

Recommendations for Achieving and Maintaining Competence and Credentialing in Critical Care Ultrasound with Focused Cardiac Ultrasound and Advanced Critical Care Echocardiography

From the Ultrasound Certification Task Force on behalf of the Society of Critical Care Medicine:

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Summary of Recommendations

The Society of Critical Care Medicine (SCCM) Ultrasound Certification Task Force has created this document to provide guidance to both providers and hospitals in the process of credentialing in critical care ultrasound and advanced critical care echocardiography (ACCE). The task force recommends incorporating focused cardiac ultrasound into the practice of critical care ultrasound (CCUS). Unlike focused cardiac ultrasound, ACCE requires a distinct approach to achieving competence. To achieve competence in CCUS and ACCE, each provider must fulfill certain requirements in licensing, didactic education, critical care board certification or its equivalent, and performance and interpretation of a minimal number of ultrasound or echocardiography exams. For ACCE only, the task force additionally advocates testamur or certification status in the adult echocardiography (ASCeXAM) OR advanced or basic perioperative transesophageal echocardiography (PTEeXAM) until a specific ACCE board-certification process exists. Both ASCeXAM and PTEeXAM are administered by the National Board of Echocardiography.

The task force also acknowledges the existence of two pathways in achieving competence in CCUS and ACCE: fellowship-based and practice-based experience pathways. These pathways differ on how and when a critical care provider gains experience in CCUS and ACCE. The requirements for these modalities are summarized in Tables 1 and 2.

Introduction

In the hands of critical care providers, CCUS and ACCE can supplement management of critically ill and injured patients and lead to the rapid diagnosis of the underlying etiology in those suffering cardiopulmonary dysfunction.¹ Providers can also perform many standard bedside procedures under ultrasound guidance, increasing safety and success rates, most notably central venous access and thoracentesis.² Ultrasound also allows critical care providers to obtain diagnostic information in a timely manner when comprehensive studies are not readily available (e.g., diagnosis or exclusion of deep venous thrombosis³ or of the source of exsanguinating hemorrhage).

As with other technologies research, training and quality control are crucial to safe clinical use and benefit to patients and healthcare systems. To improve standardization and the quality of training and clinical

application, SCCM appointed a task force to develop recommendations for achieving competence in CCUS and ACCE; these recommendations include the prerequisite medical knowledge and training, ultrasound knowledge and skills, training components and duration, training environment and supervision, and equivalence requirements for critical care providers who are already in practice. This resulting document is intended to serve as a blueprint for demonstrating competence in CCUS and ACCE, and allows both providers and credentialing bodies to establish criteria by which to judge competence and facilitate credentialing, either employing all modalities in a bundle or applying them individually in relevant settings.

Definitions Used in This Document

The SCCM Ultrasound Certification Task Force recommends that ultrasound applications in critical care medicine be classified into CCUS and ACCE. CCUS is further segmented into diagnostic ultrasound and procedural ultrasound (Table 3). CCUS is a dynamic and developing field and thus may include other applications in the future, such as visceral organ imaging (e.g., gallbladder, liver, or renal) or real-time evaluation of functional changes with bedside interventions.^{4,5} The principles outlined in this document are anticipated to be relevant to future ultrasound applications.

Proficiency

For CCUS and ACCE, proficiency involves both technical skills of acquisition and real-time interpretation of ultrasound images, with incorporation of information into immediate clinical decision-making. These skills are measurable objectives during the training process.

Competence

Competence involves a system-based approach to the acquisition and management of ultrasound equipment, proper documentation and image management, institution of a peer-review process, continuous quality improvement, and on-going education in CCUS and ACCE.⁶ Thus, the task force emphasizes the training environment and establishment of CCUS and ACCE programs to achieve competence.

Credentialing

Credentialing is the process of obtaining information on provider qualifications/competence for appointment to, or regulation of scope of practice within, the medical staff of a given hospital. Credentialing defines the clinical services a caregiver may provide and ensures that the services fall within the scope of privileges granted. Granting of clinical privileges is the goal of the credentialing process and is governed by the rules and policies of the department in which the provider intends to practice.^{7,8}

The American Medical Association's ultrasound privileging resolution⁹ has recommended that credentialing committees follow specialty-specific guidelines for decisions. In line with this resolution, the task force has outlined the main principles behind credentialing in CCUS and ACCE for critical care medicine:

1. Departments should follow the specialty-specific guidelines for the credentialing and privileging process.
2. Departments should grant CCUS and ACCE privileges separately.
3. Each department should choose which core critical care ultrasound applications are relevant to its critical care environment, should decide whether to credential for ACCE, and should track critical care providers in the use of these applications by following a continuous quality improvement process.
4. Providers applying for privileges in CCUS and ACCE should complete the necessary training outlined in this document.

5. Privileges in ACCE should require testamur or certification status on an exam of special competence — such as ASCeXAM or basic or advanced PTEeXAM — or a specific ACCE exam once one becomes available.
6. Credentialed providers should demonstrate clinical competence during each reappointment (at least every 2 years) and actively participate in continuous quality improvement as they do with other procedures and techniques in which they are credentialed.

Certification

Certification is a process by which an external agency recognizes competence. This agency is usually a specialty board that sets criteria for certification and commonly involves an examination of special competence. CCUS would not require certification, based on the experience of the American College of Emergency Medicine.⁷ Credentialing bodies should grant ACCE privileges based upon testamur or certification status. Until specific certification is available for ACCE, the task force recommends testamur or certification status based on the ASCeXAM, basic or advanced PTEeXAM (all administered by the National Board of Echocardiography), or the training and number of procedures endorsed in this document as a surrogate for formal board certification.

Relevant Policy Statements***American Medical Association***

The American Medical Association (AMA) policy statement⁹ recommends that each hospital medical staff review and approve criteria for granting ultrasound privileges based upon a physician's background and training. The AMA further recommends that credentialing criteria be in accordance with the recommended training and education standards set by each physician's specialty.

American College of Emergency Physicians

Emergency medicine was the first specialty to actively incorporate ultrasound into bedside decision-making processes. The American College of Emergency Physicians approved emergency ultrasound guidelines in 2001,¹⁰ then revised and approved them again in 2008.⁷ Their document defined emergency ultrasound scope of practice, training, and proficiency, as well as credentialing and continuous quality management. It became the basis for the rapid spread of ultrasound into emergency departments throughout the country.

Critical Care Societies

Critical Care Medicine published two supplements in 2007 that comprehensively described CCUS and ACCE, clearly defining the field.^{11, 12} The Critical Care Network of the American College of Chest Physicians, in partnership with La Société de Réanimation de Langue Française, published their competency statement on critical care ultrasonography in 2009.¹³ This statement divided applications into general critical care ultrasound and critical care echocardiography (basic and advanced), and further defined scope of practice in each area. Expanding on this in 2011, 12 critical care societies from around the world developed an expert statement on training standards in critical care ultrasonography.¹⁴ This work provided agreement among experts on various components of training in defined areas of critical care ultrasound. It further suggested that general critical care ultrasound and basic critical care echocardiography should be within the customary practice of critical care providers, with ACCE requiring additional training and examination of special competence. The task force concurred that focused cardiac ultrasound is encompassed within critical care ultrasound and that ACCE should be seen as separate and more demanding. These ideas have been developed further to simplify classification for the purpose of describing training requirements and provide the specific set of requirements to demonstrate competence.

American Society of Echocardiography

The American Society of Echocardiography introduced three levels of training in echocardiography for physicians in 1987.¹⁵ The American College of Cardiology Foundation has serially reaffirmed these recommendations, most recently in 2008.¹⁶ Each level differs in the duration of training, minimum number of studies performed and interpreted, and proficiency in transesophageal echocardiography (TEE) and special procedures. Level 1 training does not qualify the trainee to perform or interpret echocardiograms independently; it requires 3 months of full-time training, with at least 75 echocardiograms personally performed and 150 interpreted under appropriate supervision. Level 2 training allows the provider to independently perform or interpret echocardiograms; it requires 6 months of full-time training, 150 personally performed studies, and a total of 300 interpreted studies under appropriate supervision. Level 3 training qualifies a provider to become an echocardiography laboratory director, perform the full spectrum of echocardiographic studies, and train others; this level requires 12 months of full-time training,

300 personally performed and 750 interpreted studies. These training guidelines place particular emphasis on comprehensive echocardiography, which commonly does not meet the immediate needs of providers practicing in critical care settings.

Further guidance on echocardiography training of noncardiology specialists was provided in 2002 by the American Society of Echocardiography and the Society of Cardiovascular Anesthesiologists.¹⁷ Their guidelines described training requirements for perioperative TEE and became the basis for a certification process in that procedure. The requirements defined two levels of training, basic and advanced, and further provided guidance as to appropriate supervision during training. To achieve the advanced level, the trainee would personally perform 150 studies and interpret 300 studies total. This is equivalent to the level 2 training endorsed by the American College of Cardiology Foundation.

Based on the existing literature, the SCCM task force recognized ACCE as a more advanced skill and developed requirements in achieving competence in ACCE.

General Principles

The main distinction between approaches to achieving competence in CCUS and ACCE is that the latter requires a certification process or its equivalent with an examination. The task force's approach towards achieving competence in CCUS is similar to the approach that the American College of Emergency Physicians has taken towards emergency ultrasound. Instead of focusing on a specific duration of training, the emphasis is on the number of examinations performed and spectrum of pathology evaluated. The providers utilizing CCUS and ACCE must be able to recognize when timely subspecialist consultation is indicated.

Training Pathways

Training within Specialty Fellowship Program (Fellowship-Based Pathway)

Both accredited and non-accredited critical care fellowship programs may decide to offer training in CCUS and ACCE. This will either require revision of current curricula to accomplish the training goals outlined in these recommendations or creation of a fellowship solely dedicated to ACCE. Providers successfully completing a graduate training program that includes ultrasound training in general should be considered competent for the

purposes of hospital credentialing. A letter of support and description of the extent of training should be provided by the training program director.

Training Equivalence for Providers Already in Practice (Practice-Based Experience Pathway)

Providers already in practice will be able to achieve appropriate training in CCUS and ACCE without enrolling in a specific fellowship. The same standards of prerequisite medical knowledge, medical training, and goals of knowledge and technical skills apply to the practice-based experience pathway as apply to the fellowship-based pathway. If a provider has already acquired expertise in CCUS and ACCE, this experience must be documented in detail to demonstrate its equivalence to the training levels described in these recommendations. A provider with no or minimal experience in CCUS and ACCE must work with one who has the appropriate expertise and fulfills the supervision standards described in this document.

Medical Knowledge and Training

Shared CCUS and ACCE Requirements

Trainees in both CCUS and ACCE must be licensed providers who have completed an accredited specialty training program. Additionally, each trainee must have special knowledge of critically ill or injured patients by either completing an accredited or non-accredited fellowship in critical care medicine, or through practice experience providing care to critically ill or injured patients for at least 25% of clinical time during the previous 2 years.

Specific Requirements for ACCE

To achieve certification in ACCE, a candidate must first obtain board certification in a primary specialty, in addition to the experience in critical care medicine specified earlier. Given the complexity of ACCE, board certification is the basis for core clinical competence.

Scope of Ultrasound and Echocardiographic Knowledge and Skills

CCUS

Table 4 outlines the training objectives for the cognitive and technical skills needed for CCUS and ACCE. The CCUS trainee will be prepared to perform goal-directed, limited examinations to identify one or two specific findings and answer straightforward, commonly dichotomous clinical questions (e.g., presence of pericardial effusion, yes/no). Of particular note, focused cardiac ultrasound does not prepare the provider to influence the plan of

care for critically ill or injured patients in settings other than cardiac arrest and shock without the assistance of a provider with advanced training in echocardiography. Finally, seeking additional clinical expert involvement is mandatory when a provider is unsure of CCUS findings.

ACCE

Specific training in ACCE should involve the cognitive and technical skills necessary to independently practice ACCE in its full diagnostic capacity, including the necessary expertise to effect changes in the management of patients through the entire duration of the critical illness or injury (Table 5). As a result, the practicing critical care provider would develop expertise in incorporating ACCE findings into the clinical practice environment and guide the therapeutic management plan based on echocardiographic findings. Finally, because of the complexity of ACCE, the task force believes that passing an examination of special competence in echocardiography is necessary for competence. This exam could be the ASCeXAM, basic or advanced PTEeXAM, or an ACCE exam if one is developed.

Components of Training

CCUS

Components of CCUS training include independent work, proctored ultrasound examinations, and assessment of knowledge and skills. Independent work consists of a structured reading and study program as an introduction to the principles and indications for CCUS and regularly scheduled didactics to reinforce the most important aspects. The didactics, live and electronic-based modules, can consist of lectures, case studies, hands-on experience, and simulation. For providers being credentialed through the fellowship pathway, this may include a longitudinal curriculum and/or introductory course with at least 20 hours of didactics during the critical care fellowship. For those being credentialed through the practice experience pathway, this includes at least 20 hours of continuing medical education (CME) AMA Category 1 credits or their equivalent. The CME credits should be obtained while acquiring practical experience in CCUS. Regardless of the pathway, the curriculum should cover all objectives for knowledge of CCUS as specified in Table 4.

Mentoring by a credentialed expert in CCUS is an essential component to the training, and proctored examinations are the cornerstone of this process. Proctoring can be performed by a single expert in all core applications of CCUS or a combination of experts in various core applications. As knowledge and skills increase, the trainee

should start performing activities progressively more independently. A credentialed CCUS provider must review all examinations performed until the ultrasound trainee is deemed competent for independent work. The trainee must be encouraged to obtain all views consistent with CCUS whenever the clinical situation allows.

The task force recommendations on the number of CCUS examinations in its core applications are summarized in Table 6. These numbers are based on the recommendations of the American College of Emergency Medicine and are consistent with previously published recommendations for critical care medicine providers.^{7,14} These examinations must include the most commonly encountered critical care diagnoses within each core application of CCUS. All qualifying examinations must be documented, including the images and clinical report. A complete log of qualifying examinations should be kept, containing (at a minimum) the date of examination, patient indication and main diagnosis, and proctor's name and title. Finally, the trainee's progress should be regularly evaluated by the CCUS director/coordinator at the bedside or in simulated environment, and include tracking of progress in the performance of ultrasound examinations, assessment of ultrasound technique, and image interpretation. During the training process, each ultrasound examination performed by the trainee should be reviewed.

ACCE

Independent work, proctored ACCE examinations, and assessment of knowledge and skills are the main components of training. As in CCUS training, training in ACCE may include a variety of educational techniques. For providers being credentialed through the fellowship pathway, this may include a longitudinal curriculum and/or introductory course with at least 40 hours of didactics during the critical care fellowship. For those being credentialed through the practice experience pathway, this includes at least 40 hours of AMA Category 1 credits or their equivalent. The CME credits in ACCE should be obtained while acquiring experience in ACCE. Regardless of the pathway, the curriculum should cover all objectives for knowledge of ACCE as specified in Table 5.

The SCCM Ultrasound Certification Task Force recommends interpretation of 400 ACCE examinations under appropriate supervision, of which at least 200 studies must be personally performed, interpreted, and reported by the trainee. If TEE competence is desired, 100 of these examinations must be TEE studies, with

at least 50 studies personally performed, interpreted, and reported by the trainee. During the time dedicated to training, the trainee must perform at least 50 ACCE examinations annually. Qualifying examinations must include the full spectrum of critical care diagnoses. The experience and case numbers acquired during CCUS training may be counted towards further training in ACCE if conducted in a proper training environment (see section, Training Environment and Supervision). All examinations must be documented, including archiving of images and written reports. A complete log of examinations should be kept to document the breadth of experience and should include date of examination, patient indication and main diagnosis, as well as the proctor's name and title. Finally, the trainee's progress should be regularly evaluated by the ACCE director/coordinator at the bedside or in simulated environment, and include tracking of progress in obtaining echocardiography views, assessment of technique, and image interpretation. During the training process, each echocardiogram obtained by the trainee should be reviewed for feedback and educational purposes on a regular basis, preferably in real time, and within a week in emergency situations.

The task force recognizes that trainees will use their time differently depending on their clinical background. An anesthesiologist with training in perioperative TEE can apply TEE exams towards certification if the exams have been performed for monitoring purposes under appropriate supervision, making the focus of training the accrual of knowledge and skills in transthoracic echocardiography (TTE). A pulmonologist with training in chest ultrasound will need to spend the majority of time acquiring knowledge and skills in both TTE and TEE, if competence in TEE is desired.

Training recommendations in ACCE are similar to those in general echocardiography¹⁶ and advanced training in perioperative TEE,¹⁷ emphasizing exposure to the spectrum of critical care diagnoses and dependent on the volume and diversity of the critical care medicine program. Although the task force did not specify a duration of training in ACCE, critical care providers generally will be able to complete the requirements within 2 years, commonly in 12-18 months, and no longer than 4 years.

Training Environment and Supervision

An important aspect of the training environment is continuous availability of an ultrasound machine capable of high-quality 2D imaging and all Doppler applications

in the ICU. The task force recommends availability of a designated transesophageal probe in environments where TEE is frequently used. All hospital infection control protocols and storage standards should be maintained.

CCUS

The supervisor should be a provider credentialed in the core applications of CCUS and should directly observe until the trainee has consistently demonstrated adequate performance of the CCUS examination. When the trainee starts performing the examination independently, the supervisor must be readily available. In cases of clinical emergency and unavailability of the supervisor, the trainee should have confirmatory studies performed, whenever clinically possible, to support any independent activities; in these situations, studies must be reviewed within 24 hours by the supervisor. The trainee should have access to a wide variety of critically ill or injured patients in whom CCUS is performed as an integral part of patient management.

ACCE

Training should take place in a program specifically designed to accomplish proficiency in ACCE. The supervisor should be a provider credentialed in ACCE. Experience in TEE is required in a program where TEE is the preferred modality of ACCE. If the trainee has not yet accomplished CCUS training, then the same initial direct supervision should be provided for the trainee as outlined for CCUS. Just as in CCUS training, the supervisor must be readily available when the trainee starts performing the examination independently. In cases of clinical emergency and unavailability of the supervisor, the trainee must have confirmatory studies performed to support any independent activities; furthermore, the studies must be reviewed and interpretations compared within 24 hours by the supervisor. The supporting critical care medicine program must allow the trainee to experience the full spectrum of diagnostic entities in ACCE.

Continuous Quality Improvement

A quality assurance and improvement program (QA/QI) is necessary to ensure quality, facilitate education, and satisfy credentialing requirements. An over-read or peer-review service may be utilized when internal image, video, and case review is not available at a facility.

Critical Care Ultrasound/Echocardiography Director and Ultrasound Committee

The critical care ultrasound/echocardiography director should be a board-certified critical care medicine provider

who has been given administrative oversight of the ultrasound program by the institution's critical care medicine leadership. Responsibilities include coordination of education, machine acquisition and maintenance, and development, monitoring, and revision of the QA/QI process. Additional qualifying requirements for an ACCE program director include testamur or certification status in ASCeXAM or basic or advanced PTEeXAM and interpretation of 500 ACCE examinations, of which 250 critical care TTE and 100 critical care TEE examinations must be personally performed. The requirement for TEE performance only applies to programs that specifically train in TEE. The director will work with the departmental ultrasound committee, whose main role is to provide expertise in all aspects of an ultrasound program.

Documentation

For proper documentation, a written report should be generated in each patient's chart. The initial documentation may be preliminary and brief, reflecting the presence or absence of the relevant findings. More comprehensive documentation may include indication(s), technique, findings, and impression, as well as key images from the examination. The documentation may be hand-written, transcribed, templated, or computerized, but it should be consistent and follow established rules within the department. Hard copy images (paper, film, digital) should be saved within the critical care medicine or hospital archival systems. Finally, billing for CCUS and ACCE depends on proper documentation.

QA Process

The objective of the QA process is to evaluate images for technical competence, analyze interpretations for clinical accuracy, and provide feedback to improve performance. Evaluation of technical competence includes image resolution, anatomic definition, and aspects of image quality acquisition, such as gain, depth, and orientation. Accuracy of image interpretation involves comparing the CCUS and ACCE interpretation to other measures, such as consultative ultrasound and other imaging modalities, surgical procedures, or patient clinical outcome. The "gold standard" of the QA process is direct supervision of the trainee's performance of the ultrasound examination by the credentialed CCUS and ACCE provider.

The process of review usually involves both images and documentation. Video and still image review are acceptable based on the archiving capacity of the institution. Digital solutions are preferable to paper

systems as they support more robust QA activities. The system design should include a data storage component to allow retrieval of data. All images obtained before credentialing should be reviewed, whereas images from the credentialed provider may be randomly sampled during QA at pre-defined intervals. In addition to timely review, the efficient QA system should be designed to provide timely feedback to providers. The flow of a QA system consists of the following:

1. All images obtained during CCUS and ACCE evaluation are transferred to hard copy.
2. Clinical information, ultrasound findings, and additional test results can be retrieved upon request during the review.
3. The ultrasound director/ultrasound committee reviews the images and data based on criteria specified earlier.
4. Feedback is communicated to a provider.
5. CCUS and ACCE studies are archived and available for later review as needed, at least during a monthly conference.

Ultrasound Machines and Maintenance

The ultrasound machine should be chosen based on the needs and number of users. The ultrasound director is responsible for equipment-related activities: regular in-service of personnel using the equipment, management of supplies, adequate cleaning of transducers and machines with respect to infection control, maintenance of machines by clinical engineering, and efficient communication of equipment needs.

Maintenance of Competence

Credentialed providers in CCUS and ACCE should maintain their competence by continuously participating in education and QI activities. Providers should participate in ongoing education in various aspects of CCUS and ACCE. This should amount to at least 10 hours of CME credits annually or equivalents in CCUS and ACCE. Appropriate activities may include AMA PRA Category 1 credit activities, on-line educational activities, simulation, teaching, preceptorship, research, QA, administration, image review, examinations, textbook and journal readings, manuscript preparation, morbidity and mortality conferences inclusive of ultrasound cases, and other activities related to CCUS and ACCE. Additionally, each provider must perform at least 50 CCUS examinations and 50 ACCE examinations (with at least 20 TEE examinations if ongoing competence in TEE is desired) annually to maintain competence.

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Table 1. Training Pathways in Critical Care Ultrasound with Focused Cardiac Ultrasound

Requirements	Fellowship Pathway	Practice Experience Pathway
Current license to practice medicine	Required	
Current medical board certification	Certified or eligible	
Specific training/ experience in critical care	Fellowship in critical care medicine	Fellowship in critical care medicine or 24 months of clinical experience in critical care medicine, with at least 25% of clinical time dedicated to care of critically ill patients for the last 2 years of practice
Minimum number of examinations	See Table 6	
Didactics	Curriculum during fellowship training	20 hours of continuing medical education, AMA PRA Category 1 credits or their equivalent; credits should be obtained while acquiring practical experience in CCUS
Spectrum of pathology	Broad, including main diagnoses within each core application	
Examination of special competence	Not required	

AMA, American Medical Association; CCUS, critical care ultrasound plus focused cardiac ultrasound

Table 2. Training Pathways in Advanced Critical Care Echocardiography

Requirements	Fellowship Pathway	Practice Experience Pathway
Current license to practice medicine	Required	
Current medical board certification	Certified provider	
Specific training/ experience in critical care	Fellowship in critical care medicine	Fellowship in critical care medicine or 24 months of clinical experience in critical care medicine, with at least 25% of clinical time dedicated to care of critically ill patients for the last 2 years of practice
Minimum number of examinations	Interpretation of 400 examinations under appropriate supervision, of which at least 200 studies must be personally performed, interpreted, and reported by the trainee; if TEE competence is desired, 100 of these examinations must be TEE studies, with at least 50 studies personally performed, interpreted, and reported by the trainee	
Didactics	Curriculum during fellowship training	40 hours of AMA Category 1 credits or their equivalent; credits should be obtained while acquiring experience in ACCE
Spectrum of pathology	Full spectrum of critical care diagnoses	
Examination of special competence	Required (currently ASCeXAM, basic or advanced PTEeXAM)	

AMA, American Medical Association; ACCE, advanced critical care echocardiography; TEE, transesophageal echocardiography

Table 3. Core Applications of Critical Care Ultrasound in Intensive Care Unit**Diagnostic**

Focused cardiac ultrasound
 Pleural/pulmonary ultrasound
 Focused abdominal ultrasound
 Vascular ultrasound (e.g., deep venous thrombosis)

Procedural

Vascular access guidance
 Thoracentesis
 Paracentesis
 Pericardiocentesis
 Arthrocentesis
 Abscess aspiration

Table 4. Recommended Training Objectives for Critical Care Ultrasound**Knowledge**

1. Physical principles of ultrasound image formation and pulse-wave, continuous, and color Doppler
2. Artifacts and pitfalls
3. Operation of ultrasound machines, including controls and transducers
4. Equipment handling, infection control, and electrical safety
5. Data management, including image storage, integration with hospital image management systems, reporting, quality assurance process
6. Ergonomics of ultrasound exam in intensive care unit environment
7. Indications, contraindications, limitations, and potential complications of critical care ultrasound and echocardiography
8. Normal sonographic anatomy of each relevant modality and organ system
9. Standard windows and views for each relevant modality
10. Incorporation and integration of focused transthoracic with other modalities of hemodynamic monitoring
11. Normal and abnormal right and left ventricular size and systolic function
12. Normal and abnormal cardiac atrial size
13. Estimation of central venous pressure and limitation of ultrasound estimation
14. Ultrasound manifestations of pericardial effusion and signs of tamponade and limitation of ultrasound diagnosis of tamponade
15. Ultrasound manifestations of septic shock and differentiation between severe hypovolemia and vasodilatory state
16. Ultrasound manifestation of severe hypovolemia and understanding of the limitation of assessment of "fluid status" with ultrasound
17. Ultrasound manifestations of pneumothorax and understanding of the limitation in diagnosis of pneumothorax
18. Ultrasound characterization of pleural effusion
19. Ultrasound manifestations of large deep venous thrombosis in femoral veins
20. Incorporation of cardiac ultrasound in Advanced Cardiac Life Support (ACLS) protocols
21. Principles of needle/wire guidance with ultrasound for bedside procedures, including vascular access, thoracentesis, paracentesis, and tube thoracostomy

Table 4. Recommended Training Objectives for Critical Care Ultrasound (continued)**Skills:**

1. Ability to operate ultrasound machines and utilize their controls to optimize image quality
2. Ability to recognize common ultrasound artifacts (e.g. reverberation, side lobe, mirror image)
3. Ability to select an appropriate probe for a given ultrasound examination
4. Ability to insert transesophageal echocardiography probe in anesthetized, tracheally intubated patient (if this competence is desired)
5. Ability to incorporate ultrasound examinations in the bedside management of critically ill or injured patients during cardiopulmonary arrest or in shock
6. Ability to perform basic transthoracic echocardiography and differentiate normal from markedly abnormal cardiac structures and function
7. Ability to recognize marked changes in global left systolic function
8. Ability to recognize marked hypovolemia
9. Ability to recognize gross valvular lesions and dysfunction
10. Ability to detect significant pericardial effusions
11. Ability to rule out pneumothorax in patients with normal chest walls
12. Ability to assess pleural effusion: size, location, degree of loculation
13. Ability to assess alveolar/interstitial syndrome
14. Ability to recognize large deep venous thrombosis in femoral veins
15. Ability to incorporate ultrasound in patient resuscitation during cardiopulmonary arrest without interfering with ACLS protocols or interrupting chest compressions.
16. Ability to communicate ultrasound findings to other healthcare providers, the medical record, and patients
17. Recognize when referral to or consultation with other specialists is necessary
18. Ability to recognize complications of various critical care ultrasound applications
19. Ability to guide bedside procedures with ultrasound (e.g., vascular access, thoracentesis, paracentesis, arthrocentesis)
20. Ability to identify signs of chronic cardiac disease

Table 5. Recommended Training Objectives for Advanced Critical Care Echocardiography**Knowledge**

1. All knowledge needed to perform critical care ultrasound
2. Advanced knowledge of artifacts and pitfalls in interpretation.
3. Knowledge of comprehensive transthoracic and/ or transesophageal echocardiography views
4. Detailed knowledge of qualitative and quantitative echocardiography
5. Detailed knowledge of heart-lung interactions in spontaneously breathing and mechanically ventilated patients
6. Detailed knowledge of diseases of the heart relevant to care of critically ill or injured patients (e.g., dynamic left ventricular outflow tract obstruction, systolic anterior motion of the mitral valve, pericardial constriction, restrictive cardiomyopathy, ischemic cardiomyopathy, mitral or aortic stenosis)

Table 5. Recommended Training Objectives for Advanced Critical Care Echocardiography (continued)

7. Detailed knowledge of normal and abnormal left ventricular systolic function, including segmental wall motion abnormalities
8. Detailed knowledge of normal and abnormal left ventricular diastolic function
9. Detailed knowledge of normal and abnormal right ventricular function, including the appearance of acute and chronic pulmonary hypertension, right ventricular infarct, pulmonary heart failure, tricuspid annular plane systolic excursion, right ventricular fractional area change
10. Detailed knowledge of commonly encountered complications of acute coronary syndrome
11. Detailed assessment of hemodynamic significance of valve dysfunction
12. Detailed knowledge of tamponade physiology, including flow variation in the right and left hearts, chamber collapse, inferior vena cava plethora
13. In-depth knowledge of applications of critical care echocardiography in evaluating fluid responsiveness
14. Knowledge of anatomy, physiology, and implications of intracardiac and intrapulmonary shunts
15. Knowledge of echocardiographic manifestations of intracardiac masses and thrombi
16. Detailed knowledge of other diagnostic modalities relevant in hemodynamic management of critically ill or injured patients

Skills

1. All the skills needed in basic critical care ultrasound
2. Ability to perform comprehensive transthoracic and/or transesophageal echocardiography exam
3. Ability to quantify flows and pressures across various cardiac chambers
4. Ability to acquire comprehensive hemodynamic data
5. Ability to quantify systolic and diastolic left ventricular function
6. Ability to quantify right ventricular systolic function
7. Ability to recognize subtle left ventricular wall motion abnormalities
8. Ability to quantify normal and abnormal native and prosthetic valvular function
9. Ability to evaluate hemodynamic consequences of pericardial effusion and tamponade
10. Ability to assess fluid responsiveness in spontaneously breathing and mechanically ventilated patients using validated echocardiographic dynamic indices of preload
11. Ability to assess for the presence of intracardiac and intrapulmonary shunts
12. Ability to assess for intracardiac masses and thrombi
13. Ability to recognize limitations and inaccuracies of the chosen modality and identify additional diagnostic modalities necessary for the management of a critically ill patient, and recognize situations when referral to specialist is required

Table 6. Requirements for Competence in Critical Care Ultrasound Core Applications

Type of Ultrasound	Application	Minimum Number Interpreted	Minimum Number Personally Performed
Diagnostic	Basic CCE	50	30
	Pleural/pulmonary ultrasound	30	20
	Focused abdominal ultrasound	30	20
	Vascular ultrasound	30	20
Procedural	Vascular access	10	10
	Thoracentesis/ thoracostomy	5	5
	Pericardiocentesis	5	5
	Paracentesis	5	5
	Other needle guidance procedures	5	5

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