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SPECIAL CONTRIBUTION

Education

The 2023 Core Content of advanced emergency medicine ultrasonography

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Abstract

In February 2023, the American Board of Emergency Medicine (ABEM) approved modifications to the Advanced Emergency Medicine Ultrasonography (AEMUS) Core Content, which defines the areas of knowledge considered essential for the practice of AEMUS. This manuscript serves as a revision of the AEMUS Core Content originally published in 2014. The revision of the Core Content for AEMUS training aims to establish standardized education and qualifications necessary for AEMUS fellowship program leadership, clinical application, administration, quality improvement, and research. The Core Content provides the organizational framework and serves as the basis for the development of content for the Focused Practice Examination (FPE) administered by ABEM. AEMUS fellowship directors may reference the Core Content when designing AEMUS fellowship curricula to help prepare graduates for the autonomous practice of AEMUS and the FPE. In this article, an updated revision of the previously published AEMUS Core Content is detailed, and the entire development of the Core Content is presented.

KEYWORDS
advanced emergency medicine ultrasonography, core content, curriculum, Focused Practice Designation, focused practice examination

1 | INTRODUCTION

Advanced Emergency Medicine Ultrasonography (AEMUS) refers to the use of point-of-care ultrasound (POCUS) techniques by ultrasound fellowship-trained emergency physicians to evaluate emergency department patients.[1] Fellowships in AEMUS have been formed to equip emergency physicians with competencies to supervise the education, clinical use, and administration of clinical ultrasound as well as to offer research training in the field.[2,3] Currently, there exists 138 AEMUS fellowships and a considerable number of them accommodate multiple fellows.[4] The Emergency Ultrasound Fellowship Accreditation Council (EUFAC) was created to provide accreditation for AEMUS Fellowship programs.[5] To-date, there are 115 EUFAC-accredited AEMUS programs. Only training that is completed in a EUFAC-accredited AEMUS fellowship programs at the time of the fellow's graduation will meet the eligibility requirements for the Focused Practice Designation (FPD) in AEMUS offered by the American Board of Emergency Medicine (ABEM). A "Core Content" document defines the fundamental knowledge for a specific academic discipline and serves as the foundation for developing the curriculum, providing education,

and testing. Mastery of the AEMUS Core Content is attained by fellows through distinct and specialized postgraduate training, which goes beyond the education received during an Emergency Medicine residency.[6,7]

In 2007, a subcommittee for subspecialty development was formed within the Ultrasound Section of the American College of Emergency Physicians (ACEP) to explore a board certification pathway for fellowship training in clinical ultrasound. In May 2013, ABEM held its first meeting with the Clinical Ultrasonography Task Force (CUTF). The CUTF served as an external, independent body that provided content expertise to ABEM regarding the knowledge, skills, and abilities expected for a physician with recognized AEMUS expertise. Members of the CUTF represented the fellowship training and specialty societies for AEMUS. The CUTF provided feedback on the Core Content that would later serve as the basis for a pathway forward for board certification. Accordingly, the CUTF generated the first Core Content document in collaboration with ACEP, ABEM, and the Society for Academic Emergency Medicine (SAEM); the first Core Content was published in 2014.[8] It was a result of evidence-based practice and defined the comprehensive set of knowledge required to practice AEMUS.

The Core Content of AEMUS first published in 2014 encompasses a range of ultrasound applications in which fellows are expected to demonstrate competence in by the end of their training.[9] The inclusion of cardiac, lung, abdominal, renal, vascular, musculoskeletal, soft tissue, procedural, and other ultrasound applications is supported by extensive evidence demonstrating their diagnostic accuracy and impact on patient outcomes.[9-11] The Focused Assessment With Sonography for Trauma (FAST) exam demonstrates high diagnostic accuracy in detecting intra-abdominal free fluid, leading to reduced time to intervention and improved patient outcomes in trauma settings.[12,13] Evidence has shown that bedside cardiac ultrasound improves the accuracy of diagnosing pathologies such as pericardial effusion, cardiac tamponade, cardiomyopathy, and pulmonary embolism in a timely manner, guides appropriate interventions, and reduces morbidity and mortality.[14-17] Furthermore, cardiac ultrasound enhances the assessment of cardiac contractility and assists in guiding resuscitation efforts during cardiac arrest.[18,19] The evidence supporting the use of the abdominal and renal ultrasound and its impact on patient outcomes is substantial.[20-23] Numerous studies have demonstrated the diagnostic accuracy and reliability in detecting conditions such as appendicitis, cholecystitis, nephrolithiasis and abdominal aortic aneurysm and so forth.[21-29] Studies have consistently shown the diagnostic accuracy of pelvic ultrasound in detecting various obstetric conditions, including abnormal intrauterine pregnancy, ectopic pregnancy, and miscarriage.[30-32] The prompt and accurate detection of these conditions allows for expedited interventions, including surgical interventions if necessary. The rationale for the inclusion of vascular ultrasound in the Core Content is supported by robust evidence demonstrating the high accuracy of bedside lower extremity compression ultrasound in diagnosing deep vein thrombosis.[33-35] It aids in the prompt initiation of anticoagulation therapy, preventing complications associated with deep vein thrombosis. Multiple studies have demonstrated the high sensitivity and specificity of thoracic ultrasound in diagnosing pneumothorax, pleural effusion, and pulmonary edema.[36-39] These findings provide compelling evidence supporting the inclusion of thoracic ultrasound in the Core Content. Similarly, procedural ultrasound has become an integral part of AEMUS Core Content due to the strong evidence supporting its ability to improve the safety and success rates of invasive procedures performed in the emergency department.[40-43] The inclusion of other ultrasound applications, such as musculoskeletal, soft tissue, ocular ultrasound, in the Core Content was well-founded on a growing body of evidence.[44-48] Additionally, the Core Content outlined the skills required to oversee clinical ultrasound operations, including quality improvement, to help ensure patient safety. Although mastering AEMUS technical and interpretation skills is crucial, it is equally important for fellowship trainees to develop proficiency in ultrasound research, administration, program management, and educator skills. Research skills contribute to the advancement of the field, enhance critical thinking, and establish fellows as leaders and innovators. Administration and program management skills ensure effective implementation of ultrasound programs, optimizing patient care and resource utilization. Educator skills enable fellows to effectively teach and mentor others, fostering a culture of continuous learning and promoting high-quality ultrasound practice. By acquiring these additional competencies, fellowship trainees contribute to the overall advancement of AEMUS, improving patient care, and driving change in the field.

To ensure greater content validity, ABEM convened 2 focus groups during the May 2015 SAEM meeting to assist in defining the AEMUS. The attendees included AEMUS thought leaders, who served as an independent third party to provide thoughtful feedback to ABEM regarding the AEMUS Core Content. Additionally, ABEM-certified physicians participated to share insights into the ultrasonography skills that emergency physicians should possess, even without AEMUS training. The focus groups were tasked with critically reviewing the AEMUS knowledge, clinical practice, and administrative responsibilities expected from a physician certified by ABEM. The conclusions drawn by the focus groups reaffirmed the conceptual framework for the AEMUS Core Content, highlighting that AEMUS encompasses more than the skillset of an emergency physician sonologist. The expected knowledge and skills of these physicians include expertise in process improvement, advancing the field, and knowledge translation.

In March 2017, the American Board of Medical Specialties approved the AEMUS FPD.[49] This specific FPD recognizes expertise held by ABEM certified emergency physicians with sophisticated, comprehensive knowledge of AEMUS. ABEM used the AEMUS Core Content as the basis for developing blueprint and examination questions for the Focused Practice Examination (FPE) first administered in March 2022. The FPE measures the breadth and depth of knowledge that is, expected of a physician with content expertise in AEMUS. Fellowship directors and certification candidates were apprised of the complete range of content that could potentially appear on certification examinations through the Core Content document. Moreover, the Core Content served as a template for designing the curricula for AEMUS fellowship training programs in the United States.

ABEM issued its first AEMUS FPDs in the Spring of 2022. To date, the AEMUS FPE was based on the Core Content published in 2014. Recognizing AEMUS as an evolving area of expertise, a Working Group of the AEMUS Committee of the ABEM evaluated and revised the 2014 Core Content to reflect current AEMUS practice and ensure relevant content in the FPE. In February 2023, the ABEM approved modifications to the 2014 AEMUS Core Content. Beginning in 2024, the biennial AEMUS FPE will be based on the 2023 AEMUS Core Content. We aim to delineate the process used to update the previously published AEMUS Core Content and present the complete 2023 Core Content.

2 | METHODS

In Fall 2020, ABEM conducted a job analysis questionnaire (JAQ) based on the 2014 AEMUS Core Content. This survey served 2 purposes: to determine whether changes were required to the Core Content and to consider whether changes in the field would lead to a different assessment blueprint. The JAQ was sent to 713 emergency physician sonologists solicited from a list of members from the Society of Clinical Ultrasound Fellowships (SCUF). Participants were also asked to assess the frequency and importance of line items within the Core Content. To address concerns of response fatigue, the Core Content was divided into Form A and Form B. The JAQ response rate was 25% for Form A and 18% for Form B, which was similar to response rates from ABEM's other subspecialty JAQs, Emergency Medical Services and Medical Toxicology. The majority of respondents (68%, N = 90) work in an academic medical center. On average, JAQ respondents have used ultrasound in their clinical practice for 9.97 years (SD = 5.73). Approximately one-third of respondents (30%, N = 40) described their primary work site as urban, 8% (N = 10) described their primary work site as suburban, and 4% (N = 5) described their work site as state, regional, or rural.

In 2022, a Working Group within the AEMUS Examination Committee was charged with updating the 2014 Core Content document and improving the framework that conceptualized the expanding body of knowledge of AEMUS. The Working Group is comprised of 4 ABEM-certified emergency physicians (who are either current or former AEMUS fellowship directors) and ABEM staff members with expertise in psychometrics and examination design and development. ABEM followed the same approach as with its other subspecialties (Medical Toxicology and Emergency Medical Services) to revise the Core Content.[50,51]

The development of the 2023 AEMUS Core Content used a detailed analysis of the 2014 Core Content documents and review of the results of a job analysis conducted in 2020. Updates to the Core Content were incorporated based on the consensus opinion of the Working Group and the feedback provided by the JAQ respondents. It is designed to assist fellows in preparing for the FPE, fellowship program directors in designing curriculum, test item writers in developing items, and test designers in assembling the AEMUS FPE. The revised Core Content includes topics that are clinically relevant, and of potentially growing importance, while limiting the specificity of knowledge that should be expected of a candidate for AEMUS FPD.[52] Additional attention was directed toward more appropriately categorizing topic areas, updating terminology, and limiting redundancy to improve clarity and usefulness for the AEMUS community.

The 2014 Core Content was independently reviewed by 3 Working Group members initially to recommend potential edits. Each item was meticulously reviewed to determine its importance to the current practice of AEMUS. One of the goals of the Working Group was to reorganize the Core Content by focusing on clinical relevance. Each recommendation was subsequently discussed by all 4 Working Group members and ABEM staff members. The final version was based on consensus among all participants. The Working Group members then reviewed the entire document for consistency and presented the draft Core Content to the ACEP, SAEM and SCUF leadership for public comment. The ultrasonography sections and academies within Emergency Medicine served as the independent voice of content expertise. Additional edits were made based on recommendations from the ACEP, SAEM, and SCUF leadership. After final editing and cross-referencing, the 2023 Core Content document was referred to the ABEM Board of Directors for approval.

The 2023 Core Content remains divided into 4 broad categories (Table 1): 1.0 Image Acquisition and Interpretation Skills, 2.0 Education Skills, 3.0 Research skills, and 4.0 Administration Skills. Each of these categories is further divided into broad topics and subtopics. The summary of 2022 AEMUS Working Group Core Content changes is included in Table 2. The AEMUS Committee adopted the 2023 Core Content of AEMUS as a better reflection of the current practice of AEMUS by emergency physicians.

3 | DISCUSSION

Recognizing that the AEMUS Core Content will be used by fellowship directors to design curricula, the Working Group aimed to include advances in AEMUS practice, additional topics, decrease ambiguity, and increase clarity and clinical relevance of the Core Content items. Likewise, certain sections were expanded to be more consistent with their relative weight in current AEMUS practice. This document presents a structured framework for fellowship training in clinical ultrasound applications, education, research, and administrative skills. In addition, it provides guidance and instruction to fellowship directors and candidates and will be utilized as a foundation for developing future certification and examination questions. The Core Content is a guideline and, while no guideline encompasses every aspect of a topic, the Working Group felt that it was important to be specific, when possible. For example, the subsection that is, listed as "First Trimester Assessment" was updated to remove blighted ovum and include new topics, such as anembryonic pregnancy, subchorionic hemorrhage, fetal demise, spontaneous abortion, retained products of conception, ectopic pregnancy, and molar pregnancy. The Working Group also added topics related to technology that are increasingly used in clinical practice, such as continuous wave Doppler and

TABLE 1 2023 Advanced Emergency Medicine Ultrasonography Core Content.

1.0 Image acquisition and interpretation skills
1.1 Clinical Ultrasonography Fellow Core Content
1.1.1 Physics
1.1.1.1 Basic
1.1.1.1.1 Artifacts
1.1.1.1.2 Knobs
1.1.1.1.3 Planes
1.1.1.1.4 Properties of sound waves
1.1.1.1.4.1 Background physics
1.1.1.1.4.2 Display
1.1.1.1.4.3 Image resolution
1.1.1.1.4.4 Transducers
1.1.1.1.4.5 Ultrasound beam
1.1.1.1.4.6 Miscellaneous
1.1.1.1 Advanced
1.1.1.2.1 Aliasing
1.1.1.2.2 Doppler techniques
1.1.1.2.2.1 Color
1.1.1.2.2.2 Spectral
1.1.1.2.2.3 Continuous wave Doppler
1.1.1.2.2.4 Tissue Doppler
1.1.1.2.5 Miscellaneous
1.1.1.3 Biological effects and safety
1.1.2 Cardiac
1.1.2.1 Basic
1.1.2.1.1 Cardiac arrest
1.1.2.1.2 Global left ventricular function
1.1.2.1.3 Global right ventricular size
1.1.2.1.4 Pericardial fluid
1.1.2.1.5 Tamponade physiology
1.1.2.1.6 Inferior vena cava
1.1.2.2 Advanced
1.1.2.2.1 Advanced views
1.1.2.2.1.1 Suprasternal notch
1.1.2.2.1.2 Right ventricular outflow
1.1.2.2.2 Aortic root assessment
1.1.2.2.3 Cardiac output assessment
1.1.2.2.4 Chamber size, pressure, and comparison
1.1.2.2.5 Regional wall motion abnormalities
1.1.2.2.6 Valvular assessment
1.1.2.2.7 Global right ventricular function
1.1.2.2.8 Diastolic function
1.1.2.2.9 Transesophageal echocardiogram

(Continues)

TABLE 1 (Continued)

1.1.3 Chest and lung
1.1.3.1 Basic
1.1.3.1.1 Pleural fluid
1.1.3.1.2 Pneumothorax
1.1.3.1.3 Alveolar interstitial syndrome
1.1.3.2 Advanced
1.1.3.2.1 Consolidation
1.1.3.2.2 Pleural disease
1.1.3.2.3 Pulmonary edema
1.1.3.2.4 Pneumonia
1.1.3.2.5 Atelectasis
1.1.3.2.6 Chronic obstructive pulmonary disease
1.1.3.2.7 Diaphragm
1.1.4 Aorta
1.1.4.1 Basic
1.1.4.1.1 Abdominal aortic aneurysm
1.1.4.1.2 Abdominal aortic branches
1.1.4.2 Advanced
1.1.4.2.1 Aortic dissection
1.1.4.2.2 Periaortic structures (veins, lymph, etc.)
1.1.5 Renal
1.1.5.1 Basic
1.1.5.1.1 Hydronephrosis
1.1.5.1.2 Bladder volume
1.1.5.2 Advanced
1.1.5.2.1 Cysts
1.1.5.2.1.1 Simple
1.1.5.2.1.2 Complex
1.1.5.2.2 Masses
1.1.5.2.3 Renal vessel assessment
1.1.5.2.4 Renal parenchymal assessment
1.1.5.2.5 Renal transplant
1.1.5.2.6 Stone assessment
1.1.5.2.6.1 Ureteral jets
1.1.5.2.6.2 Twinkling artifact
1.1.5.2.7 Renal size
1.1.6 Male genito-urinary
1.1.6.1 Basic
1.1.6.2 Advanced
1.1.6.2.1 Scrotum and scrotal contents
1.1.6.2.1.1 Abscess and cellulitis
1.1.6.2.1.2 Hydrocele
1.1.6.2.1.3 Varicocele
1.1.6.2.1.4 Hernia

(Continues)

TABLE 1 (Continued)

1.1.6.2.2 Testicle
1.1.6.2.2.1 Cysts
1.1.6.2.2.2 Epididymo-orchitis
1.1.6.2.2.3 Masses/calcifications
1.1.6.2.2.4 Parenchymal assessment
1.1.6.2.2.5 Torsion
1.1.6.2.2.6 Trauma
1.1.7 Hepatobiliary
1.1.7.1 Basic
1.1.7.1.1 Cholelithiasis
1.1.7.1.2 Cholecystitis
1.1.7.1.3 Choledocholithiasis
1.1.7.2 Advanced
1.1.7.2.1 Gallbladder and biliary tree
1.1.7.2.1.1 Ductal assessment
1.1.7.2.1.2 Masses
1.1.7.2.1.3 Polyps
1.1.7.2.1.4 Sludge
1.1.7.2.1.5 Wall assessment
1.1.7.2.1.5.1 Adenomyomatosis
1.1.7.2.1.5.2 Emphysematous cholecystitis
1.1.7.2.1.5.3 Global and focal wall thickening
1.1.7.2.1.5.4 Pericholecystic abnormalities
1.1.7.2.2 Liver
1.1.7.2.2.1 Cysts
1.1.7.2.2.2 Pneumobilia
1.1.7.2.2.3 Masses
1.1.7.2.2.4 Parenchymal assessment
1.1.7.2.3 Portal vein Doppler
1.1.7.2.4 Portal venous thrombosis
1.1.7.2.5 Intraductal dilation
1.1.8 Other abdomen
1.1.8.1 Trauma
1.1.8.1.1 Basic (see integrated examinations section)
1.1.8.1.2 Advanced (see integrated examinations section)
1.1.8.2 Non-trauma
1.1.8.2.1 Basic
1.1.8.2.1.1 Peritoneal fluid assessment
1.1.8.2.2 Advanced
1.1.8.2.2.1 Appendix
1.1.8.2.2.2 Gastric ultrasound
1.1.8.2.2.2.1 Pyloric stenosis
1.1.8.2.2.2.2 Gastric contents/volume

(Continues)

TABLE 1 (Continued)

1.1.8.2.2.3 Bowel
1.1.8.2.2.3.1 Ileus
1.1.8.1.2.2.3.2 Intussusception
1.1.8.2.2.3.3 Obstruction
1.1.8.2.2.3.4 Colitis/diverticulitis
1.1.8.2.2.4 Hernias
1.1.8.2.2.5 Pancreas
1.1.8.2.2.5.1 Masses
1.1.8.2.2.5.2 Pseudocysts
1.1.8.2.2.6 Pneumoperitoneum
1.1.8.2.2.7 Spleen
1.1.8.2.2.7.1 Cysts
1.1.8.2.2.7.2 Disruption of internal architecture
1.1.8.2.2.7.3 Masses
1.1.8.2.2.7.4 Parenchymal assessment
1.1.8.2.2.7.5 Splenic size
1.1.9 Ocular
1.1.9.1 Basic
1.1.9.1.1 Retinal detachment
1.1.9.1.2 Vitreous assessment
1.1.9.1.2.1 Detachment
1.1.9.1.2.2 Hemorrhage
1.1.9.2 Advanced
1.1.9.2.1 Extra-ocular muscle assessment
1.1.9.2.2 Foreign body
1.1.9.2.3 Lens dislocation
1.1.9.2.4 Optic nerve sheath diameter
1.1.9.2.5 Peri-orbital emphysema
1.1.9.2.6 Pupillary assessment
1.1.9.2.7 Retro-bulbar hematoma
1.1.9.2.8 Periorbital cellulitis/orbital cellulitis
1.1.9.2.9 Globe rupture
1.1.10 Female pelvis
Transabdominal and/or transvaginal approaches
1.1.10.1 Basic obstetrics
1.1.10.1.1 First trimester assessment
1.1.10.1.1.1 Intra-uterine pregnancy
1.1.10.1.1.1.1 Gestational sac
1.1.10.1.1.1.2 Yolk sac
1.1.10.1.1.1.3 Fetal heart rate
1.1.10.2 Simple cysts
1.1.10.3 Advanced obstetrics
1.1.10.3.1 First trimester assessment
1.1.10.3.1.1 Anembryonic pregnancy

(Continues)

TABLE 1 (Continued)

1.1.10.3.1.2 Fetal dating
1.1.10.3.1.3 Subchorionic hemorrhage
1.1.10.3.1.4 Fetal demise
1.1.10.3.1.5 Spontaneous abortion
1.1.10.3.1.6 Retained products of conception
1.1.10.3.1.7 Ectopic pregnancy
1.1.10.3.1.8 Molar pregnancy
1.1.10.3.2 Second and third trimester assessment
1.1.10.3.2.1 Amniotic fluid assessment
1.1.10.3.2.2 Fetal dating
1.1.10.3.2.3 Fetal station
1.1.10.3.2.4 Placental location
1.1.10.4 Advanced gynecology
1.1.10.4.1 Adnexa
1.1.10.4.1.1 Abscess
1.1.10.4.1.2 Cysts
1.1.10.4.1.3 Masses
1.1.10.4.1.4 Torsion
1.1.10.4.2 Uterus
1.1.10.4.2.1 Cysts
1.1.10.4.2.2 Endometrioma
1.1.10.4.2.3 Masses
1.1.11 Procedures
1.1.11.1 Basic
1.1.11.1.1 Abscess drainage
1.1.11.1.2 Foreign body removal
1.1.11.1.3 Paracentesis
1.1.11.1.4 Pericardiocentesis
1.1.11.1.5 Thoracentesis
1.1.11.1.6 Vascular access
1.1.11.1.7 Arthrocentesis
1.1.11.1.8 Regional anesthesia
1.1.11.2 Advanced
1.1.11.2.1 Cardiac pacer wire placement
1.1.11.2.2 Endotracheal tube evaluation
1.1.11.2.3 Guiding and verifying tube and catheter placement
1.1.11.2.3.1 Foley
1.1.11.2.3.2 Gastrostomy
1.1.11.2.3.3 Midline catheter
1.1.11.2.4 Lumbar puncture
1.1.11.2.5 Cricothyrotomy
1.1.12 Venous/arterial assessment
1.1.12.1 Basic
1.1.12.1.1 Deep venous thrombosis lower extremity
1.1.12.1.2 Inferior vena cava
1.1.12.2 Advanced

(Continues)

TABLE 1 (Continued)

1.1.12.2.1 Deep venous thrombosis neck
1.1.12.2.2 Deep venous thrombosis upper extremity
1.1.12.2.3 Peripheral vein thrombophlebitis
1.1.12.2.4 Doppler evaluation
1.1.12.2.4.1 Arterial Doppler assessment
1.1.12.2.4.2 Pseudoaneurysm
1.1.12.2.4.3 Arteriovenous fistula
1.1.13 Soft tissue
1.1.13.1 Basic
1.1.13.1.1 Abscess
1.1.13.1.2 Cellulitis
1.1.13.1.3 Foreign body detection
1.1.13.2 Advanced
1.1.13.2.1 Fasciitis
1.1.13.2.2 Lymph node assessment
1.1.13.2.3 Myositis
1.1.13.2.4 Soft tissue masses
1.1.14 Musculoskeletal
1.1.14.1 Basic
1.1.14.1.1 Effusion
1.1.14.1.2 Fractures
1.1.14.2 Advanced
1.1.14.2.1 Joints
1.1.14.2.2 Ligaments
1.1.14.2.3 Muscles
1.1.14.2.4 Tendons
1.1.14.2.5 Bursae
1.1.15 Pediatrics
Assessment would include the relevant applications contained within the curriculum, however, specifically focus on the following:
1.1.15.1 Basic
1.1.15.1.1 FAST
1.1.15.2 Advanced
1.1.15.2.1 Appendix
1.1.15.2.2 Hip assessment
1.1.15.2.3 Intussusception
1.1.16 Head and neck
1.1.16.1 Basic
1.1.16.1.1 Neck masses
1.1.16.2 Advanced
1.1.16.2.1 Salivary glands
1.1.16.2.2 Thyroid cysts
1.1.16.2.3 Sinuses
1.1.16.3 Airway
1.1.16.3.1 Cartilages
1.1.16.3.2 Trachea
1.1.16.3.3 Vocal cords

(Continues)

TABLE 1 (Continued)

1.1.17 Integrated examinations and syndromes
1.1.17.1 Basic trauma primary survey
1.1.17.1.1 Pericardial fluid
1.1.17.1.2 Peritoneal fluid
1.1.17.1.3 Pleural fluid
1.1.17.1.4 Pneumothorax
1.1.17.2 Advanced trauma secondary survey
1.1.17.2.1 Limited solid organ injury
1.1.17.2.2 Musculoskeletal
1.1.17.2.3 Optic nerve sheath diameter
1.1.17.2.4 Soft tissue
1.1.17.3 Undifferentiated abdominal pain
1.1.17.4 Undifferentiated chest pain
1.1.17.5 Undifferentiated dyspnea
1.1.17.6 Undifferentiated hypotension
2.0 Education skills
2.1 Development of educational content
2.1.1 Assessment of content and curricular development
2.1.2 Didactic lecture preparation
2.1.3 Utilization of social media and mixed media
2.2 Presentation of educational content
2.2.1 Assessment of presentation content and organization
2.2.2 Oral presentation and speaking skills
2.2.3 Visual presentation skills
2.3 Bedside hands-on instruction
2.3.1 Assessment of hands-on education methods
2.4 Competency assessment of hands-on and theoretical skills
2.4.1 Evaluation of competency pathway comprehension
2.4.1.1 Accreditation
2.4.1.2 Certification
2.4.1.3 Credentialing
2.4.2 Evaluation of functional knowledge and cognitive abilities
2.4.2.1 Chart review
2.4.2.2 Image review
2.4.2.3 Lectures
2.4.2.4 Written or online examinations
2.4.3 Evaluation of psychomotor skills
2.4.3.1 Direct observation assessments
2.4.3.2 Procedural competence
2.4.3.3 Scanning sessions
2.4.3.4 Simulator sessions
2.4.4 Evaluation of teaching skills
2.4.4.1 Direct observation
2.4.4.2 Lectures
2.4.4.3 Written evaluations

(Continues)

TABLE 1 (Continued)

3.0 Research skills
3.1 Research didactic and coursework
3.1.1 Critical analysis of medical literature
3.1.2 Fundamental knowledge of epidemiology and biostatistics
3.1.3 Informed consent, legal, and ethics regulations
3.1.4 Research acquisition, analysis, and interpretation skills
3.2 Research project development
3.2.1 Question and hypothesis development
3.2.2 Literature search and review
3.2.3 Methodology, data collection, management, and analysis
3.2.4 Institutional review board submission
3.3 Research project abstract and manuscript preparation
3.4 Research education and administration
3.5 Fellowship research evaluation and assessment
4.0 Administration skills
4.1 Quality improvement principles and program
4.1.1 Assessment and feedback strategy
4.1.2 Critical findings
4.1.3 Peer review
4.1.4 Sampling
4.1.5 Risk management
4.1.6 Incidental findings
4.2 Leadership
4.2.1 Administrative oversight
4.2.2 Communication
4.2.3 Education oversight
4.2.3.1 Non-physicians
4.2.3.2 Physicians
4.2.4 Equipment oversight
4.2.5 Research oversight
4.2.6 Risk management oversight
4.2.7 Workflow solution oversight
4.2.8 System-wide ultrasound
4.3 Program systems
4.3.1 Disinfection principles
4.3.2 Equipment and hardware
4.3.2.1 Purchase
4.3.2.2 Maintenance and cleaning
4.3.3 Safety principles
4.3.4 Workflow design, software, and solutions
4.3.4.1 Electronic and digital interface
4.3.4.2 Image archiving
4.3.4.3 Policies and procedures

(Continues)

TABLE 1 (Continued)

4.4 Relationships and networks
4.4.1 Biomedical engineering
4.4.1.1. Performance testing
4.4.2 Coders and billers
4.4.3 Hospital credentialing and privileging
4.4.4 Hospital purchasing
4.4.5 Industry
4.4.5.1 Conflict of interest
4.4.6 Infection control
4.4.7 Information technologists
4.4.8 Institutional review board
4.4.9 International organizations
4.4.10 Legal and risk management
4.4.11 Local organizations
4.4.12 Materials management
4.4.13 Medical staff services
4.4.14 Other departments
4.4.15 National organizations
4.4.15.1 Non-governmental
4.4.15.1.1 Multi-specialty
4.4.15.1.2 Specialty-specific
4.4.15.2 Governmental
4.4.15.2.1 Government agencies
4.4.15.2.2 Public health agencies
4.4.16 Quality improvement committee
4.4.17 Prehospital ultrasound
4.5 Coding and billing
4.5.1 Coding
4.5.2 Documentation
4.5.3 Payer structure
4.5.4 Policy
4.5.4.1 State
4.5.4.2 National
4.5.5 Terminology
4.5.6 Denials
4.6 Economics
4.6.1 Microeconomics
4.6.1.1 Allocation of resources
4.6.1.2 Basic accounting
4.6.1.3 Principles of department and division budgeting
4.6.2 Macroeconomics
4.6.2.1 Allocation of resources
4.6.2.2 Billing
4.6.2.3 Departmental revenue
4.6.2.4 Hospital revenue

TABLE 2 Summary of 2022 Advanced Emergency Medicine Ultrasonography Core Content working group changes.

Location	Description of change
1.1	Changed clinical ultrasonography fellow applications content to clinical ultrasonography fellow Core Content
1.1.1.1.4.2	Changed display and monitors to display
1.1.1.1.4.6	Added miscellaneous
1.1.1.2.2.3	Added continuous wave Doppler
1.1.1.2.2.4	Added tissue Doppler
1.1.1.2.2.5	Added miscellaneous
1.1.1.4	Deleted performance testing
1.1.2.1.1	Changed asystole to cardiac arrest
1.1.2.1.6	Added inferior vena cava
1.1.2.2.1.1	Added suprasternal notch
1.1.2.2.1.2	Added right ventricular outflow
1.1.2.2.5	Changed regional wall motion to regional wall motion abnormalities
1.1.2.2.7	Added global right ventricular function
1.1.2.2.8	Added diastolic function
1.1.2.2.9	Added transesophageal echocardiogram
1.1.3.1.3	Added alveolar interstitial syndrome
1.1.3.2.2	Deleted alveolar interstitial syndrome
1.1.3.2.3	Added pulmonary edema
1.1.3.2.4	Deleted rib and sternal fracture
1.1.3.2.4	Added pneumonia
1.1.3.2.5	Added atelectasis
1.1.3.2.6	Added chronic obstructive pulmonary disease
1.1.3.2.7	Added diaphragm
1.1.4.1.2	Added abdominal aortic branches
1.1.4.2.1	Deleted aortic arch assessment
1.1.4.2.2	Added periaortic structures (veins, lymph, etc.)
1.1.4.2.3	Deleted aortic root assessment
1.1.4.2.4	Deleted descending aorta assessment
1.1.4.2.5	Deleted thoracic aneurysm
1.1.5.1.2	Changed qualitative bladder volume to bladder volume
1.1.5.2.1	Deleted artifacts
1.1.5.2.1.1	Deleted twinkling
1.1.5.2.3	Deleted congenital renal abnormalities
1.1.5.2.3	Changed renal Doppler to renal vessel assessment
1.1.5.2.5	Deleted quantitative bladder volume
1.1.5.2.6.2	Added twinkling artifact
1.1.5.2.7	Added renal size
1.1.6.2.1.4	Added hernia
1.1.6.2.2.3	Changed masses to masses/calcifications
1.1.6.2.2.6	Added trauma

(Continues)

TABLE 2 (Continued)

Location	Description of change
1.1.7.1.2	Added cholecystitis
1.1.7.1.3	Added choledocholithiasis
1.1.7.2.1.5.4	Changed pericholecystic fluid to pericholecystic abnormalities
1.1.7.2.1.5.5	Deleted porcelain gallbladder
1.1.7.2.2.2	Changed disruption of internal architecture to pneumobilia
1.1.7.2.5	Added intraductal dilation
1.1.8.2.2.2	Added gastric ultrasound
1.1.8.2.2.2.1	Added pyloric stenosis
1.1.8.2.2.2.2	Added gastric contents/volume
1.1.8.2.2.3.4	Deleted pyloric stenosis
1.1.8.2.2.3.4	Added colitis/diverticulitis
1.1.8.2.2.7.5	Added splenic size
1.1.9.1.1	Deleted undifferentiated vitreous chamber pathology
1.1.9.1.1	Added retinal detachment
1.1.9.1.2	Changed vitreous detachment and hemorrhage to vitreous assessment (was moved from 1.1.9.2.9)
1.1.9.1.2.1	Added detachment
1.1.9.1.2.2	Added hemorrhage
1.1.9.2.7	Deleted retinal detachment
1.1.9.2.8	Added periorbital cellulitis/orbital cellulitis
1.1.9.2.9	Changed vitreous detachment and hemorrhage to globe rupture
1.1.10.1.1.1.3	Changed fetal assessment to fetal heart rate
1.1.10.1.2	Deleted free fluid
1.1.10.2	Changed basic gynecology to simple cysts
1.1.10.3.1.1	Changed blighted ovum to anembryonic pregnancy
1.1.10.3.1.4	Added fetal demise
1.1.10.3.1.5	Added spontaneous abortion
1.1.10.3.1.6	Added retained products of conception
1.1.10.3.1.7	Added ectopic pregnancy
1.1.10.3.1.8	Added molar pregnancy
1.1.10.3.2	Changed second trimester assessment to second and third trimester assessment
1.1.10.3.2.1	Deleted fetal dating
1.1.10.3.3	Deleted third trimester assessment
1.1.10.3.3.1	Deleted adnexa (see below)
1.1.10.4.1.3	Deleted ectopic pregnancy
1.1.10.4.2.2	Changed endometritis to endometrioma
1.1.10.4.2.4	Deleted retained products of conception
1.1.11.1.7	Added arthrocentesis
1.1.11.1.8	Added regional anesthesia
1.1.11.2.1	Deleted arthrocentesis
1.1.11.2.3.3	Changed PICC catheter to midline catheter

(Continues)

TABLE 2 (Continued)

Location	Description of change
1.1.11.2.5	Added cricothyrotomy
1.1.11.2.6	Deleted regional anesthesia
1.1.12.2.3	Added peripheral vein thrombophlebitis
1.1.12.2.4.1	Changed arterial flow to arterial Doppler assessment
1.1.12.2.4.3	Added arteriovenous fistula
1.1.13.2.4	Deleted peritonsillar abscess
1.1.14.1.1	Added effusion
1.1.14.1.2	Added fractures
1.1.14.2.1	Deleted bones
1.1.14.2.5	Added bursae
1.1.15.1.1	Added FAST
1.1.15.2.4	Deleted lumbar puncture
1.1.15.2.5	Deleted pyloric stenosis
1.1.16.1.1	Added neck masses
1.1.16.2.1	Deleted neck masses
1.1.16.2.3	Deleted vocal cords
1.1.16.2.3	Added sinuses
1.1.16.3	Added airway
1.1.16.3.1	Added cartilages
1.1.16.3.2	Added trachea
1.1.16.3.3	Added vocal cords
1.1.17.4	Changed undifferentiated chest pain and/or dyspnea to undifferentiated chest pain
1.1.17.5	Added undifferentiated dyspnea
1.2	Deleted clinical ultrasonography training with non-emergency medicine specialties
2.4.3.1	Deleted ethics
2.4.3.2	Changed observed structured clinical examinations to direct observation assessments
4.1.6	Added incidental findings
4.2.8	Added system-wide ultrasound
4.4.1.1	Added performance testing
4.4.3	Deleted departmental physicians and non-physicians
4.4.3	Changed hospital credentialing and privileging committees to hospital credentialing and privileging
4.4.5.1	Added conflict of interest
4.4.17	Added prehospital ultrasound
4.5.6	Added denials

tissue Doppler. Revisions to some sections were made to increase the knowledge that an AEMUS fellow should have about certain topics. For example, the "Airway" subsection was added under the "Head and Neck" section to include sonographic anatomy and pathology related to cartilages, trachea, and vocal cords. Similarly, the following topics were included in the "Chest and Lung" section: pulmonary edema,

pneumonia, atelectasis, chronic obstructive pulmonary disease, and diaphragm. The "Cardiac" and "Aorta" sections were reorganized, and pertinent topics were grouped in each section. To increase clarity, "Asystole" was changed to "Cardiac Arrest." Given its significance, "Pyloric stenosis" was removed from the "Bowel" category and placed under a new gastric ultrasound category. In addition, retinal detachment is now listed separately from vitreous assessment.

The modifications made to the 2014 AEMUS Core Content involve integrating evidence-based practices across various ultrasound applications. Over the past decade, AEMUS has evolved significantly, with improved diagnostic accuracy, expanded therapeutic applications, and seamless integration into clinical practice. Professional societies and international organizations have released guidelines and recommendations for AEMUS use, focusing on protocol development, quality assurance, and accreditation programs for safe and effective implementation. The inclusion of additional items in the Core Content is supported by a growing body of literature, including systematic reviews, meta-analyses, and prospective studies, demonstrating the diagnostic accuracy, timeliness, and impact on patient outcomes. In the following sections, we will outline the current evidence and rationale behind the modifications made to various ultrasound applications.

Recent advancements in portable ultrasound technology, including tissue Doppler imaging (TDI) and continuous wave Doppler (CWD), have greatly improved the diagnostic capabilities of portable ultrasound machines. TDI has gained increasing acceptance as a noninvasive method for assessing myocardial velocities during systole and diastole, regional wall motion abnormalities, and estimating ventricular filling pressures. The use of TDI in the emergency department has proven valuable in diagnosing diastolic dysfunction, myocardial ischemia, and cardiomyopathies.[53–55] CWD is essential for evaluating abnormalities like stenosis, regurgitation, or shunts and provides quantitative measurements aiding in the diagnosis and assessment of valvular diseases. CWD is particularly valuable in situations where there is concern for increased right ventricular systolic pulmonary artery pressure, as it can measure the peak velocity of the tricuspid regurgitant jet. Recent studies have shown the utility of estimating the tricuspid regurgitant jet to detect acute right ventricular strain in evaluating patients with pulmonary embolism in the emergency department.[56–59]

The existing literature extensively supports the use of ultrasound in cardiac arrest. It has been proven to enhance the detection of reversible causes, assess compression quality during CPR, guide resuscitation efforts, and aid in determining survival prognosis based on specific findings.[60-62] Compared to manual palpation and Doppler ultrasonography, POCUS provides a more accurate evaluation of cardiac activity.[63] The presence of cardiac activity on ultrasound correlated with improved survival rates for hospital admission and discharge.[64] Multiple studies have demonstrated the accuracy and reliability of inferior vena cava (IVC) ultrasound in assessing fluid status and guiding fluid management decisions.[65-67] However, more recent literature suggests that the use of IVC ultrasound is burdened by technical limitations and errors in interpretation.[68] As an advanced sonographer, one should be aware of these limitations. The assessment of right ventricular function using focused cardiac ultrasound has received substantial evidence-based support. Abnormalities in right ventricular function parameters have diagnostic and management implications for conditions affecting the right ventricle, including pulmonary embolism, pulmonary hypertension, and septic right ventricular dysfunction.[69-71] Lahham et al[72] found that TAPSE measurements less than 15.2 mm exhibited high specificity in identifying clinically significant acute pulmonary embolism. POCUS also enables the assessment of right ventricular outflow tract velocity and pulmonary artery systolic pressure, which are valuable in evaluating conditions like pulmonary embolism and assessing the hemodynamic impact of right ventricular dysfunction.[57]

Prior studies have demonstrated the accuracy and clinical relevance of focused cardiac ultrasound in evaluating diastolic function parameters such as mitral inflow velocities (E and A waves), deceleration time, and TDI of the mitral annulus (E' wave).[53,55] These parameters provide valuable information about left ventricular relaxation, filling pressures, and diastolic dysfunction. The accuracy of focused cardiac ultrasound in assessing diastolic function has been validated through comparisons with comprehensive echocardiography.[53,55,73–75] Current evidence has demonstrated the accuracy and clinical relevance of POCUS in detecting and characterizing regional wall motion abnormalities.[76–79] It allows for real-time visualization of myocardial segments, enabling clinicians to assess regional wall motion and identify abnormalities indicative of ischemia, infarction, or other cardiac pathologies. The evidence supporting the use of POCUS in assessing regional wall motion abnormalities includes comparisons with standard echocardiography and other imaging modalities. These studies have shown a high degree of agreement and correlation, validating the accuracy and reliability of ultrasound for this purpose. Resuscitative transesophageal echocardiography (TEE) has evolved into a valuable tool in the emergency department for critically ill patients. The literature provides compelling evidence supporting its use in assessing cardiac function, identifying reversible causes of cardiac arrest, and monitoring intervention effectiveness during resuscitation. TEE has demonstrated the ability to change management plans and improve rates of return of spontaneous circulation and survival.[80–82]

The evidence supporting the use of thoracic ultrasound in pulmonary edema, pneumonia, atelectasis, and chronic obstructive pulmonary disease (COPD) is derived from observational studies, systematic reviews, and meta-analyses. Thoracic ultrasound is a reliable diagnostic and monitoring tool for pulmonary edema, with a sensitivity of 94% and specificity of 92.4% in detecting B-lines associated with acute cardiogenic pulmonary edema.[83] In pneumonia evaluation, it provides real-time visualization of lung parenchyma, aiding in the detection of consolidation, pleural effusion, and associated complications. Compared to chest X-ray, thoracic ultrasound demonstrates higher sensitivity (95%) and specificity (90%) in detecting pneumonia.[84] It also exhibits high sensitivity (98%) and specificity (97%) in detecting atelectasis and distinguishing it from other abnormalities. In COPD assessment, thoracic ultrasound offers valuable information on lung hyperinflation, diaphragmatic excursion, and disease severity, assisting in treatment decisions, and therapy monitoring.[85-87]

POCUS is strongly supported by evidence for assessing hernia, cholecystitis, and diverticulitis. Its integration into clinical practice improves patient care through timely and accurate diagnoses, leading to better outcomes. Ultrasound demonstrates a sensitivity of 86% and specificity of 77% in diagnosing inguinal hernias, enabling informed decisions on management, including surgical intervention.[88,89] In cholecystitis, bedside ultrasound has a sensitivity of 87% and specificity of 82%, while decreasing length of stay by up to 7% (22 min) overall and up to 15% (52 min) during evening or nighttime evaluations compared to radiology ultrasound.[29,90] In diagnosing colonic diverticulitis, ultrasound alone demonstrates 92% sensitivity and 97% specificity, comparable to CT scan.[91] Bedside gastric ultrasound is highly sensitive (100%) and specific (97%) in identifying or ruling out a full stomach when gastric content uncertainty arises.[92] Additionally, POCUS is a valuable tool for assessing pregnancy-related conditions, such as anembryonic pregnancy, fetal demise, spontaneous abortion, retained products of conception, ectopic pregnancy, and molar pregnancy. Several studies have examined its sensitivity and specificity, with sensitivity exceeding 90% and specificity exceeding 98% for diagnosing intrauterine pregnancy.[93] For ectopic pregnancy detection, emergency physician-performed pelvic ultrasound shows sensitivity of 76%–90% and specificity of 88%–92%.[94,95] When compared to comprehensive pelvic ultrasound in radiology departments, patients who received emergency physician-performed pelvic ultrasound experienced a reduction in emergency department length of stay by 73 min.[96,97]

Ultrasound has been extensively studied and consistently shown to be accurate and reliable in detecting fractures, assessing joint effusions, and characterizing bursal abnormalities. Its diagnostic capabilities provide valuable information for timely and targeted interventions, influencing management decisions. Studies have demonstrated high sensitivity and specificity of ultrasound in detecting fractures, particularly in pediatric forearm fractures, with a pooled sensitivity and specificity above 90%.[98,99] In the case of joint effusions, ultrasound is beneficial for distinguishing effusions from soft tissue abnormalities, leading to appropriate therapy and avoiding unnecessary joint aspirations. Clinician-performed ultrasound has been shown to impact management decisions in 65% of patients with suspected joint effusions, reducing futile joint aspirations and guiding the necessity for aspiration when appropriate.[100] In the past decade, the use of ultrasound for tracheal and airway assessment has significantly advanced, particularly in the emergency department. The effectiveness of ultrasound for assessment of the airway has been supported by evidence, demonstrating its utility in various clinical scenarios. Studies have shown that clinician performed tracheal ultrasound aids in identifying difficult airways, assessing intubation feasibility, and reducing complications during airway management.[101–104] Furthermore, it plays a valuable role in guiding procedures like needle cricothyrotomy and confirming endotracheal tube placement. Recent cardiac resuscitation guidelines have recognized tracheal ultrasound as an alternative confirmatory test in cardiac arrest patients. The pooled sensitivity and specificity of transtracheal ultrasonography for detecting endotracheal intubation were 98% and 97%, respectively.[105–107] Emerging evidence supports the use of POCUS in detecting conditions such as AV fistula, peripheral vein septic thrombophlebitis, and ocular infections in emergency settings. The use of ultrasound allows for accurate and timely diagnosis, guiding appropriate management decisions.[108,109,110] Recent literature has explored the application of prehospital ultrasound in the field of emergency medicine, revealing its feasibility in integrating ultrasound into prehospital care. Prehospital ultrasound use holds promise for enhancing trauma, cardiac, and obstetric care. By improving diagnostic accuracy, guiding treatment decisions, and enabling early interventions, prehospital ultrasound has the potential to significantly improve patient outcomes in these areas.[111–113]

Incidental findings are commonly observed during POCUS imaging. Although the majority of these findings are benign and do not require immediate intervention, a small percentage holds clinical significance and necessitate further evaluation or management. In one study, incidental findings were encountered in approximately 9% of FAST examinations, with kidney and pelvic cysts being the most frequent.[114] Another study reported incidental findings in 26% of POCUS examinations, primarily involving the renal and biliary systems.[115] These studies underscore the importance of recognizing and appropriately managing incidental findings due to their potential impact on patient care and outcomes. Health systems have recognized the importance of implementing a comprehensive clinical ultrasound program, leading to emergency physicians taking on the responsibility of spearheading these initiatives within their respective health systems. To ensure the effective utilization of POCUS across different clinical settings and to maintain consistent and high-quality standards, several key components need to be addressed. These components include leadership, training, competency, credentialing, quality assurance and improvement, documentation, archiving, workflow, equipment, and infrastructure, with a particular focus on communication and information technology. It is essential for AEMUS fellowship trainees to be well-versed in these aspects to successfully establish a system wide clinical ultrasound program.[116]

AEMUS continues to be a rapidly evolving field. Expertise is growing as the number of AEMUS-trained fellows continues to increase. The 2023 Core Content is intended to be a "living document," in keeping with the evolving practice of AEMUS. The AEMUS Committee anticipates periodic updates to the Core Content and recommends that these updates occur approximately every 4 years.

AUTHOR CONTRIBUTIONS

All authors contributed to the Core Content revisions. Srikar Adhikari drafted the initial manuscript. All authors reviewed and revised the manuscript, approved the final manuscript as submitted, and agree to be accountable for all aspects of the work.

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REFERENCES

1. Ultrasound guidelines: emergency, point-of-care and clinical ultrasound guidelines in medicine. *Ann Emerg Med*. 2017;69(5):e27-e54. doi:10.1016/j.annemergmed.2016.08.457

2. Adhikari S, Fiorello A. Emergency ultrasound fellowship training: a novel team-based approach. *J Ultrasound Med*. 2014;33(10):1821-1826. doi:10.7863/ultra.33.10.1821
3. Moak JH, Gaspari RJ, Raio CC, et al. Motivations, job procurement, and job satisfaction among current and former ultrasound fellows. *Acad Emerg Med*. 2010;17(6):644-648. doi:10.1111/j.1553-2712.2010.00749.x
4. SCUF. Accessed April 8, 2023. https://www.eusfellowships.com
5. EUFAC. Accessed April 8, 2023. https://eufacouncil.org
6. Akhtar S, Theodoro D, Gaspari R, et al. Resident training in emergency ultrasound: consensus recommendations from the 2008 Council of Emergency Medicine Residency Directors Conference. *Acad Emerg Med*. 2009;16(suppl 2):S32-36. doi:10.1111/j.1553-2712.2009.00589.x
7. Nelson M, Abdi A, Adhikari S, et al. Goal-directed focused ultrasound milestones revised: a multiorganizational consensus. *Acad Emerg Med*. 2016;23(11):1274-1279. doi:10.1111/acem.13069
8. Lewiss RE, Tayal VS, Hoffmann B, et al. The core content of clinical ultrasonography fellowship training. *Acad Emerg Med*. 2014;21(4):456-461. doi:10.1111/acem.12349
9. American College of Emergency Physicians. Emergency ultrasound guidelines. *Ann Emerg Med*. 2009;53(4):550-570. doi:10.1016/j.annemergmed.2008.12.013
10. Moore CL, Molina AA, Lin H. Ultrasonography in community emergency departments in the United States: access to ultrasonography performed by consultants and status of emergency physician-performed ultrasonography. *Ann Emerg Med*. 2006;47(2):147-153. doi:10.1016/j.annemergmed.2005.08.023
11. Emergency Ultrasound Imaging Criteria Compendium. Accessed June 28, 2023. https://www.acep.org/patient-care/policy-statements/Emergency-Ultrasound-Imaging-Criteria-Compendium
12. Melniker LA, Leibner E, McKenney MG, Lopez P, Briggs WM, Mancuso CA. Randomized controlled clinical trial of point-of-care, limited ultrasonography for trauma in the emergency department: the first sonography outcomes assessment program trial. *Ann Emerg Med*. 2006;48(3):227-235. doi:10.1016/j.annemergmed
13. Ma OJ, Mateer JR, Ogata M, Kefer MP, Wittmann D, Aprahamian C. Prospective analysis of a rapid trauma ultrasound examination performed by emergency physicians. *J Trauma*. 1995;38(6):879-885. doi:10.1097/00005373-199506000-00009
14. Jones AE, Tayal VS, Sullivan DM, Kline JA. Randomized, controlled trial of immediate versus delayed goal-directed ultrasound to identify the cause of nontraumatic hypotension in emergency department patients. *Crit Care Med*. 2004;32(8):1703-1708. doi:10.1097/01.ccm.0000133017.34137.82
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):186-193. doi:10.1111/j.1553-2712.2002.tb00242.x
16. Levitt MA, Jan BA. The effect of real time 2-D-echocardiography on medical decision-making in the emergency department. *J Emerg Med*. 2002;22(3):229-233. doi:10.1016/s0736-4679(01)00479-6
17. Mandavia DP, Hoffner RJ, Mahaney K, Henderson SO. Bedside echocardiography by emergency physicians. *Ann Emerg Med*. 2001;38(4):377-382. doi:10.1067/mem.2001.118224
18. Blaivas M, Fox JC. Outcome in cardiac arrest patients found to have cardiac standstill on the bedside emergency department echocardiogram. *Acad Emerg Med*. 2001;8(6):616-621. doi:10.1111/j.1553-2712.2001.tb00174.x
19. Salen P, Melniker L, Chooljian C, et al. Does the presence or absence of sonographically identified cardiac activity predict resuscitation outcomes of cardiac arrest patients? *Am J Emerg Med*. 2005;23(4):459-462. doi:10.1016/j.ajem.2004.11.007
20. Rosen CL, Brown DF, Sagarin MJ, Chang Y, McCabe CJ, Wolfe RE. Ultrasonography by emergency physicians in patients with suspected ureteral colic. *J Emerg Med*. 1998;16(6):865-870. doi:10.1016/s0736-4679(98)00100-0
21. Kartal M, Eray O, Erdogru T, Yilmaz S. Prospective validation of a current algorithm including bedside US performed by emergency physicians for patients with acute flank pain suspected for renal colic. *Emerg Med J*. 2006;23(5):341-344. doi:10.1136/emj.2005.028589
22. Gaspari RJ, Horst K. Emergency ultrasound and urinalysis in the evaluation of flank pain. *Acad Emerg Med*. 2005;12(12):1180-1184. doi:10.1197/j.aem.2005.06.023
23. Lindelius A, Törngren S, Nilsson L, Pettersson H, Adami J. Randomized clinical trial of bedside ultrasound among patients with abdominal pain in the emergency department: impact on patient satisfaction and health care consumption. *Scand J Trauma Resusc Emerg Med*. 2009;17:60. doi:10.1186/1757-7241-17-60
24. Fox JC, Solley M, Anderson CL, Zlidenny A, Lahham S, Maasumi K. Prospective evaluation of emergency physician performed bedside ultrasound to detect acute appendicitis. *Eur J Emerg Med*. 2008;15(2):80-85. doi:10.1097/MEJ.0b013e328270361a
25. Kuhn M, Bonnin RL, Davey MJ, Rowland JL, Langlois SL. Emergency department ultrasound scanning for abdominal aortic aneurysm: accessible, accurate, and advantageous. *Ann Emerg Med*. 2000;36(3):219-223. doi:10.1067/mem.2000.108616
26. Tayal VS, Graf CD, Gibbs MA. Prospective study of accuracy and outcome of emergency ultrasound for abdominal aortic aneurysm over two years. *Acad Emerg Med*. 2003;10(8):867-871. doi:10.1111/j.1553-2712.2003.tb00630.x
27. Kendall JL, Shimp RJ. Performance and interpretation of focused right upper quadrant ultrasound by emergency physicians. *J Emerg Med*. 2001;21(1):7-13. doi:10.1016/s0736-4679(01)00329-8
28. Miller AH, Pepe PE, Brockman CR, Delaney KA. ED ultrasound in hepatobiliary disease. *J Emerg Med*. 2006;30(1):69-74. doi:10.1016/j.jemermed.2005.03.017
29. Blaivas M, Harwood RA, Lambert MJ. Decreasing length of stay with emergency ultrasound examination of the gallbladder. *Acad Emerg Med*. 1999;6(10):1020-1023. doi:10.1111/j.1553-2712.1999.tb01186.x
30. Durham B, Lane B, Burbridge L, Balasubramaniam S. Pelvic ultrasound performed by emergency physicians for the detection of ectopic pregnancy in complicated first-trimester pregnancies. *Ann Emerg Med*. 1997;29(3):338-347. doi:10.1016/s0196-0644(97)70345-7
31. Mateer JR, Valley VT, Aiman EJ, Phelan MB, Thoma ME, Kefer MP. Outcome analysis of a protocol including bedside endovaginal sonography in patients at risk for ectopic pregnancy. *Ann Emerg Med*. 1996;27(3):283-289. doi:10.1016/s0196-0644(96)70260-3
32. Adhikari S, Blaivas M, Lyon M. Diagnosis and management of ectopic pregnancy using bedside transvaginal ultrasonography in the ED: a 2-year experience. *Am J Emerg Med*. 2007;25(6):591-596. doi:10.1016/j.ajem.2006.11.020
33. Blaivas M, Lambert MJ, Harwood RA, Wood JP, Konicki J. Lower-extremity Doppler for deep venous thrombosis–can emergency physicians be accurate and fast? *Acad Emerg Med*. 2000;7(2):120-126. doi:10.1111/j.1553-2712.2000.tb00512.x
34. Crisp JG, Lovato LM, Jang TB. Compression ultrasonography of the lower extremity with portable vascular ultrasonography can accurately detect deep venous thrombosis in the emergency department. *Ann Emerg Med*. 2010;56(6):601-610. doi:10.1016/j.annemergmed.2010.07.010
35. Burnside PR, Brown MD, Kline JA. Systematic review of emergency physician-performed ultrasonography for lower-extremity deep vein thrombosis. *Acad Emerg Med*. 2008;15(6):493-498. doi:10.1111/j.1553-2712.2008.00101.x
36. Blaivas M, Lyon M, Duggal S. A prospective comparison of supine chest radiography and bedside ultrasound for the diagnosis of trau-

matic pneumothorax. *Acad Emerg Med*. 2005;12(9):844-849. doi:10.1197/j.aem.2005.05.005

37. Ding W, Shen Y, Yang J, He X, Zhang M. Diagnosis of pneumothorax by radiography and ultrasonography: a meta-analysis. *Chest*. 2011;140(4):859-866. doi:10.1378/chest.10-2946
38. Liteplo AS, Marill KA, Villen T, et al. Emergency thoracic ultrasound in the differentiation of the etiology of shortness of breath (ETUDES): sonographic B-lines and N-terminal pro-brain-type natriuretic peptide in diagnosing congestive heart failure. *Acad Emerg Med*. 2009;16(3):201-210. doi:10.1111/j.1553-2712.2008.00347.x
39. Grimberg A, Shigueoka DC, Atallah AN, Ajzen S, Iared W. Diagnostic accuracy of sonography for pleural effusion: systematic review. *Sao Paulo Med J*. 2010;128(2):90-95. doi:10.1590/s1516-31802010000200009
40. Milling TJ Jr, Rose J, Briggs WM, et al. Randomized, controlled clinical trial of point-of-care limited ultrasonography assistance of central venous cannulation: the Third Sonography Outcomes Assessment Program (SOAP-3) Trial. *Crit Care Med*. 2005;33(8):1764-1769. doi:10.1097/01.ccm.0000171533.92856.e5
41. Costantino TG, Parikh AK, Satz WA, Fojtik JP. Ultrasonography-guided peripheral intravenous access versus traditional approaches in patients with difficult intravenous access. *Ann Emerg Med*. 2005;46(5):456-461. doi:10.1016/j.annemergmed.2004.12.026
42. Nomura JT, Leech SJ, Shenbagamurthi S, et al. Humphrey M, Gukhool JA. A randomized controlled trial of ultrasound-assisted lumbar puncture. *J Ultrasound Med*. 2007;26(10):1341-1348. doi:10.7863/jum.2007.26.10.1341
43. Nazeer SR, Dewbre H, Miller AH. Ultrasound-assisted paracentesis performed by emergency physicians vs the traditional technique: a prospective, randomized study. *Am J Emerg Med*. 2005;23(3):363-367. doi:10.1016/j.ajem.2004.11.001
44. Tayal VS, Hasan N, Norton HJ, Tomaszewski CA. The effect of soft-tissue ultrasound on the management of cellulitis in the emergency department. *Acad Emerg Med*. 2006;13(4):384-388. doi:10.1197/j.aem.2005
45. Squire BT, Fox JC, Anderson C. ABSCESS: applied bedside sonography for convenient evaluation of superficial soft tissue infections. *Acad Emerg Med*. 2005;12(7):601-606. doi:10.1197/j.aem.2005.01.016
46. Tayal VS, Neulander M, Norton HJ, Foster T, Saunders T, Blaivas M. Emergency department sonographic measurement of optic nerve sheath diameter to detect findings of increased intracranial pressure in adult head injury patients. *Ann Emerg Med*. 2007;49(4):508-514.
47. Blaivas M. Bedside emergency department ultrasonography in the evaluation of ocular pathology. *Acad Emerg Med*. 2000;7(8):947-950. doi:10.1111/j.1553-2712.2000.tb02080.x
48. Valley VT, Stahmer SA. Targeted musculoarticular sonography in the detection of joint effusions. *Acad Emerg Med*. 2001;8(4):361-367. doi:10.1111/j.1553-2712.2001.tb02114.x
49. American Board of secondary Medicine. Focused Practice Designation. Accessed April 8, 2023. https://www.abem.org/public/become-certified/focused-practice-designation
50. Delbridge TR, Dyer S, Goodloe JM, et al. The 2019 core content of emergency medical services medicine. *Prehosp Emerg Care*. 2020;24(1):32-45. doi:10.1080/10903127.2019.1603560
51. Hendrickson RG, Bania TC, Baum CR, et al. The 2021 core content of medical toxicology. *J Med Toxicol*. 2021;17(4):425-436. doi:10.1007/s13181-021-00844-5
52. Ma J, Mateer J, Reardon R, et al. *Emergency Ultrasound*. 4th ed. McGraw-Hill Publishers; 2021.
53. Del Rios M, Colla J, Kotini-Shah P, Briller J, Gerber B, Prendergast H. Emergency physician use of tissue Doppler bedside echocardiography in detecting diastolic dysfunction: an exploratory study. *Crit Ultrasound J*. 2018;10(1):4. doi:10.1186/s13089-018-0084-5
54. Santos TM, Franci D, Schweller M, et al. Left ventricle tissue Doppler imaging predicts disease severity in septic patients newly admitted in an emergency unit. *J Emerg Med*. 2015;49(6):907-915. doi:10.1016/j.jemermed.2015.06.054
55. Ehrman RR, Russell FM, Ansari AH, et al. Can emergency physicians diagnose and correctly classify diastolic dysfunction using bedside echocardiography? *Am J Emerg Med*. 2015;33(9):1178-1183. doi:10.1016/j.ajem.2015.05.013
56. Binder ZW, O'Brien SE, Boyle TP, Cabral HJ, Pare JR. Tricuspid regurgitant jet velocity point-of-care ultrasound curriculum development and validation. *POCUS J*. 2021;6(2):88-92. 10.24908/pocus.v6i2.15190
57. Shah BR, Velamakanni SM, Patel A, Khadkikar G, Patel TM, Shah SC. Analysis of the 60/60 sign and other right ventricular parameters by 2D transthoracic echocardiography as adjuncts to diagnosis of acute pulmonary embolism. *Cureus*. 2021;13(3):e13800. doi:10.7759/cureus.13800
58. Binder ZW, O'Brien SE, Boyle TP, Cabral HJ, Sekhavat S, Pare JR. Novice physician ultrasound evaluation of pediatric tricuspid regurgitant jet velocity. *West J Emerg Med*. 2020;21(4):1029-1035. doi:10.5811/westjem.2020.3.45882
59. Raja Shariff RE, Beng KH, Yuen BT, Sin TY, Ghazi AM. Notching into a diagnosis-incorporating Doppler interrogation into point-of-care ultrasonography to diagnose a submassive pulmonary embolism. *CASE*. 2022;6(6):250-253. doi:10.1016/j.case.2022.04.009
60. Dudek M, Szarpak L, Peacock FW, et al. Diagnostic performance of point-of-use ultrasound of resuscitation outcomes: a systematic review and meta-analysis of 3265 patients. *Cardiol J*. 2023;30(2):237-246. doi:10.5603/CJ.a2021.0044
61. sou PY, Kurbedin J, Chen YS, et al. Accuracy of point-of-care focused echocardiography in predicting outcome of resuscitation in cardiac arrest patients: a systematic review and meta-analysis. *Resuscitation*. 2017;114:92-99. doi:10.1016/j.resuscitation.2017.02.021
62. Gaspari R, Weekes A, Adhikari S, et al. Emergency department point-of-care ultrasound in out-of-hospital and in-ED cardiac arrest. *Resuscitation*. 2016;109:33-39. doi:10.1016/j.resuscitation.2016.09.018
63. Zengin S, Gümüşboğa H, Sabak M, ŞH Eren, Altunbas G, Al B. Comparison of manual pulse palpation, cardiac ultrasonography and Doppler ultrasonography to check the pulse in cardiopulmonary arrest patients. *Resuscitation*. 2018;133:59-64. doi:10.1016/j.resuscitation.2018.09.018
64. Kedan I, Ciozda W, Palatinus JA, Palatinus HN, Kimchi A. Prognostic value of point-of-care ultrasound during cardiac arrest: a systematic review. *Cardiovasc Ultrasound*. 2020;18(1):1. doi:10.1186/s12947-020-0185-8
65. Kim DW, Chung S, Kang WS, Kim J. Diagnostic accuracy of ultrasonographic respiratory variation in the inferior vena cava, subclavian vein, internal jugular vein, and femoral vein diameter to predict fluid responsiveness: a systematic review and meta-analysis. *Diagnostics*. 2021;12(1):49. doi:10.3390/diagnostics12010049
66. Zhang Z, Xu X, Ye S, Xu L. Ultrasonographic measurement of the respiratory variation in the inferior vena cava diameter is predictive of fluid responsiveness in critically ill patients: systematic review and meta-analysis. *Ultrasound Med Biol*. 2014;40(5):845-853. doi:10.1016/j.ultrasmedbio.2013.12.010
67. Long E, Oakley E, Duke T, Babl FE, Paediatric Research in Emergency Departments International Collaborative (PREDICT). Does respiratory variation in inferior vena cava diameter predict fluid responsiveness: a systematic review and meta-analysis. *Shock*. 2017;47(5):550-559. doi:10.1097/SHK.0000000000000801
68. Di Nicolò P, Tavazzi G, Nannoni L, Corradi F. Inferior vena cava ultrasonography for volume status evaluation: an intriguing promise never fulfilled. *J Clin Med*. 2023;12(6):2217. doi:10.3390/jcm12062217

69. Weekes AJ, Thacker G, Troha D, et al. Diagnostic accuracy of right ventricular dysfunction markers in normotensive emergency department patients with acute pulmonary embolism. *Ann Emerg Med*. 2016;68(3):277-291. doi:10.1016/j.annemergmed.2016.01.027
70. Dresden S, Mitchell P, Rahimi L, et al. Right ventricular dilatation on bedside echocardiography performed by emergency physicians aids in the diagnosis of pulmonary embolism. *Ann Emerg Med*. 2014;63(1):16-24. doi:10.1016/j.annemergmed.2013.08.016
71. Daley JI, Dwyer KH, Grunwald Z, et al. Increased sensitivity of focused cardiac ultrasound for pulmonary embolism in emergency department patients with abnormal vital signs. *Acad Emerg Med*. 2019;26(11):1211-1220. doi:10.1111/acem.13774
72. Lahham S, Fox JC, Thompson M, et al. Tricuspid annular plane of systolic excursion to prognosticate acute pulmonary symptomatic embolism (TAPSEPAPSE study). *J Ultrasound Med*. 2019;38(3):695-702. doi:10.1002/jum.14753
73. Unlüer EE, Bayata S, Postaci N, et al. Limited bedside echocardiography by emergency physicians for diagnosis of diastolic heart failure. *Emerg Med J*. 2012;29(4):280-283. doi:10.1136/emj.2011.111229
74. Via G, Tavazzi G. Diagnosis of diastolic dysfunction in the emergency department: really at reach for minimally trained sonologists? A call for a wise approach to heart failure with preserved ejection fraction diagnosis in the ER. *Crit Ultrasound J*. 2018;10(1):26. doi:10.1186/s13089-018-0107-2
75. King SA, Salerno A, Downing JV, et al. POCUS for diastolic dysfunction: a review of the literature. *POCUS J*. 2023;8(1):88-92. 10.24908/pocus.v8i1.15803
76. Frenkel O, Riguzzi C, Nagdev A. Identification of high-risk patients with acute coronary syndrome using point-of-care echocardiography in the ED. *Am J Emerg Med*. 2014;32(6):670-672. doi:10.1016/j.ajem.2014.03.003
77. Xu C, Melendez A, Nguyen T, et al. Point-of-care ultrasound may expedite diagnosis and revascularization of occult occlusive myocardial infarction. *Am J Emerg Med*. 2022;58:186-191. doi:10.1016/j.ajem.2022.06.010
78. Croft PE, Strout TD, Kring RM, Director L, Vasaiwala SC, Mackenzie DC. WAMAMI: emergency physicians can accurately identify wall motion abnormalities in acute myocardial infarction. *Am J Emerg Med*. 2019;37(12):2224-2228. doi:10.1016/j.ajem.2019.03.037
79. Sağlam C, Ünlüer EE, Yamanoğlu NGÇ, et al. Accuracy of emergency physicians for detection of regional wall motion abnormalities in patients with chest pain without ST-Elevation myocardial infarction. *J Ultrasound Med*. 2021;40(7):1335-1342. doi:10.1002/jum.15513
80. Parker BK, Salerno A, Euerle BD. The use of transesophageal echocardiography during cardiac arrest resuscitation: a literature review. *J Ultrasound Med*. 2019;38(5):1141-1151. doi:10.1002/jum.14794
81. Guidelines for the use of Transesophageal Echocardiography (TEE) in the ED for cardiac arrest. *Ann Emerg Med*. 2017;70(3):442-445. doi:10.1016/j.annemergmed.2017.06.033
82. Teran F, Dean AJ, Centeno C, et al. Evaluation of out-of-hospital cardiac arrest using transesophageal echocardiography in the emergency department. *Resuscitation*. 2019;137:140-147. doi:10.1016/j.resuscitation.2019.02.013
83. Al Deeb M, Barbic S, Featherstone R, Dankoff J, Barbic D. Point-of-care ultrasonography for the diagnosis of acute cardiogenic pulmonary edema in patients presenting with acute dyspnea: a systematic review and meta-analysis. *Acad Emerg Med*. 2014;21(8):843-852. doi:10.1111/acem.12435
84. Ye X, Xiao H, Chen B, Zhang S. Accuracy of lung ultrasonography versus chest radiography for the diagnosis of adult community-acquired pneumonia: review of the literature and meta-analysis. *PLoS One*. 2015;10(6):e0130066. doi:10.1371/journal.pone.0130066
85. An TJ, Yoo YJ, Lim JU, et al. Diaphragm ultrasound is an imaging biomarker that distinguishes exacerbation status from stable chronic obstructive pulmonary disease. *Int J Chron Obstruct Pulmon Dis*. 2022;17:3-12. doi:10.2147/COPD.S341484
86. Staub LJ, Mazzali Biscaro RR, Kaszubowski E, Maurici R. Lung ultrasound for the emeregncy diagnosis of pneumonia, acute heart failure, and exacerbations of chronic obstructive pulmonary disease/asthma in adults: A systematic review and meta-analysis. *J Emerg Med*. 2019;56(1):53-69. doi:10.1016/j.jemermed.2018.09.009
87. Xie C, Sun K, You Y, et al. Feasibility and efficacy of lung ultrasound to investigate pulmonary complications in patients who developed postoperative Hypoxaemia-a prospective study. *BMC Anesthesiol*. 2020;20(1):220. doi:10.1186/s12871-020-01123-6
88. Al Jalbout N, Liteplo A, Shokoohi H. Point-of care ultrasound in stratifying clinically evolving inguinal and femoral hernias. *J Emerg Med*. 2022;63(2):257-264. doi:10.1016/j.jemermed.2022.04.034. Epub 2022 Jul 22.
89. Robinson A, Light D, Kasim A, Nice C. A systematic review and meta-analysis of the role of radiology in the diagnosis of occult inguinal hernia. *Surg Endosc*. 2013;27(1):11-18. doi:10.1007/s00464-012-2412-3
90. Summers SM, Scruggs W, Menchine MD, et al. A prospective evaluation of emergency department bedside ultrasonography for the detection of acute cholecystitis. *Ann Emerg Med*. 2010;56(2):114-122. doi:10.1016/j.annemergmed.2010.01.014
91. Cohen A, Li T, Stankard B, Nelson M. A prospective evaluation of point-of-care ultrasonographic diagnosis of diverticulitis in the emergency department. *Ann Emerg Med*. 2020;76(6):757-766. doi:10.1016/j.annemergmed.2020.05.017
92. Kruisselbrink R, Gharapetian A, Chaparro LE, et al. Diagnostic accuracy of point-of-care gastric ultrasound. *Anesth Analg*. 2019;128(1):89-95. doi:10.1213/ANE.0000000000003372
93. McRae A, Murray H, Edmonds M. Diagnostic accuracy and clinical utility of emergency department targeted ultrasonography in the evaluation of first-trimester pelvic pain and bleeding: a systematic review. *CJEM*. 2009;11(4):355-364. doi:10.1017/s1481803500011416
94. Stein JC, Wang R, Adler N, et al. Emergency physician ultrasonography for evaluating patients at risk for ectopic pregnancy: a meta-analysis. *Ann Emerg Med*. 2010;56(6):674-683. doi:10.1016/j.annemergmed.2010.06.563
95. Ultrasound guidelines: emergency, point-of-care and clinical ultrasound guidelines in medicine. *Ann Emerg Med*. 2017;69(5):e27-e54. doi:10.1016/j.annemergmed.2016.08
96. Chiem AT, Chan CH, Ibrahim DY, et al. Pelvic ultrasonography and length of stay in the ED: an observational study. *Am J Emerg Med*. 2014;32(12):1464-1469. doi:10.1016/j.ajem.2014.09.006
97. Beals T, Naraghi L, Grossestreuer A, Schafer J, Balk D, Hoffmann B. Point of care ultrasound is associated with decreased ED length of stay for symptomatic early pregnancy. *Am J Emerg Med*. 2019;37(6):1165-1168. doi:10.1016/j.ajem.2019.03.025
98. Snelling PJ, Jones P, Bade D, et al, BUCKLED Trial Group. Ultrasonography or radiography for suspected pediatric distal forearm fractures. *N Engl J Med*. 2023;388(22):2049-2057. doi:10.1056/NEJMoa2213883
99. Douma-den Hamer D, Blanker MH, Edens MA, et al. Ultrasound for distal forearm fracture: a systematic review and diagnostic meta-analysis. *PLoS One*. 2016;11(5):e0155659. doi:10.1371/journal.pone.0155659
100. Adhikari S, Blaivas M. Utility of bedside sonography to distinguish soft tissue abnormalities from joint effusions in the emergency department. *J Ultrasound Med*. 2010;29(4):519-526. doi:10.7863/jum.2010.29.4.519
101. Pourmand A, Lee D, Davis S, Dorwart K, Shokoohi H. Point-of-care ultrasound utilizations in the emergency airway management: an evidence-based review. *Am J Emerg Med*. 2017;35(8):1202-1206. doi:10.1016/j.ajem.2017.02.032

102. Gottlieb M, Holladay D, Burns KM, Nakitende D, Bailitz J. Ultrasound for airway management: an evidence-based review for the emergency clinician. *Am J Emerg Med*. 2020;38(5):1007-1013. doi:10.1016/j.ajem.2019.12.019
103. You-Ten KE, Siddiqui N, Teoh WH, Kristensen MS. Point-of-care ultrasound (POCUS) of the upper airway. *Can J Anaesth*. 2018;65(4):473-484. doi:10.1007/s12630-018-1064-8
104. Adhikari S, Zeger W, Schmier C, et al. Pilot study to determine the utility of point-of-care ultrasound in the assessment of difficult laryngoscopy. *Acad Emerg Med*. 2011;18(7):754-758. doi:10.1111/j.1553-2712.2011.01099.x
105. Gottlieb M, Holladay D, Peksa GD. Ultrasonography for the confirmation of endotracheal tube intubation: a systematic review and meta-analysis. *Ann Emerg Med*. 2018;72(6):627-636. doi:10.1016/j.annemergmed.2018.06.024
106. Das SK, Choupoo NS, Haldar R, Lahkar A. Transtracheal ultrasound for verification of endotracheal tube placement: a systematic review and meta-analysis. *Can J Anaesth*. 2015;62(4):413-423. doi:10.1007/s12630-014-0301-z. Epub 2014 Dec 24.
107. Lin J, Bellinger R, Shedd A, et al. Point-of-Care ultrasound in airway evaluation and management: a comprehensive review. *Diagnostics*. 2023;13(9):1541. doi:10.3390/diagnostics13091541
108. Beam G, Check R, Denne N, Minardi J, End B. Point-of-care ultrasound findings in a case of orbital cellulitis: a case report. *J Emerg Med*. 2021;61(2):157-160. doi:10.1016/j.jemermed.2021.03.033
109. Derr C, Shah A. Bedside ultrasound in the diagnosis of orbital cellulitis and orbital abscess. *Emerg Radiol*. 2012;19(3):265-267. doi:10.1007/s10140-011-0993-0
110. Adhikari S. Point-of-care ultrasound diagnosis of peripheral vein septic thrombophlebitis in the emergency department. *J Emerg Med*. 2013;44(1):183-184. doi:10.1016/j.jemermed.2011.08.014
111. Gamberini L, Tartaglione M, Giugni A, et al. The role of prehospital ultrasound in reducing time to definitive care in abdominal trauma patients with moderate to severe liver and spleen injuries. *Injury*. 2022;53(5):1587-1595.doi:10.1016/j.injury.2021.12.008
112. O'Dochartaigh D, Douma M. Prehospital ultrasound of the abdomen and thorax changes trauma patient management: a systematic review. *Injury*. 2015;46(11):2093-2102. doi:10.1016/j.injury.2015.07.007
113. Heegaard W, Hildebrandt D, Spear D, Chason K, Nelson B, Ho J. Prehospital ultrasound by paramedics: results of field trial. *Acad Emerg Med*. 2010;17(6):624-630. doi:10.1111/j.1553-2712.2010.00755.x
114. Valenzuela J, Stilson B, Patanwala A, Amini R, Adhikari S. Prevalence, documentation, and communication of incidental findings in focused assessment with sonography for trauma (FAST) examinations. *Am J Emerg Med*. 2020;38(7):1414-1418. doi:10.1016/j.ajem.2019.11.040
115. Tewari A, Shuaib W, Maddu KK, et al. Incidental findings on bedside ultrasonography: detection rate and accuracy of resident-performed examinations in the acute setting. *Can Assoc Radiol J*. 2015;66(2):153-157. doi:10.1016/j.carj.2014.04.004
116. Strony R, Marin JR, Bailitz J, et al. Systemwide clinical ultrasound program development: an expert consensus model. *West J Emerg Med*. 2018;19(4):649-653. doi:10.5811/westjem.2018.4.37152

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