

Assessing Competence in Critical Care Echocardiography: Development and Initial Results of an Examination and Certification Processes

OBJECTIVES: To describe the development and initial results of an examination and certification process assessing competence in critical care echocardiography.

DESIGN: A test writing committee of content experts from eight professional societies invested in critical care echocardiography was convened, with the Executive Director representing the National Board of Echocardiography. Using an examination content outline, the writing committee was assigned topics relevant to their areas of expertise. The examination items underwent extensive review, editing, and discussion in several face-to-face meetings supervised by National Board of Medical Examiners editors and psychometricians. A separate certification committee was tasked with establishing criteria required to achieve National Board of Echocardiography certification in critical care echocardiography through detailed review of required supporting material submitted by candidates seeking to fulfill these criteria.

SETTING: The writing committee met twice a year in person at the National Board of Medical Examiner office in Philadelphia, PA.

SUBJECTS: Physicians enrolled in the examination of Special Competence in Critical Care Electrocardiography (CCEeXAM).

MEASUREMENTS AND MAIN RESULTS: A total of 524 physicians sat for the examination, and 426 (81.3%) achieved a passing score. Of the examinees, 41% were anesthesiology trained, 33.2% had pulmonary/critical care background, and the majority had graduated training within the 10 years (91.6%). Most candidates work full-time at an academic hospital (46.9%).

CONCLUSIONS: The CCEeXAM is designed to assess a knowledge base that is shared with echocardiologists in addition to that which is unique to critical care. The National Board of Echocardiography certification establishes that the physician has achieved the ability to independently perform and interpret critical care echocardiography at a standard recognized by critical care professional societies encompassing a wide spectrum of backgrounds. The interest shown and the success achieved on the CCEeXAM by practitioners of critical care echocardiography support the standards set by the National Board of Echocardiography for test-taker status and certification in this imaging specialty area.

KEY WORDS: anesthesiology; board certification; critical care; critical care echocardiography; emergency medicine

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The management of the critically ill patient involves the intersection of multiple medical and surgical specialties. The application of critical care ultrasonography, of which critical care echocardiography (CCE) is a key component, has been well defined in comprehensive statements by the national and international professional societies (1–7). CCE, performed by the clinician at the bedside, may be used to immediately identify life-threatening causes of hemodynamic failure, categorize shock states, guide the management of cardiopulmonary failure, track response to therapy, and follow the evolution of the disease process at the bedside of the patient (8–11).

Echocardiography, when performed by the critical care clinician, can be divided into two categories: basic echocardiography and advanced CCE. Basic echocardiography is endorsed as a core skill for critical care providers and does not require certification (12). Advanced CCE incorporates additional skill in image acquisition, interpretation, and clinical integration of echocardiography results to immediately guide hemodynamic management at the point-of-care (13–15). This requires competence in a variety of measurements that are not part of basic echocardiography such as assessment of dynamic indices of preload sensitivity, ventilator induced heart-lung interactions, and integration of thoracic ultrasonography with echocardiographic findings (16). In addition to having knowledge in CCE, the critical care clinician should also be able to recognize when consultative echocardiography is required.

Prior to the development of the National Board of Echocardiography (NBE) certification in CCE, critical care physicians could take the NBE Examination of Special Competence in Adult Echocardiography (ASCeXAM), which cardiologists are required to pass for the NBE echocardiography certification process. However, critical care physicians could not obtain

certification by the NBE in echocardiography, as the NBE requires fellowship training in cardiovascular disease. Noncardiologists who passed the ASCeXAM were limited to “testamur” status. This fact, coupled with the perception that the ASCeXAM did not test for knowledge that was unique to CCE, motivated the North American professional societies representing critical care physicians, in conjunction with the American Society of Echocardiography, to propose that the NBE develop a certification process for CCE. The goal of this article is to describe the thoughtful collaboration and rigorous methods of North American CCE stakeholders in the development and the results of the first NBE qualifying examination for CCE, a prerequisite for the new NBE certification in CCE. This examination has relevance to clinicians who have interest in demonstrating competence and obtaining certification in this field.

OBJECTIVES OF THE CCE EXAMINATION

The primary aim of the NBE board examination is to provide physicians an objective means to demonstrate expertise and advanced knowledge in CCE (Table 1). This competence is based on standards developed through collaboration among the relevant professional societies representing the critical care and echocardiography communities and, when subsequently combined with competence in practice requirements, to provide a pathway for national level certification in CCE. As the practice of critical care is not restricted to a single specialty, the NBE examination writing committee included content experts from multiple specialties that provide critical care services (Table 2). This ensured that the stake holding specialties could represent their area of expertise in order to provide depth

TABLE 1.
Goals of the Examination of Special Competence in Critical Care Echocardiography (CCEeXAM) and Certification

| |
|--|
| Development of curricula and scope of the practice of critical care echocardiography. |
| Assessment of the level of knowledge in critical care echocardiography with a valid test. |
| Enhance the professional development in critical care echocardiography. |
| To have formal recognition of physicians with advanced knowledge and skills in critical care echocardiography by the National Board of Echocardiography. |
| Improve quality patient care in the practice of critical care echocardiography. |

TABLE 2.
**Representative Societies in the
 Development of a Critical Care
 Echocardiography Examination**

| |
|---|
| American Society of Echocardiography |
| American College of Chest Physicians |
| Society of Critical Care Medicine |
| American Thoracic Society |
| American College of Emergency Physicians |
| Canadian Critical Care Society |
| Society of Cardiovascular Anesthesiologists |
| World Interactive Network Focused on Critical Ultrasound |

and insight on the core content of CCE and to develop a comprehensive examination that would encompass a broad scope of practice in critical care medicine. The society representatives on the committee were nominated by their representative society leadership for their notoriety as content experts in their given specialty. The NBE is dedicated to promoting committee diversity and inclusion as outlined on their website (17). Although echocardiography is the focus, the examination also covers essential ultrasonography-related topics unique to critical care such as thoracic, abdominal, and vascular ultrasonography.

REQUIREMENTS TO TAKE THE CCE EXAMINATION

The prerequisites for the Examination of Special Competence in Critical Care Echocardiography (CCEeXAM) are similar to those of the ASCeXAM. Applicants must hold a valid license to practice medicine at the time of application. Critical care physicians from outside of North America may apply for the examination. A detailed description of the examination requirements can be found on the NBE CCEeXAM website (18).

TEST DEVELOPMENT

The NBE, in partnership with the National Board of Medical Examiners (NBMEs), developed the examination. The first step in developing the examination was

to decide on what content should be tested and in what proportions, so a content design (blueprinting) process was implemented. The CCEeXAM test development committee met for 1 full day at NBME headquarters to initiate the examination structuring process. First, the committee reviewed background materials relevant to the examination, including the ASCeXAM content outline and other documents. Then, the members achieved consensus on the major topics to be included in the examination and in what proportions. Next, the members specified subtopics within each major area and added them to the content outline. Ultimately, the committee accepted three major sections: Functional Anatomy, Clinical Diagnosis and Management, and Technical Skills and Equipment Optimization. The CCE committee members reviewed related subtopics and the content outline (blueprint) as a whole and finalized it (19).

The next step in the development process was to write the questions (referred to as “items”) according to the blueprint in the specified proportions. The committee was given extensive training in examination question writing, both online and in person, and followed the process that has been used by the NBME and NBE for decades to develop a fair and representative examination (20, 21). With this training and the examination content set, each member of the writing committee was assigned topics relevant to their areas of expertise for item development. Item vignettes, stems, and responses underwent extensive review, editing, and discussion in several face-to-face meetings supervised by NBME psychometricians and editors. Items that did not generate unanimous committee approval were eliminated from the examination pool. A small percentage of items were drawn from the ASCeXAM item pool.

The first CCEeXAM was administered in January 2019. The examination consisted of 200 multiple choice items with video and still images and was administered in computer-based centers operated by a national testing service. The duration of the examination was 4 hours and will be offered annually.

Scoring the Examination

The results of the examination were analyzed, and items that had unexpected statistics were identified and sent for joint review by NBME psychometricians and CCEeXAM committee members. For each reviewed

TABLE 3.
Practice Patterns and Test Results of the 2019 Critical Care Echocardiography Examination Candidates

| Critical Care Demographic Questions | | |
|--|------------------------|-----------------------|
| Test Results | Passed 81.3% (n = 426) | Failed 18.7% (n = 98) |
| Two individuals that passed the exam did not answer any of the demographic questions | | |
| I have been practicing CCE for how many years | Passed | Failed |
| 0-2 yr, n (%) | 155 (36.6) | 42 (42.9) |
| 3-5 yr, n (%) | 153 (36.1) | 33 (33.7) |
| 6-10 yr, n (%) | 79 (18.6) | 18 (18.3) |
| 11-15 yr, n (%) | 23 (5.4) | 1 (1) |
| 16-20 yr, n (%) | 5 (1.2) | 4 (4.1) |
| 20+ yr, n (%) | 9 (2.1) | 0 |
| Total | 424 | 98 |
| Training background | | |
| Anesthesiology, n (%) | 180 (42.5) | 35 (35.7) |
| Surgery, n (%) | 5 (1.2) | 9 (9.2) |
| Emergency medicine, n (%) | 36 (8.5) | 6 (6.1) |
| Neurology, n (%) | 2 (0.5) | 1 (1) |
| Pulmonary/critical care, n (%) | 138 (32.5) | 36 (36.7) |
| Other, n (%) | 63 (14.9) | 11 (11.2) |
| Total | 424 | 98 |
| Currently I spend the majority of my time in | | |
| Anesthesiology, n (%) | 130 (30.7) | 27 (27.6) |
| Surgery, n (%) | 3 (0.7) | 5 (5.1) |
| Emergency medicine, n (%) | 21 (4.9) | 3 (3.1) |
| Pulmonary/critical care, n (%) | 199 (46.9) | 44 (44.9) |
| Neurology critical care, n (%) | 6 (1.4) | 15 (15.3) |
| Other | 65 (15.3) | 4 (4.1) |
| Total | 424 | 98 |
| Type of practice | | |
| Private, n (%) | 10 (2.4) | 4 (4.1) |
| Hospital, n (%) | 101 (23.7) | 31 (31.6) |

(Continued)

TABLE 3. (Continued).**Practice Patterns and Test Results of the 2019 Critical Care Echocardiography Examination Candidates**

| Critical Care Demographic Questions | | |
|---|------------------------|-----------------------|
| Test Results | Passed 81.3% (n = 426) | Failed 18.7% (n = 98) |
| Private and hospital, n (%) | 22 (5.2) | 8 (8.2) |
| Full-time academic, n (%) | 205 (48.1) | 41 (41.8) |
| Part-time academic, n (%) | 11 (2.6) | 2 (2) |
| Fellow, n (%) | 68 (15.9) | 12 (12.2) |
| Other, n (%) | 9 (2.1) | 0 |
| Total | 426 | 98 |
| Echocardiograms performed and interpreted | | |
| None, n (%) | 8 (1.9) | 5 (5.1) |
| < 5/wk, n (%) | 87 (20.4) | 36 (36.7) |
| 5-10/wk, n (%) | 189 (44.4) | 40 (40.8) |
| 11-20/wk, n (%) | 94 (22.1) | 8 (8.1) |
| > 20/wk, n (%) | 48 (11.3) | 9 (9.2) |
| Total | 426 | 98 |
| CCE training | | |
| Formal instruction critical care training/fellowship, n (%) | 271 (63.6) | 49 (50) |
| Other than formal instruction, n (%) | 155 (36.1) | 49 (50) |
| Total | 426 | 98 |
| Length of CCE training | | |
| 3-5 mo, n (%) | 96 (22.5) | 28 (28.6) |
| 6-11 mo, n (%) | 54 (12.7) | 12 (12.2) |
| 12 or more mo, n (%) | 125 (29.3) | 14 (14.3) |
| None, n (%) | 151 (35.4) | 44 (44.9) |
| Total | 426 | 98 |

CCE = critical care echocardiography.

Standard Setting

The next step in the process was to decide how much knowledge a candidate needed to demonstrate in order to pass the examination, that is, what is the minimum proficiency level required to pass a candidate? Since

performance (cut score), a modified Angoff method was employed (21). The modified Angoff method for determining a passing score for licensing and certification is used extensively to determine the cut score for NBME examinations. To do this, examination writers independently read each examination question and

estimated how many examinees meeting the minimum standard would correctly answer the question. The examination writers were then shown the actual percentage of examinees who answered the question correctly, and with these data, they then rerated the difficulty of the question. With expert opinion on the difficulty of the question, matched with actual performance data, the difficulty of each question was determined. The results of this process were then summarized and discussed. With expert consensus and actual performance data on how difficult the test was, the groups were then polled for what they thought would be an acceptable on a passing rate. The passing rate is set only after this process is complete. Because the passing score is determined after the examination is given, questions cannot be modified or manipulated to change the passing rate. The procedure required committee members to meet face-to-face at NBME headquarters for a full day.

Once the CCEeXAM committee set the standard, the recommendations were voted on by the NBE Board and made final. The 2019 examinees were then notified of their test results and given a breakdown of their scores by item content. The writing committee received statistical information about the candidates including area of specialty, years in practice, type and duration of echocardiography training, number of ultrasound examinations performed per year, and passing score.

Certification in CCE

Certification in CCE is a multistep process. Similar to the ASCeXAM, the individual who passes the examination is designated as a “testamur.” Further criteria must be satisfied in order to achieve NBE certification. Upon successful completion and review of supporting documents, the NBE has named this achievement “Certification in Special Competence in CCE.”

Currently, there are two pathways to achieve certification: training and practice. The practice pathway is a provision for those providers who practice CCE but did not obtain dedicated critical care training or completed critical care fellowship prior to the development of the CCE examination. The requirements for certification can be accessed on the NBE CCEeXAM website (18).

The certification committee is composed of a subset of members drawn from the examination writing committee and meets twice a year in person to review

applications. Certification lags behind successful passing of the CCEeXAM because of the time it takes to develop the echocardiography log (**Appendix 1**, <http://links.lww.com/CCM/G212>) and other supporting documents. Data of this process are currently limited, so although an overview of the process of achieving certification is described in this article, greater detail and the results will be reported separately when available.

RESULTS OF THE 2019 EXAMINATION

A total of 524 physicians took the examination, and 426 (81.3%) achieved a passing score. Of the examinees, 41% were anesthesiology trained, and 33.2% had pulmonary/critical care background. Training, practice patterns, and pass/fail data are summarized in **Table 3**.

DISCUSSION

The first CCEeXAM was well attended with 524 physicians taking the examination. This number exceeded the initial interest in cardiology and anesthesiology NBE exams and is well above the number needed to maintain the viability of the process. The number of candidates indicates interest in the NBE CCE certification by the critical care community. The pass rate for the new CCE examination is within the range of pass rates for the ASCeXAM. The second CCEeXAM was given in January 2020, and the writing group is well into preparation for the 2021 and 2022 editions.

Critical care physicians from a variety of training backgrounds were in the examinee group. In addition to a strong showing from clinicians with pulmonary/critical care background, anesthesiologists were well represented. This may reflect the interest in CCE among cardiac anesthesiologists, as it is a natural extension of their background in intraoperative transesophageal echocardiography and their involvement with provision of critical care services in the postoperative cardiac surgery ICU. Aronson et al (22) described the development of certification in perioperative transesophageal echocardiography for anesthesiologists and cardiologists. They included biographic data and performance of more than 1,200 applicants (mostly anesthesiologists) who took the examination over 5 years. Comparatively, more than 500 individuals applied to the CCEeXAM in the first year alone, demonstrating a clear interest in establishing the domain of the practice of CCE in the critical care community.

The CCE certification committee has noted strong interest among fellows in certification, and, as the practice pathway sunsets, we predict that fellows will constitute the majority of future candidates. The committee notes that the requirements for certification on the practice pathway are challenging (critical care time documentation, retrieval of echocardiography examination information and log certification, and CME documentation) and urge current fellows to take advantage of their status if considering certification prior to graduation.

The NBE has deliberately established a certification pathway for inclusion of clinicians who provide critical care services but did not pursue critical care fellowship training. The grand-parenting of noncritical care fellowship trained individuals provides an avenue for certification until 2026. This pathway is specifically designed for clinicians who provide critical services on a regular basis. This includes hospitalists and graduates of residency programs that did not have a critical care board certification option such as emergency medicine physicians. The NBE certification provides these physicians with objective evidence of competence in CCE, is useful for hospital credentialing, and supports reimbursement for these services. The natural progression in the process is to become a testamur and then achieve certification. Although we advocate for NBE CCE certification, this pathway does not relate to or restrict appropriately trained providers in the use of CCE nor does it obstruct or limit use of CCE, if the clinician is appropriately trained and privileged in their home institution.

SUMMARY

The CCEeXAM is designed to assess a knowledge base that is shared with echocardiologists in addition to that which is unique to critical care. The NBE certification establishes that the physician has achieved the ability to independently perform and interpret CCE at a standard recognized by critical care professional societies encompassing a wide spectrum of backgrounds. The interest shown and the success achieved on the CCEeXAM by practitioners of CCE support the standards set by the NBE for testamur status and certification in this imaging specialty area.

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