricula and recommendations for cardiologist and cardiac sonographer champions to employ when more advanced cardiac POCUS and CCE trainees request educational experiences. A disease-based, modular curriculum directed at the advanced cardiac POCUS and CCE trainees, featuring specific instruction in elements of scanning and interpretation is also available (https://aseuniversity.org/ase/).

Other opportunities made available to the UAPE and cardiac POCUS user by the ASE include formal hands-on scanning workshops and the dedicated Learning Track at the ASE Scientific Sessions each year. Most of these workshops are curriculum-based activities, where experts have carefully vetted learning objectives, and presented material is evaluated by experienced educators, peer-reviewed, and taught by experts.

A. Scanning Simulators and Mannequins

Hand position and avoidance of orientation and imaging pitfalls are key aspects of teaching scanning technique. Routine acquisition of images in a standard fashion facilitates reproduction of standard images that are particularly important for serial studies. Scanning educational structures should progress the trainee through a hierarchy of lessons

and help refresh previous diagnostic skills (competency-based progression). Limiting the number and complexity of cardiac techniques taught and stressing simple motor memory skills are critical for the success of initial training.

The need to provide standardized scanning training has led to the development of simulators, including mannequins. Like online educational resources, simulators may decrease the burden on sonographers and other professionals to train learners in cardiac anatomy, image acquisition and interpretation. Realistic mannequins coupled with probes connected to computer displays can guide the trainee on proper probe placement while displaying the acquired image from each position, including the ability to compare the trainee's image plane with ideal planes, providing quantitative measures of scanning accuracy.[24] Trainees can scan through hundreds of stored patient cases with thousands of pathology variations for wide exposure. Given the relatively high cost of such simulation programs and, particularly, simulator mannequins, institutions should consider the investment if they can be used by all users of ultrasound technology including cardiology fellows, sonography students and non-cardiac trainees.

B. Portfolio

Online courses and pay-to-learn conferences in cardiac POCUS and CCE play an important educational role, particularly in exposure to pathology and focused exams. However, such courses may lack the time and resource commitment needed to provide repetitive instruction in imaging skills or to provide necessary ongoing quality assurance/quality improvement. There are many sites for learning cardiac ultrasound, but the echocardiography laboratory remains an invaluable resource for practical and concentrated opportunities for learning and practice. Trainees can efficiently learn and practice skills from probe cleaning methods to image acquisition and interpretation techniques applicable to actual patients. There is no substitute for practical and timely feedback on imaging and interpretive performance. Additionally, an echocardiography laboratory can play a central role in promoting high standards for image acquisition and interpretation, teaching trainees to recognize when one has acquired acceptable quality images. Such standards may be difficult to maintain if only relying upon online courses, pay-to-learn conferences, and simulators/mannequins.

An imaging portfolio can document the number of successful imaging cases, serve to validate both the trainee and the lab experience, and provide a confidence-building reference of the new user's capability. It is a requirement of some subspecialty training programs (www.chestnet.org/Education/Advanced-Clinical-Training/Certificate-of-Completion-Program/Critical-Care-Ultrasonography#Req; http://winfocus.org/curriculum/). Determining how each case is adjudicated, particularly in relation to its completeness, should involve input from the trainee's department or certification program. The criteria for CCE cases are well established (Appendix 1). Ideally, an echocardiographer or sonographer should observe the acquisition of imaging planes and the recording of the best image. If this is not always possible, given limited resources, echocardiographer or sonographer trainers may need to review saved studies and provide feedback at a later time (see Appendix 2 for sample evaluation forms). The number of required cases varies depending upon subspecialty cardiac ultrasound training program needs. With respect to cardiac POCUS (and, by extension, UAPE), current literature suggests that >30 scans should be performed[13,25] and this number is specifically endorsed by the Alliance for Physician Certification & Advancement (APCA) POCUS certification pathway (https://www.apca.org/pocus/). Explicitly, National Board of Echocardiography (NBE) certification in CCE requires a minimum of 150 scans to be performed and interpreted by the trainee, under the supervision of an NBE certified physician**.** Independent of the number of scans, cardiac POCUS and CCE users must include in their portfolio cases with pathology apropos to their clinical focus. Imaging multiple patients with appropriate disease states enables the ability to recognize the important findings as well as gain an experiential understanding of the limitations of focused imaging to characterize these states. This suggests that during a limited training rotation, trainees may not encounter an adequate range of clinical diagnoses, even if they have reached the minimum number required.

Review of scans in a case repository cannot substitute for scanning real patients with relevant pathology, but it can supplement the interpretive component of cardiac ultrasound training. The writing group recommends that repositories include complete sonographer studies, rather than single teaching images or learner-acquired images. Trainees should gain appreciation for aspects of echocardiography that are omitted from their training and recognize the limitations of UAPE, POCUS and, in some cases, CCE exams compared to a complete echocardiogram. For example, moderate aortic stenosis may not be appreciated in a POCUS study that omits spectral Doppler. The content and number of studies in the image repository should be designed to expose trainees to artifacts, normal findings, and pathologies common to their practices. The echocardiography lab should exercise the usual precautions regarding personally identifiable information: either the study should be copied to an image server stripped of identifying data, or the list of study image names or medical record numbers should be stored on password-secured computers within the hospital or clinic firewall. Appendix 3 is a suggested checklist of clinical diagnoses for cardiac POCUS and CCE trainees and may form the basis for an echocardiography laboratory's case repository.

The act of performing exams over a period of time, rather than "all-at-once," provides reinforcement of skills and is preferable for learning, despite a longer time commitment. The number and frequency of exams to be performed by trainees in UAPE, cardiac POCUS and CCE to maintain requisite skills has not been empirically determined. Unfortunately, the retention of learned techniques is quickly lost[25,26] unless there is a plan for continued practice. Modular curricula can be important both for achievement and maintenance of skills.

Fundamental UAPE and cardiac POCUS skills can be acquired in a relatively short period of time, and skills can be mainted via "drop-in refresher courses" similar to CPR re-certification. The echocardiography laboratory can remain a nearby, ongoing resource particularly for the new cardiac ultrasound user, to seek expert opinion and imaging practice. Drop-in refresher courses may or may not be sufficient for practitioners of CCE if they do not perform more extensive exams on a regular basis.

C. Micro-learning

Short term **micro-learning** moments are highly valuable for "quick tips" or refreshers. A common method of delivery of such methods is through social media. For example, Twitter, a messaging app restricted to 280 characters with addition of images and videos, is commonly used to present case examples and images. These short educational 'clips' can be grouped and tagged using hashtags such as #POCUS, #MedEd, and #FOAMUS and include the @ASE360 'handle' to share with others. Similarly, free online videos, image libraries, and

websites with cases and discussion may be used for demonstrative purposes. These applications and websites have appeal in the smartphone era, where learning can occur between other tasks. Given the brevity of these resources, these methods are useful not only to answer a specific question, but also to allow learners to participate in a community while belonging to a larger, albeit virtual network.

Micro-learning environments have important disadvantages to consider pertaining to cardiac ultrasound learning. Often case examples may be ad hoc, without expert vetting. The accuracy of the information presented may not have been verified. Another important criticism is that while this type of learning is sufficient for 'quick tips', it may not be the best driver for building deep expertise or 'clinical wisdom'. Nevertheless, such resources may be useful for ongoing learning opportunities, to serve as refresher opportunities, and to provide exposure to new areas that the learner may wish to pursue in greater depth through more formal training.

Key Points

- Online resources can reduce the reliance on echocardiography laboratory resources to teach basic concepts.
- Simulators and mannequins may decrease the burden on sonographers and other professionals to train learners in cardiac anatomy, image acquisition and interpretation.
- Imaging portfolios are a requirement of some subspecialty training programs. In POCUS training, >30 scans should be performed. National Board of Echocardiography (NBE) certification in CCE requires a minimum of 150 scans to be performed and interpreted by the trainee, under the supervision of an NBE certified physician.
- Practice scan cases should include pathology relevant to the trainees' practice and include all relevant views.
- Trainees may not encounter an adequate range of clinical diagnoses, and review of scans in a case repository can supplement the interpretive training.
- The retention of learned techniques is quickly lost unless there is a plan for continued practice.

IV. RECOMMENDATION 3: IN GENERAL, AVOID CERTIFYING GLOBAL COMPETENCY

When echocardiography laboratories participate in UAPE, cardiac POCUS or CCE training, they take on some responsibility for the trainees. It is the responsibility of all cardiac ultrasound trainers, but particularly the echocardiography laboratory, to emphasize the importance of not using findings for management decisions until competency is attained.

Feedback is important in the training process, but echocardiography laboratories are not generally qualified to certify cardiac POCUS trainees, let alone critical care clinicians and emergency medicine physicians, for independent practice. Reaching a certain number of scans or interpretations, or spending a specific amount of time in training, does not necessarily ensure competency.

Therefore, the writing group recommends that echocardiography laboratory trainers attest **only** to the number of scans and interpretations that a trainee performed and/or the breadth of cases reviewed or scanned and/or the amount of time spent training in the echocardiography laboratory. The writing group recommends that echocardiography trainers **not** attest to the general competence of trainees, unless the echocardiography laboratory administers the training program or has made arrangements to evaluate a trainee's competence by more comprehensive methods than attesting to numbers or time. Instead, certification should be the purview of the trainees' departments, organizations, or specialty societies, which may choose to consider the attestation of numbers, breadth of exposure and/or training time in the echocardiography laboratory in determining eligibility for certification.

There is one important caveat to this recommendation. The first written NBE exam for the CCE was offered in January 2019, and as mentioned above, certification criteria include documentation of clinical training in the care of patients in the critical care setting and the performance and interpretation of 150 CCE scans and interpretations. Many CCE trainees will seek certification as part of a critical care training program. In these circumstances, a program director or chair will certify the trainee, likely after having obtained input on training duration and number of studies performed during time spent in the echocardiography laboratory.

There will be other CCE trainees who are seeking certification through the Practice Experience Pathway. These trainees will need to have an NBE board-certified echocardiography supervisor sign a letter attesting to their competence after performance and interpretation of 150 CCE scans and interpretations. To do so, echocardiography laboratory trainers must be familiar with the standard requirements and limitations of CCE. They should also know the elements of CCE that are outside the purview of standard echocardiography (Appendix 1) and acknowledge that trainees must seek this training elsewhere if it cannot be provided in the echocardiography laboratory. The NBE does not provide explicit guidance as to how to adjudicate these scans and interpretations to determine competence but does require the supervisor to attest that she or he has personally reviewed a subset and to attest that the trainee "has the clinical competence and professional qualities necessary to perform as a critical care echocardiographer" (http://echoboards.org/docs/CCEeXAM_Cert_App-2019.pdf). The echocardiography expert should never simply "sign off" on a list of 150 studies.

This writing group recommends that if an echocardiography expert wishes to sign such a letter, she or he personally review at least 10% of complete scans and interpretations (i.e., not just a subset of normal examinations performed on patients with good quality images). These studies should be compared to sonographer- or echocardiographer-acquired images and echocardiographer interpretations on the same patients. Scans and interpretations should be assessed for completeness (using the CCE standards), image quality, and accuracy (considering correct findings, missed findings, overcalls and misinterpretations).

Key Points

- In general, certification of competency should be the purview of the trainees' departments, organizations, or specialty societies, not the echocardiography laboratory.
- Number of scans or time spent in training does not necessarily ensure competency.
- An important caveat is that CCE trainees seeking certification through the Practice Experience Pathway must have an NBE board-certified echocardiography supervisor sign a letter attesting to their competence after performance and interpretation of 150 CCE scans and interpretations. These supervisors

must be familiar with the standard requirements and limitations of CCE and the elements of CCE that are outside the purview of standard echocardiography.

- The supervisor should never simply "sign off" on a list of 150 scans and interpretations without review. She or he should personally review at least 10% of complete scans and interpretations with comparison to sonographer or echocardiographer-acquired images and echocardiographer interpretations.
- Scans and interpretations should be assessed for completeness (using the CCE standards), image quality, and accuracy (considering correct findings, missed findings, overcalls and misinterpretations).

V. RECOMMENDATION 4: COUNT THE COST IN ECHOCARDIOGRAPHY LABORATORY RESOURCES

Participating in cardiac ultrasound training requires resources and, in turn, well-directed and coordinated resource utilization. Specifically, training programs are best served by unreserved institutional/departmental support, considerable faculty experience, dedicated faculty time and resources, information technology support, and hospital or clinic-wide coordination.[27] Training encompasses different aspects with different levels of resource utilization, depending on the needs of the trainees, as outlined above.

Echocardiography laboratories, before agreeing to provide training to departments or specific individuals, should determine whether they have resources to provide the required training components (Table 3). A lab with limited resources may be able to offer only observership, UAPE or novice cardiac POCUS experiences but not the other categories of training service such as that required for formal CCE board certification (Figure 5).

Some resources necessary for the success of an expanded training program can be leveraged from the existing infrastructure of the echocardiography laboratory. These include access to space, administrative support, technical support, equipment, the electronic medical record (EMR), the cardiovascular Picture Archival and Communication System (PACS), and structured reporting systems. Additional equipment requiring investment for an expanded training program may include: full-feature echocardiographic machines, hand-held or laptop devices with cardiac probes, additional PACS and EMR workstations and any necessary third-party vendor applications to be used by these additional trainees. Server space for storage of cardiac POCUS and CCE images, for archiving and/or for quality assurance, is an important component, and it must be determined whether this space will be made available on the echocardiography laboratory's PACS or a separate system. Transthoracic cardiac ultrasound training simulators and mannequins require not only funding but also space.

In addition to sonographer and physician staff in an echocardiography laboratory, scanning and interpretation may be taught by general cardiology fellows and advanced cardiovascular (CV) imaging fellows in institutions where cardiology training programs exist. Interpretation trainers should provide review, assessment and feedback on trainees' understanding of cardiac anatomy and ultrasound physics and scanning and interpreting abilities. Ideally, an echo lab would have the resources to employ a dedicated trainer/educator.

Additional expert resource needs are less obvious. Cardiac POCUS and CCE programs may request that echocardiography personnel play a role in ongoing quality assurance and provide expert consultation. Portability and immediacy of diagnostic test results are key components of point of care ultrasound because they facilitate rapid implementation of treatments; thus UAPE, cardiac POCUS and CCE exams are particularly useful off-hours and on weekends. Over-reads, second opinions, and/or confirmatory testing with a full echocardiographic exam or alternative imaging procedure should be available. There must be supervision of trainees using cardiac ultrasound "on-call", but even certified practitioners can benefit from experts who are available to help with image acquisition and/or interpretation. In some instances these experts may be from the echocardiography laboratory. Furthermore, quality assurance, quality improvement and peer review programs ideally should involve experts, who may also be from the echocardiography laboratory. Finally, echocardiography laboratory technical support can play an important role in archiving images and reports.

In addition to personnel, machine, support and space resources, the patient population should guide realistic expectations of how likely a trainee is to encounter a particular pathology of interest. The types of cases performed by an echocardiography laboratory may not be sufficient to give trainees adequate breadth of exposure during their available timeframe. For example, an outpatient lab may have limited exposure to critically ill patients, and CCE trainees in this setting may lack exposure to the abnormal ultrasound findings in cardiac tamponade and acute pulmonary embolism despite reaching the required number of studies. Furthermore, the echocardiography lab may be not be able to provide expertise in all of the content areas required by the trainee's scope of practice. For example, the echocardiography lab may not be equipped to provide training in lung ultrasound or may not routinely assess some measurements particular to critical care, such as stroke volume variation. Finally, even well-resourced echocardiography labs that serve as training sites for cardiology fellows and sonographers must determine whether their existing resources are adequate to meet the needs of extra trainees without compromising their primary responsibility to train cardiologists and sonographers.

Table 3 Resource checklist for expansion of UAPE, POCUS and CCE training

1. Is there adequate equipment (imaging machines, reading stations, etc.)?
2. Does the echo lab need to provide server space to archive images for trainees?
3. Are trainers available to teach scanning skills?
4. Are trainers available to teach interpretation?
5. Is there a need for off-hours scanning assistance (or "backup" scanning)?
6. Is there a need for off-hours image review?
7. Can the echo lab provide necessary training in extra-cardiac imaging?
8. Will the echo lab's patient population provide adequate exposure to clinical findings?
9. Are echo lab resources adequate to meet needs of UAPE, cardiac POCUS or CCE trainees as well as cardiology fellows and sonographers?
10. Are there an adequate number of experts (sonographers, echocardiographers, cardiology fellows) to provide ongoing quality assurance in scanning and interpretation?

CCE, critical care echocardiography; *POCUS*, point of care cardiac ultrasound; *UAPE*, ultrasound assisted physical examination.

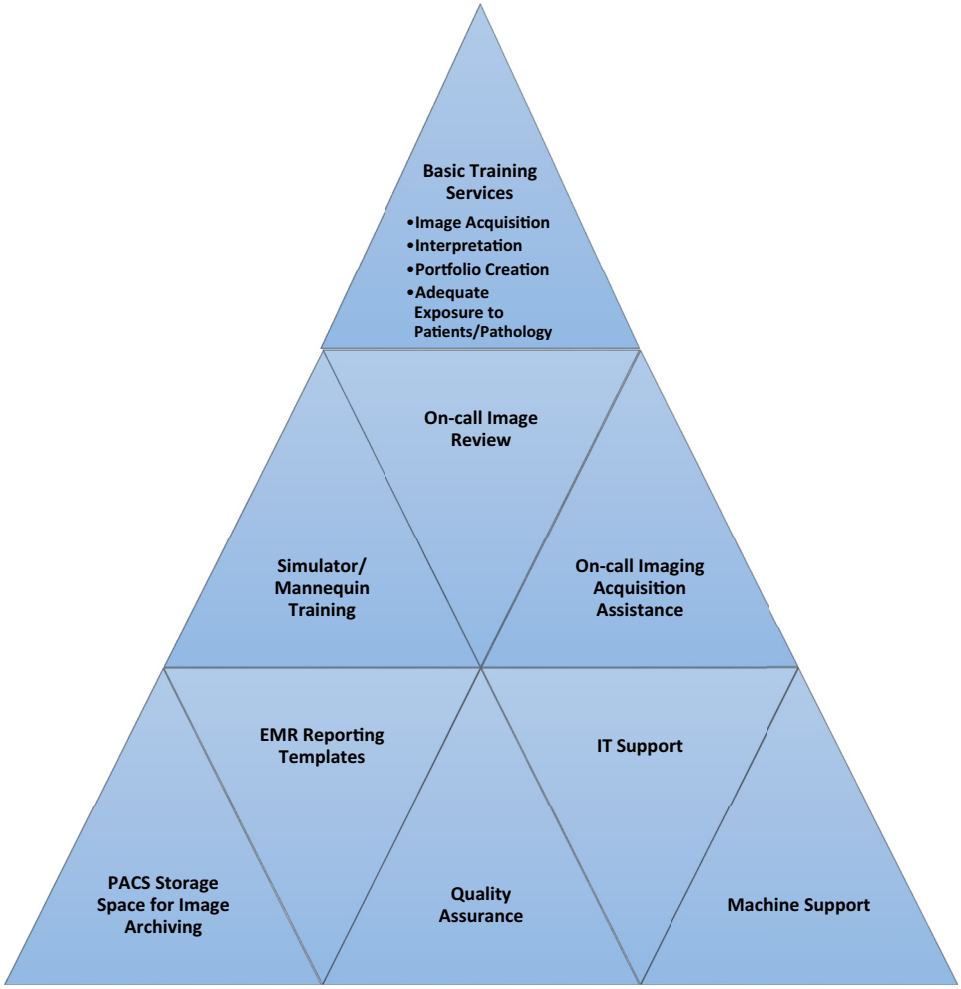

Figure 5 Echocardiography laboratory services.

Key Points

- Echocardiography laboratories, before agreeing to provide training to departments or specific individuals, should determine whether they have resources to provide the required training components, including personnel, space, machines, PACS resources, technical expertise, oversight capacity, quality assurance resources and exposure to an adequate case mix.
- Even well-resourced echocardiography labs with primary responsibilities for quality training of sonographers and cardiology fellows may require extra resources in order to take on other trainees.

VI. RECOMMENDATION 5: ADVOCATE FOR RESOURCES TO MEET EXTRA NEEDS

Ideally, resources will be readily available to meet the needs of UAPE, cardiac POCUS and CCE trainees. In reality, the echocardiography lab director and others must thoughtfully consider what is necessary and then advocate for those resources, whether from the cardiology division, the hospital or clinic, or the trainees' department(s). Contributions logically take the form of financial compensation for expert time and use of equipment and teaching tools. Although this number should not necessarily be employed as a "going rate" for education, and local costs vary, the writing group conservatively estimates that if an expert sonographer spends the time equivalent of one comprehensive study per day in mentoring a UAPE, cardiac POCUS or CCE trainee in 50 scans over a 2-week period, the relevant reimbursement would be around $5,000 (using the Centers for Medicare and Medicaid Services reimbursement for a comprehensive echocardiogram at https://federalregister.gov/d/2018-15958). For comparison, the CHEST ACCP ultrasound curriculum is $8,000 (http://www.chestnet.org/Education/Advanced-Clinical-Training/Certificate-of-Completion-Program/Critical-Care-Ultrasonography).

Other modes of financial compensation may be in the form of contributions to sonographer/staff continuing education or the salaries of educators who serve the needs of multiple different departments. Salary support of a "teaching sonographer", "teaching echocardiographer" or "teaching fellow" could be shared by these various departments. Departments and/or training programs may share or jointly buy ultrasound equipment with the echocardiography laboratory and/or contribute to PACS expansion and maintenance.

Alternatively, an echocardiography laboratory may seek in-kind contributions or exchanges. Cardiac anesthesiology programs can

Table 4 Resource contributions for echocardiography laboratory participation in cardiac POCUS and CCE training

	Personnel	Machines/programs/space	Teaching tools
Existing Resources	• Sonographers • Echocardiographers • Cardiology fellows • Advanced CV imaging fellows	• Full feature echo machines • Workstations • EMR • PACS • Reporting software	• Conferences • Reading sessions • Image review on PACS • Online ASE or other educational materials
Additional Resources	• Sonographer educator FTE (full/partial) • Echocardiography educator or advanced CV imaging fellow FTE (full/partial)	• Hand held devices • Laptop devices • PACS maintenance or expansion	• Computer-based training courses • Simulators
In-Kind Resources	• Trainee assists with workflow, room turnover, IV starts • Reciprocal training experiences • Administrative support for QA • Technical support	• Office space • Scanning rooms	• Sponsor sonographer education • Sponsor cardiology fellow education

ASE, American Society of Echocardiography; *CCE*, critical care echocardiography; *CV*, cardiovascular; *EMR*, electronic medical record; *FTE*, full time equivalent; *PACS*, Picture Archival and Communication System; *POCUS*, point of card ultrasound; *QA*, quality assurance; *UAPE*, ultrasound assisted physical examination.

provide intraoperative or intraprocedural TEE training experiences for cardiology fellows, in exchange for training of its fellows. Cardiology fellows can learn lung ultrasound and other non-cardiac imaging from critical care and emergency medicine faculty.

Other methods of contribution may take the form of educational resources such as online training courses and ultrasound simulators/mannequins that facilitate the initial training of all cardiac ultrasound learners (including cardiology fellows) lessening the burden on sonographers or others to demonstrate the acquisition of views. Training space to house these units and other equipment dedicated to training purposes may constitute particularly important contributions to some echocardiography laboratories. Table 4 provides a list of resource contributions.

These "asks" should be justified as contributing not only to the ability of the echocardiography laboratory to serve trainees but also to promote and maintain quality, with a link drawn between adequate resources and a level of training that produces high quality users of cardiac ultrasound, benefitting patients. Depending on trainee requirements, trainers need sufficient time and resources to assess trainees, develop curriculum, guide training experiences and participate in ongoing quality assurance, in addition to educating cardiology fellows and sonographers. A sample request letter describing necessary resources is provided as Appendix 5.

Key Points

- Echocardiography lab directors and others may need to advocate for additional resources, including financial contributions to staff time, machines, or educational materials, or in-kind contributions such as training for cardiology fellows in critical care echocardiography, and in intraprocedural and intraoperative TEE

VII. CONCLUSION

Participation in UAPE, cardiac POCUS and/or CCE training is an important but potentially complex endeavor. There are important differences in aspects of UAPE, cardiac POCUS, CCE, and standard echocardiography training and practice (Appendix 4). Trainees come with a broad range of needs and levels of experience and competence, and echocardiography laboratory teachers should elicit trainees' objectives and assess skills in order to tailor educational experiences. Many trainees, especially in the academic setting, will spend time in the echocardiography laboratory as one component of an ultrasound training program. Educational resources such as online and in-person training courses and simulators can facilitate the teaching of basic principles, but scanning of patients and interpreting the images acquired remain crucial. In general, echocardiography laboratories should attest to breadth and duration of training experience and case numbers, but not certify global competency. Echocardiography laboratories should take stock of their resources before deciding whether to participate in training and carefully consider the types of training experiences they can reasonably offer. It may be necessary to seek additional resources in order to sustain or augment training capacity. Ultimately, participation in training should foster further collaboration between cardiac UAPE/cardiac POCUS/CCE users and the echocardiography laboratory, merging the strengths of rapid evaluation with comprehensive assessment of cardiac structure and function and providing a robust environment for quality assessment and improvement.

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SUPPLEMENTARY DATA

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REFERENCES

1. Kimura BJ, Shaw DJ, Amundson SA, Phan JN, Blanchard DG, DeMaria AN. Cardiac limited ultrasound examination techniques to augment the bedside cardiac physical examination. J Ultrasound Med 2015;34(9):1683-90.
2. Available at: https://www.pocus.org/wp-content/uploads/pdf/APCA18-004-WEB-CARDIAC.pdf.
3. Johri AM, Durbin J, Newbigging J, Tanzola R, Chow R, De S, et al. Cardiac point-of-care ultrasound: state-of-the-art in medical school education. J Am Soc Echocardiogr 2018;31(7):749-60.
4. Rozycki GS, Ochsner MG, Schmidt JA, Frankel HL, Davis TP, Wang D, et al. A prospective study of surgeon-performed ultrasound as the primary adjuvant modality for injured patient assessment. J Trauma 1995;39(3):492-8. discussion 498-500.
5. Jensen MB, Sloth E, Larsen KM, Schmidt MB. Transthoracic echocardiography for cardiopulmonary monitoring in intensive care. Eur J Anaesthesiol 2004;21:700-7.
6. Perera P, Mailhot T, Riley D, Mandavia D. The RUSH exam: Rapid ultrasound in shock in the evaluation of the critically lll. Emerg Med Clin North Am 2010;28(1):29-56.
7. Breitkreutz R, Walcher F, Seeger FH. Focused echocardiographic evaluation in resuscitation management: concept of an advanced life support-conformed algorithm. Crit Care Med 2017;35(Suppl.):S150-61.
8. Spencer KT, Kimura BJ, Korcarz CE, Pellikka PA, Rahko PS, Siegel RJ. Focused cardiac ultrasound: recommendations from the American Society of Echocardiography. J Am Soc Echocardiogr 2013;26(6):567-81.
9. AlEassa EM, Ziesmann MT, Kirkpatrick AW, Wurster CL, Gillman LM. Point of care ultrasonography use and training among trauma providers across Canada. Can J Surg 2016;59(1):6-8.
10. Ailon J, Mourad O, Nadjafi M, Cavalcanti R. Point-of-care ultrasound as a competency for general internists: a survey of internal medicine training programs in Canada. Can Med Educ J 2016;7(2):e51-69.
11. McCormick TJ, Miller EC, Chen R, Naik VN. Acquiring and maintaining point-of-care ultrasound (cardiac POCUS) competence for anesthesiologists. Can J Anaesth 2018;65(4):427-36.
12. Millington SJ, Arntfield RT, Hewak M, Hamstra SJ, Beaulieu Y, Hibbert B, et al. The rapid assessment of competency in echocardiography scale: validation of a tool for point-of-care ultrasound. J Ultrasound Med 2016;35(7):1457-63.
13. Vignon P, Mücke F, Bellec F, Marin B, Croce J, Brouqui T, et al. Basic critical care echocardiography: validation of a curriculum dedicated to noncardiologist residents. Crit Care Med 2011;39(4):636-42.
14. Beraud AS, Rizk NW, Pearl RG, Liang DH, Patterson AJ. Focused transthoracic echocardiography during critical care medicine training: curriculum implementation and evaluation of proficiency. Crit Care Med 2013;41(8):e179-81.
15. Moore CL, Rose GA, Tayal VS, Sullivan DM, Arrowood JA, Kline JA. Determination of left ventricular function by emergency physician echocardiography of hypotensive patients. Acad Emerg Med 2002;9(3):186-93.
16. Lucas BP, Candotti C, Margeta B, Evans AT, Mba B, Baru J, et al. Diagnostic accuracy of hospitalist-performed hand-carried ultrasound echocardiography after a brief training program. J Hosp Med 2009;4(6):340-9.
17. Expert Round Table on Echocardiography in ICU. International consensus statement on training standards for advanced critical care echocardiography. Intensive Care Med 2014;40(5):654-66.
18. Cecconi M, De Backer D, Antonelli M, Beale R, Bakker J, Hofer C, et al. Consensus on circulatory shock and hemodynamic monitoring. Writing group of the European Society of Intensive Care Medicine. Intensive Care Med 2014;40(12):1795-815.
19. Millington SJ, Arntfield RT, Guo RJ, Koenig S, Kory P, Noble V, et al. The assessment of competency in thoracic sonography (ACTS) scale: validation of a tool for point-of-care ultrasound. Crit Ultrasound J 2017;9(1):25-32.
20. Millington SJ, Hewak M, Arntfield RT, Beaulieu Y, Hibbert B, Koenig S, et al. Outcomes from extensive training in critical care echocardiography: identifying the optimal number of practice studies required to achieve competency. J Crit Care 2017;40:99-102.
21. Price S, Via G, Sloth E, Guarracino F, Breitkreutz R, Catena E, et al. Echocardiography practice, training and accreditation in the intensive care: document for the World Interactive Network Focused On Critical Ultrasound (WINFOCUS). Cardiovasc Ultrasound 2008;6:49-83.
22. Gaudet J, Waechter J, McLaughlin K, Ferland A, Godinez T, Bands C, et al. Focused critical care echocardiography: development and evaluation of an image acquisition assessment tool. Crit Care Med 2016;44(6):e329-35.
23. Wilkinson JS, Barake W, Smith C, Thakrar A, Johri AM. Limitations of condensed teaching strategies to develop hand-held cardiac ultrasonography skills in internal medicine residents. Can J Cardiol 2016;32(8):1034-7.
24. Sheehan FH, Otto CM, Freeman RV. Echo simulator with novel training and competency testing tools. Stud Health Technol Inform 2013;184:397-403.
25. Kimura BJ, Sliman S, Waalen J, Amundson SA, Shaw DJ. Retention of ultrasound skills and training. J Am Soc Echocardiogr 2016;29(10):992-7.
26. Nardi M, Shaw DJ, Amundson SA, Phan JN, Kimura BJ. Creating a novel cardiac limited ultrasound exam curriculum for internal medicine residency. J Med Educ Curric Dev 2016;3:115-24.
27. Strony R, Marin JR, Bailitz J, Dean AJ, Blaivas M, Tayal V, et al. Systemwide clinical ultrasound program development: an expert consensus panel. West J Emerg Med 2018;19(4):649-53.

APPENDIX 1. CONTENT OUTLINE FOR THE EXAMINATION OF SPECIAL COMPETENCE IN CRITICAL CARE ECHOCARDIOGRAPHY

1 Functional Anatomy
- **1.A Left ventricle**
  - 1.A.1 Systolic function (qualitative, quantitative)
  - 1.A.2 Diastolic function
  - 1.A.3 LV chamber quantification
  - 1.A.4 Masses/thrombi
  - 1.A.5 Cardiomyopathies
- **1.B Right ventricle**
  - 1.B.1 RV chamber quantification
  - 1.B.2 Function
  - 1.B.3 Estimated right heart pressure
- **1.C Atria**
  - 1.C.1 Chamber quantification
  - 1.C.2 Atrial septum
  - 1.C.3 Masses/thrombi
  - 1.C.4 Left atrial hemodynamics
- **1.D Valvular disease**
  - 01.D.01 Aortic
  - 01.D.02 Mitral
  - 01.D.03 Tricuspid
  - 01.D.04 Pulmonic
  - 01.D.05 Endocarditis
  - 01.D.06 Prosthetic valve disease/dysfunction
- **1.E Pericardium**
  - 1.E.1 Pericardial effusion
  - 1.E.2 Constrictive pericarditis
  - 1.E.3 Hematoma
- **1.F Great vessels**
  - 1.F.1 Aorta
  - 1.F.2 Pulmonary artery
  - 1.F.3 IVC and SVC
- **1.G Devices and foreign bodies**
  - 01.G.01 Catheters
  - 01.G.02 Pacing wires
  - 01.G.03 Cannulae
- **1.H Intracardiac masses**
  - 01.H.01 Left ventricle
  - 01.H.02 Right Ventricle
  - 01.H.03 Atria
- **I.I Adult congenital**
  - 1.I.1 Atrial septal defect
  - 1.I.2 Ventricular septal defect
  - 1.I.3 Bicuspid valve
  - 1.I.4 Patent foramen ovale
  - 1.I.5 Persistent left superior vena cava

2 Clinical Diagnosis and Management
- **2.A Shock**
  - 2.A.1 Obstructive
  - 2.A.2 Hypovolemic
  - 2.A.3 Distributive
  - 2.A.4 Cardiogenic
- **2.B Volume assessment**
  - 2.B.1 Fluid responsiveness
  - 2.B.2 Volume overload
- **2.C Acute cardiovascular presentations**
  - 2.C.1 Myocardial infarction
  - 2.C.2 Regional wall motion abnormalities
  - 2.C.3 Pulmonary embolism
  - 2.C.4 Aortic dissection
  - 2.C.5 Valvular heart disease
  - 2.C.6 Cardiomyopathy
  - 2.C.7 Congenital heart disease
- **2.D Trauma**
  - 02.D.01 Blunt
  - 02.D.02 Penetrating
- **1.H Respiratory failure**
  - 1.H.1 Cardiac versus pulmonary
  - 1.H.2 Adverse effects of mechanical ventilation
- **1.I Cardiac arrest**
  - 1.I.1 Etiology
  - 1.I.2 Classification
  - 1.I.3 Appropriate implementation

2 Technical Skills & Equipment Optimization
- **I.II Physics**
  - 1.II.1 2D ultrasonography
  - 1.II.2 Doppler ultrasonography
  - 1.II.3 M mode
  - 1.II.4 Enhanced cardiac ultrasound (contrast)
- **I.III Artifacts**
  - 1.III.1 Reverberations
  - 1.III.2 Side lobe
  - 1.III.3 Mirror image/refraction
  - 1.III.4 Acoustic shadowing
  - 1.III.5 Aliasing
  - 1.III.6 Electrical interference
- **I.IV Image Acquisition**
  - 1.IV.1 Probe position
  - 1.IV.2 Probe manipulation
  - 1.IV.3 Probe selection
  - 1.IV.4 Indications
  - 1.IV.5 Canonical views
  - 2.D.1 Image optimization
  - 2.D.2 Normal variants
  - 2.D.3 Patient positioning
  - 2.D.4 Cardiac versus abdominal presets

3 C Integrated ultrasound imaging
- **3.E Lung and pleural**
  - 3.E.1 Postintubation assessment
  - 3.E.2 A line versus B line
  - 3.E.3 Pleural effusion
  - 3.E.4 ARDS
  - 3.E.5 Pneumonia with sepsis
  - 3.E.6 Pneumothorax
- **3.F Vascular**
  - 3.F.1 DVT
- **3.G Abdominal**
  - 3.G.1 Evaluation for free fluid

APPENDIX 2. EVALUATION

The echocardiography laboratory may be tasked with evaluation of the learner's image acquisition and interpretation skills. This

Reference	Trainees	Elements	Scale/score
Cawthorn, *et al.*	Medical Students	Image Quality Interpretation Accuracy	0-9 rating Accurate/Not accurate
Kimura, *et al.*	Internal Medicine Residents	Image quality Interpretation Knowledge Interpretation skills	Points (0-4) Points (0-2) Points (0-2)
Jozwiak, *et al.*	Critical Care Residents	Quality of views Semi-quantitative measurements	Points (0,2,3) Points (0,2,3)
Gaudet, *et al.*	Critical Care Subspecialty	Specific structures in each view Overall diagnostic quality for specific clinical questions	Points (0,0.5,1,2) Points (0-2)

evaluation will depend on the expected goals. One might have a different evaluation for a medical student learning ultrasound assisted physical examination than an attending physician learning critical care echocardiography. In some cases, a lab may wish to score images using a subjective assessment of overall quality. In other cases, a lab may wish to create or use a more detailed scoring system that accounts for specific elements of image acquisition, including such aspects as gain, depth, and position, as well as the amount of time it takes to acquire the image. Some labs may wish to assess only image quality, others may wish to score image quality with diagnostic accuracy. The table lists a few of the published tools.

Complete References

Cawthorn TR, Nickel C, O'Reilly M, Kafka H, Tam JW, Jackson LC, *et al.* Development and evaluation of methodologies for teaching focused cardiac ultrasound skills to medical students. J Am Soc Echocardiogr 2014;27:302-9.

Gaudet J, Waechter J, McLaughlin K, Ferland A, Godinez T, Bands C, *et al.* Focused critical care echocardiography: development and evaluation of an image acquisition assessment tool. Crit Care Med 2016;44:e329-35.

Jozwiak M, Monnet X, Cinotti R, Bontemps F, Reignier J, Belliard G. Prospective assessment of a score for assessing basic critical-care transthoracic echocardiography skills in ventilated critically ill patients. Ann Intensive Care 2014;4:12. eCollection 2014.

Kimura BJ, Amundson SA, Phan JN, Agan DL, Shaw DJ. Observations during development of an internal medicine residency training program in cardiovascular limited ultrasound examination. J Hosp Med 2012;7:537-42.

APPENDIX 3. PORTFOLIO CHECKLISTS

Cardiac POCUS Case Repository

1. Normal patient
2. Normal patient with fair/poor image quality
3. Hyperdynamic hypovolemia
4. Moderately reduced ejection fraction, atrial enlargement, IVC plethora
5. Severely reduced ejection fraction, atrial enlargement, IVC plethora
6. Moderate or greater left ventricular hypertrophy with atrial enlargement, IVC plethora
7. Pulmonary embolism with acute cor pulmonale
8. Rheumatic heart disease with severe mitral stenosis
9. Severe aortic stenosis
10. Pericardial effusion with RA chamber collapse

CCE Case Repository

1. Normal patient
2. Normal patient with fair/poor image quality
3. Type A aortic dissection
4. Type B aortic dissection
5. Hyperdynamic hypovolemia
6. Cardiomyopathy with global hypokinesis, at least moderately reduced ejection fraction in the setting of clinical diagnosis of sepsis
7. Heart failure with fluid overload, severely reduced ejection fraction, biatrial enlargement
8. Renal failure with fluid overload
9. Clinical diagnosis of sepsis with hyperdynamic LVEF and underfilling
10. Segmental wall motion abnormalities of ischemia/infarct
11. LV apical thrombus
12. Takotsubo (stress induced) cardiomyopathy
13. Moderate left ventricular hypertrophy with diastolic dysfunction
14. Acute cor pulmonale from ARDS
15. Chronic pulmonary hypertension from COPD with acute exacerbation
16. Pulmonary embolism with acute cor pulmonale with McConnell's sign
17. Pulmonary embolism with acute cor pulmonale without McConnell's sign
18. Thrombus in transit
19. Cardiac arrest
20. Aortic sclerosis without stenosis
21. Aortic root dilation with moderate aortic insufficiency
22. Severe aortic stenosis
23. Dynamic outflow obstruction with SAM
24. Tricuspid endocarditis with regurgitation
25. Rheumatic mitral stenosis
26. Mitral prolapse with regurgitation
27. Malignant pericardial effusion without tamponade
28. Tamponade with RA chamber collapse, inflow variation
29. Tamponade with RV chamber collapse
30. Atrial myxoma
31. Normally functioning bioprosthetic aortic valve
32. Stenotic bioprosthetic aortic valve
33. Normally functioning bioprosthetic mitral valve
34. Regurgitant bioprosthetic mitral valve
35. Normally functioning mechanical mitral valve
36. Stenotic mechanical mitral valve
37. Moderate to large ASD
38. Acquired (post infarct) VSD
39. Bicuspid aortic valve

ARDS, acute respiratory distress syndrome; *ASD*, atrial septal defect; *COPD*, chronic obstructive pulmonary disease; *LV*, left ventricle; *RA*, right atrium; *RV*, right ventricle; *SAM*, systolic anterior motion of the mitral valve; *VSD*, ventricular septal defect.

Appendix 4 Considerations in UAPE, Cardiac POCUS, Critical Care Echocardiography and Implications for Training

	UAPE/cardiac POCUS	CCE	Standard comprehensive echocardiography	Implications
General screen orientation and PLAX and subcostal R/L orientation	Presets on machines used for radiologic imaging may not be the same as used for cardiac imaging	Presets on machines used for radiologic imaging may not be the same as used for cardiac imaging	Cardiologic (screen marker on right); Cranial is to the right of screen (subcostal IVC view)	Must learn screen orientation marker, probe directional marker, and how to manipulate and align them
Patient positioning	Supine, semi-Fowler's, or upright in wheelchair	Often restricted in positioning, intubated, ventilation mode can confound dynamics; Patient usually supine; Pacer/ defibrillator pads may obstruct access; Infection precautions	Optimized, left lateral, with bed cut out for apical imaging (non-portable exams)	Often have to accept foreshortened apical views; Effect of upright position on venous return unclear
Measurement burden	Minimal; Emphasis on robust 2D signs, or limited color Doppler; Finding of interest only	Basic assessment of valves, filling pressures, cardiac output; May include chamber quantification	Meticulous comprehensive measurements of all standard areas; Increasingly includes advanced quantification, 3D, strain	Less time needed to learn to image and interpret comprehensive echo measurements
Length of exam	Rapid, often <5-10 minutes; Reporting often presence/ absence of finding of interest	Depends on indication	Lengthy, 45-60 minutes with extensive reporting of all findings; Additional time for use of ultrasound enhancing agents	Emphasis on speed and efficiency in setting of specific indications
Scanning position	Standing, leaning, one hand holding device, often during physical, bright room	Ideally seated in darkened, quiet room, but may not be possible (Standing, beside patient, bright room)	Seated, most often left-hand imaging, usually in darkened, quiet room	Less gel, less disrobing of patient, dominant hand imaging, higher gain necessary in bright rooms
Equipment	Simplified device, organ pre-sets, potential for much wear and tear	2D, color and spectral Doppler but may have limited potential for modifying image	Complete and modifiable knobs, multiple transducers, durable	Recognize limitations of device
Curriculum	Limited, quick look signs, and many organs often evaluated	Scanning protocol and interpretation focused on findings seen in pertinent clinical situations, other organs often evaluated	Comprehensive evaluation of the heart only	Extra cardiac imaging may require training outside of the echo lab
Hierarchy to learning tasks	Learn PLAX and subcostal first, then progress to other views (PSAX, A4C, A2C, SC4, IVC)	All views and at least basic techniques to evaluate clinical diagnoses	All views and techniques equally necessary to perform; Advanced valvular quantification, strain and 3D becoming standard	Complementary nature of different views and techniques, appropriate to trainee's level and focus

A4C, apical four-chamber view; *A2C*, apical two-chamber view; *CCE*, critical care echocardiography (including what may be termed "advanced cardiac POCUS"); *IVC*, inferior vena cava; *PLAX*, parasternal-long axis of the left ventricle; *POCUS*, point-of-care ultrasound; *PSAX*, parasternal short-axis of the left ventricle (apical, mid, base); *R/L*, right/left; *SC4*, subcostal four-chamber view; *UAPE*, ultrasound assisted physical examination.

APPENDIX 5

Dear_____,

Our echocardiography laboratory currently offers formal Level II training to cardiology fellows *[as well as Level III Echo Fellowship training; multi-modality cardiac imaging training; sonographer training; training for practicing cardiologists].* We have been asked to provide training in cardiac ultrasound for learners from other departments. In order to provide a new program for these trainees, without compromising the teaching of our existing trainees and/or compromising the quality of care we are able to deliver to our patients, it will be necessary for us first to secure additional resources.

There has been a dramatic increase in the use of cardiac ultrasound by clinicians outside the cardiology community, spurred by the development of small portable ultrasound machines.

[The National Board of Echocardiography has developed a formal Critical Care Echocardiography certification process requiring attestation of 150 scans performed and interpreted. These scans must be attested to by an NBE certified expert and contribute to a portfolio encompassing a wide range of pathology relevant to critical care. This process will require the creation of a new training program, hitherto not offered at our institution. Objectives and training requirements are outlined by the NBE (https://www.echoboards.org/docs/CCEeXAM%20Content%20Outline-Updated%207-18.pdf). An explanation of this training program and its relation to the echocardiography laboratory has been provided by a recently developed report by the American Society of Echocardiography (ASE), our main professional society. Our echocardiography laboratory has been asked by the [Critical Care Program] Director to assist in the development of this portfolio for at least one trainee in critical care echocardiography (CCE) to meet the new certification criteria, attested to by our NBE-certified expert in echocardiography.]

[The _____ department has requested to have their trainees rotate through our echocardiography laboratory in order to gain cardiac ultrasound training.]

[Our echocardiography laboratory has been asked to participate in the quality assurance/quality improvement aspects of cardiac ultrasound performance at our institution.]

[Our echocardiography laboratory will provide assistance with expert over-reads of the images acquired by these users of cardiac ultrasound.]

We would appreciate your assistance in procuring resources necessary to provide these educational and clinical services. We have assessed our current resources and have determined that the following additional resources are required:

__Additional PACS Workstation(s)
__Additional Reporting Workstation(s)
__Echocardiography Machines(s)
__Hand-Carried Cardiac Ultrasound Machines(s)
__Cardiac Ultrasound Simulator
__Educational Software
__Educational Conference Room
__Administrative Support for Quality Assurance
__Technical Support
__Teaching Sonographer salary support
__Expanded Server Space

Thank you for your consideration.
Sincerely,