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Emergency Ultrasound Guidelines
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Emergency Ultrasound Guidelines

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SECTION 1: INTRODUCTION

Emergency ultrasound has seen its clinical use expand greatly since its original application in emergency medicine decades ago.[1-5] The use of emergency ultrasound is now widespread at both community and academic hospitals of all sizes and also by medical personnel in out-of-hospital scenarios.[6-8] Focused emergency ultrasound is utilized to diagnose acute life-threatening conditions, guide invasive procedures, and treat emergency medical conditions and has ultimately improved the care of countless patients worldwide.[9]

In June 2001 ACEP approved the first specialty-specific comprehensive guidelines for use of ultrasound in emergency medicine.[10] Since those guidelines were published, world events, priorities in medical care, the growth of emergency medicine and ultrasound use in other medical specialties have emphasized the critical role of emergency ultrasound in modern medical care. In the United States, the health system continues to strain in the face of record numbers of patients visiting emergency departments (EDs) and provider shortages, putting emphasis on early recognition of emergency conditions with ultrasound.[11] Throughout medicine, the increasing emphasis on patient safety, quality care, efficiency, less invasive treatment and non-ionizing imaging has found a natural fit with the advantages of ultrasound.[12] Many of those resistant to clinician-performed ultrasound in other traditional imaging specialties have now started to acknowledge the use of ultrasound by emergency physicians, and emergency medicine has become the leading non-traditional clinical specialty integrating ultrasound into practice.[13] Outside the United States, other developed countries and new economic powers have rapidly adopted ultrasound while the use of ultrasound in remote and developing nations naturally supplants other traditional and very expensive diagnostic entities. With United States involvement in military conflicts, the use of emergency ultrasound has become an indispensable tool for evaluation of those injured in the battlefield.[14]

Since the initial publication of the ACEP 2001 guidelines, the use of ultrasound in emergency conditions has matured and expanded beyond the boundaries of that document. For example, emergency physicians now perform lung ultrasound, soft tissue evaluation, and shock assessment and are creating novel uses in response to the clinical challenges they face in the ED.[15,16]Also spurring the growth of ultrasound is the requirement that ACGME emergency medicine training programs demonstrate competency in bedside ultrasound for its graduates. Thus new graduates in emergency medicine now have been taught clinical ultrasound as a core skill in their specialty training. Furthermore, the body of knowledge of emergency ultrasound has been recognized by many centers as unique and many fellowship programs now exist, providing advanced training for interested physicians.

Hospitals focusing on patient safety have also embraced national and international safety guidelines that strongly recommend the use of ultrasound in central venous access; a critical procedure with significant potential complications that was routinely performed "blindly" before the clinical use of ultrasound.[17,18] In the last decade, advances in technology have led to smaller, more portable and easier to use machines with increasingly better image quality.[19] These fundamental equipment changes have led to machines being specifically designed for emergency medicine practitioners and the unique settings in which they work. Furthermore, the political barriers navigated by the specialty of emergency medicine in order to establish clinician-performed point of care ultrasound have helped pave the way for other allied specialties to improve patient care in critical care and anesthesia.[20,21] This has led to a larger group of non-traditional physicians performing ultrasound at most hospitals. The expanded use of bedside ultrasound is the direct consequence of a series of related events all directed towards a combined effort to improve patient care at the bedside.

The 2008 ACEP Ultrasound Guidelines represent the most current comprehensive specialty-specific guidelines in emergency ultrasound. These new guidelines now categorize ultrasound techniques into specific clinical entities that are more applicable to emergency care practice. The new categories also provide the flexibility and structure for training and credentialing of emergency physicians. The combined categories describe the expanded scope of practice of emergency ultrasound applications. This document also details training pathways, quality improvement, documentation and credentialing guidelines required to implement a successful program in emergency ultrasound. Emergency physicians, medical staff, hospitals, medical organizations, and regulatory bodies may use these guidelines in development, maintenance, and growth of emergency ultrasound to enhance patient care at bedside.

SECTION 2: SCOPE OF PRACTICE

Emergency ultrasound is the medical use of ultrasound technology for the bedside diagnostic evaluation of emergency medical conditions and diagnoses, resuscitation of the acutely ill, critically ill or injured, guidance of high risk or difficult procedures, monitoring of certain pathologic states and as an adjunct to therapy. Emergency ultrasound examinations are performed and interpreted by emergency physicians or those under the supervision of emergency physicians in the setting of the ED or a non-ED emergency setting such as out-of-hospital, battlefield, space, clinic, or any remote setting.

Emergency ultrasound may also be performed in other hospital settings if needed for emergent situations. Other medical specialties may wish to use this document if they perform emergency ultrasounds in the manner described above. However, those guidelines which apply to ultrasounds performed by consultants, especially other imaging specialists, or in a different setting do not apply to emergency physicians.[22,23]

Typically, emergency ultrasound is a goal-directed focused ultrasound examination that answers brief and important clinical questions in an organ system or for a clinical symptom or sign involving multiple organ systems.[24] Emergency ultrasound is synonymous with the terms bedside, point-of-care, focused, clinical and physician performed. Emergency ultrasound is complementary to the physical examination but should be considered a separate entity that adds anatomic, functional, and physiologic information to the care of the emergent patient. It may be performed as a single examination, repeated due to clinical need or deterioration, or used for monitoring of physiologic or pathologic changes.

Emergency ultrasound as described above uses a different paradigm than traditional, consultative ultrasound such as those ultrasound exams performed in US laboratories or departments.[25]

Emergency ultrasound is an emergency medicine procedure, and should not be considered in conflict with exclusive "imaging" contracts seen with consultative ultrasound. In addition, emergency ultrasound should be reimbursed as a separate billable procedure.

Table 1. Core emergency ultrasound applications.

Trauma
Intrauterine Pregnancy
AAA
Cardiac
Biliary
Urinary Tract
DVT
Soft-tissue/musculoskeletal
Thoracic
Ocular
Procedural Guidance

Emergency ultrasound is performed, interpreted, and integrated in an immediate and rapid manner dictated by the clinical scenario. It can be applied to any emergency medical condition in any setting with the limitations of time, patient condition, operator ability, and technology limitations. (See ACEP Emergency Ultrasound Imaging Criteria Compendium.)

Emergency ultrasound can be classified into the following functional clinical categories:

1. *Resuscitative*: ultrasound use as directly related to an acute resuscitation
2. *Diagnostic*: ultrasound utilized in an emergent diagnostic imaging capacity
3. *Symptom or sign-based*: ultrasound used in a clinical pathway based upon the patient's symptom or sign (eg, shortness of breath)
4. *Procedure guidance*: ultrasound used as an aid to guide a procedure
5. *Therapeutic and Monitoring*: ultrasound use in therapeutics or in physiological monitoring

Within these broad functional categories of use, we have identified 11 core or primary emergency ultrasound applications listed in Table 1. The criteria for inclusion as core are widespread use, significant evidence base, uniqueness in diagnosis or decisionmaking, or importance in primary emergency diagnosis and resuscitation. Some have been well established for the last 2 decades, and some (DVT, soft-tissue/musculoskeletal, thoracic, ocular) have more recently emerged due to utility, safety, and research.[15,16,26-28] Evidence for these core applications may be found in Appendix 1. The descriptions of these examinations may be found in the ACEP US Imaging Criteria.[29] Many other applications may be used by emergency physicians, and their non-inclusion in the core applications should not diminish their importance in practice.

As a class of ultrasound procedures, each emergency ultrasound application represents a clinical bedside skill that can be of great advantage in a variety of emergency settings. In classifying an emergency ultrasound a single application may appear in more than one category and clinical setting. For example, a focused cardiac ultrasound may be utilized to

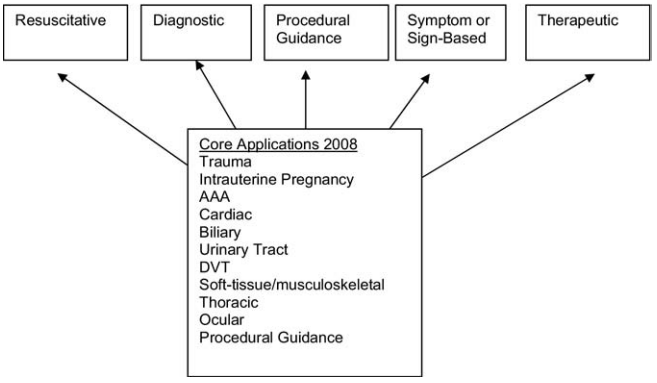

Figure 1. ACEP 2008 emergency ultrasound guidelines scope of practice.

Table 2. Other emergency ultrasound applications (adjunct or emerging).

Advanced Echo [74,75]
Transesophageal Echo[76]
Bowel (including intussusception, appendicitis, pyloric stenosis, diverticulitis, SBO)[77,78]
Adnexal Pathology[79]
Testicular[80]
Transcranial Doppler [81]
Contrast Studies[82]

identify a pericardial effusion in the diagnosis in the finding of an enlarged heart on chest x-ray. The focused cardiac ultrasound may be utilized in a cardiac resuscitation setting to differentiate true pulseless electrical activity from profound hypovolemia. In addition, the same focused cardiac study can be combined with one or more additional emergency ultrasound types, such as the focused abdominal, the focused aortic or the focused chest ultrasound, into a clinical algorithm and used to evaluate a presenting symptom complex. Examples of this would be the evaluation of patients with undifferentiated non-traumatic shock or the FAST (or extended FAST) examination in the patient presenting with trauma.[30] See Figure 1. Other ultrasound applications are performed by emergency physicians, and may be integrated depending on the setting, training, and needs of that particular ED or EM group. Table 2 lists other emergency ultrasound applications.

Other settings or populations

Pediatrics. Ultrasound is an ideal diagnostic tool for children. It may reduce or limit the increased risks of radiation-induced cancers by serving as an alternative to computed tomography.[31-33] As in adult patients, emergency ultrasound in children can be life-saving, time-saving, increase procedural efficiency and maximize patient safety.[35,36] Furthermore, scanning techniques from adult applications transfer easily to relevant pediatric applications (eg, knowledge of performing the FAST exam or transabdominal pelvic ultrasound transfers to scanning the bladder prior to urinary catheterization in infants).

Out-of-hospital and remote locations. There is increasing evidence that ultrasound has a legitimate role in out-of-hospital emergency care.[8,37-39] Challenges to the widespread implementation of out-of-hospital ultrasound include significant training and equipment requirements, and the need for careful physician oversight and quality assurance. Studies focusing on patient outcomes need to be conducted to further define the role of out-of-hospital ultrasound and to identify settings where the benefit to the patient justifies the investment of resources necessary to implement such a program. Ultrasound use in outer space is unique as the main imaging modality for space exploration and missions.[40] Ultrasound has been also used in remote settings such as international exploration, mountain base camps, and cruise ships.[41] The increasing portability of US machines with increasing image resolution has expanded the use of emergent imaging in such settings.

Emergency ultrasound in the international arena including field, rural, and disaster situations. There have been increasing efforts by individuals, groups and organizations to teach ultrasound in health care locations outside of the physical space of an ED.[42,43] Domestic and international natural disasters, eg, tsunami, hurricane, famine, or man-made disasters, eg, battlefield, or refugee camps, present less traditional environments where ultrasound can direct and optimize patient care.[44-46] Remote geographies such as rural areas, developing countries, or small villages often share the common characteristics of limited technology (ie, x-ray, CT, MRI), unreliable electrical supplies, and minimally trained health care providers. Increasing appreciation for ultrasound has evolved with the realization that this technology is portable, less costly, battery power accessible, may be powered by solar panels and is simple to learn. Furthermore, emergency physicians are particularly equipped to teach simple, focused, goal-directed applications.

Military and tactical emergency ultrasound. Bedside ultrasound by emergency physicians in the military has many unique and important applications that are suited for use in an austere battlefield environment.[14] Emergency physicians deployed in far forward austere settings, who have little or no access to traditional radiography, use bedside ultrasound for many advanced applications involving both trauma and medical management of military personnel and civilians. Standard uses include traditional exams such as EFAST, RUQ, renal, DVT, echo and first trimester pregnancy.[47] Unique but important applications also include fracture detection, foreign body detection/removal, assessment of IVC diameter as measure of resuscitation, as well as other soft tissue applications. In addition, important procedural guidance assistance in performing nerve blocks, arthrocentesis, lumbar puncture, abscess localization, and central venous access. At all echelons of care, but more frequently at the theater hospital level, ultrasound is used as an advanced form of triage during mass casualty events in critical multi-trauma patients. Bedside ultrasound provides rapid information on combat casualties

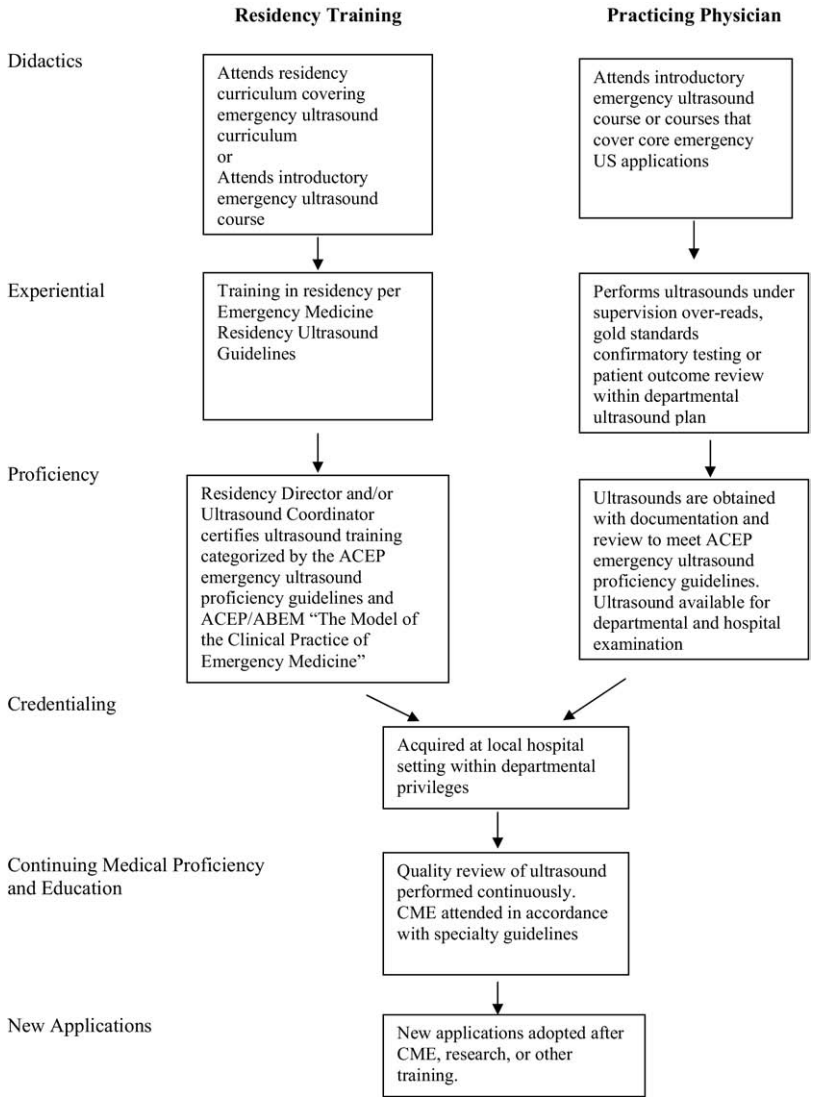

Figure 2. Pathways for emergency ultrasound training, credentialing, and incorporation of new applications.

with multiple wounds from a combination of mechanisms. Emergency physicians using bedside ultrasound are able to rapidly triage hypotensive patients who are in need of immediate operative intervention such as those with hemopericardium and hemoperitoneum versus those bleeding from other sites, including pelvic fractures and extremity wounds so ubiquitous in recent conflicts.

SECTION 3: TRAINING AND PROFICIENCY

Emergency ultrasound requires emergency physicians to become knowledgeable in the indications for ultrasound applications, competent in image acquisition and interpretation, and able to integrate the findings appropriately in the clinical management of his or her patients.[58] These various aspects of the clinical use of emergency ultrasound all require proper education and training. The ACGME mandates procedural competency for all EM residents in emergency ultrasound as it is considered a "skill integral to the practice of Emergency Medicine" as defined by the 2007 *Model of Clinical Practice of Emergency Medicine*.[59] This section of the Model of Clinical Practice assumes prior comprehension of emergency medical conditions and the ability to manage these conditions in the ED or setting. Within this section, we recognize the new spectrum of training in emergency ultrasound from undergraduate medical education through post-graduate training, where skills are introduced, applications are learned, core concepts are reinforced and new applications and ideas are introduced in life-long practice of ultrasound in emergency medicine.

Core Emergency Ultrasound Training - Pathways for Completion

In 2008, there are two pathways for emergency physicians for completion of training for basic emergency ultrasound competency. See Figure 2. The pathway for physicians in

residency training in emergency ultrasound is to obtain basic competency during their 3 to 4-year ACGME-approved emergency medicine residency program. A practice-based pathway allows those emergency physicians not previously exposed to training in emergency ultrasound during residency to become proficient in utilizing this technology. Both of these training pathways require didactic lessons, hands-on skill sessions, and a quality assurance program set up to review examinations at least until the physician has the ability to integrate this skill safely into clinical practice. The core curriculum for emergency ultrasound for both pathways is listed in Appendix 2.

Residency-based pathway. The residency-based pathway for training and proficiency in emergency ultrasound is adopted from a document written in coordination with a consensus conference sponsored by residency leaders in EM with representation by ACEP. As emergency physicians integrate ultrasound into patient care in the ED, these suggestions will adapt to the EM training environment. It should be noted that the intent of the guidelines is to provide minimum education standards for all EM residency programs for reference when establishing an emergency ultrasound training program. Emergency ultrasound skills are critical to the clinical development of an emergency physician and a minimum skill-set should be mandatory for all graduating EM residents.[50,51] The ultrasound education provided to EM residents should be structured to allow residents to incorporate ultrasound into daily clinical practice.[52] Image acquisition and interpretation are integral to the concept of emergency ultrasound but the ability to integrate findings into direct patient care in a busy clinical environment is the ultimate goal. Specific applications are listed previously in these guidelines. Specific guidelines for residency-based US education are listed in Appendix 3.

Practice-based pathway. A practice-based pathway for physicians who have completed their residency training without emergency ultrasound training should include initial training in a 16 to 24 hour introductory course (Appendix 4) covering the core applications with practical hands-on sessions. Shorter formatted (4-8 hour) CME courses covering single or a combination of applications may also be used to cover core and other emergency ultrasound applications. Some didactic training may take place by electronic means (slide, video, Internet, online tutorials, CDs, DVDs, and others) but hands-on training must be incorporated for initial training of Core Emergency Ultrasound applications.[50, 53,54] A wide variety of practical training models have been used in these courses, eg, didactic image presentation, video review of genuine cases, multimedia simulation models, animal models, normal human models, cadaver models, peritoneal dialysis models and patients with clinical pathology (with their consent).

The training process for emergency ultrasonography should then move beyond didactic and practical hands-on training to include experiential and competency components. The experiential component emphasizes and develops the psychomotor and cognitive components of emergency ultrasound. The skill of the practitioner improves significantly with repetition and there is overlap in the learning curves of the different primary applications when they are learned together. For example, competency in one abdominal application leads to better technique and interpretation when learning other applications. This period can be viewed as a training, proctoring, or provisional privileging period. Ultrasound examinations performed during this period should be reviewed for technique, speed of image acquisition, organ definition, and diagnostic accuracy.[55]

Methods of determining competency include traditional testing, testing using simulator models, videotape review, observation of bedside skills, over-reading of images by experienced sonologists (expert physicians who perform and interpret ultrasound examinations), and monitoring of error rates through a quality assurance process. Performance improvement programs that monitor accuracy will help to ensure that quality ultrasound studies are being performed. If there is no US director or established US program, a cumulative log comparing training ultrasound examinations to other imaging tests, surgical findings, or patient outcome is a reasonable process to assess competency.

At the end of this period of experiential training, we recommend that at least 25 documented and reviewed cases should have been obtained in each of the core applications with a range of 25-50 cases. Some applications such as ultrasound for procedural access require fewer cases given the prior knowledge and clinical experience with the blind procedural technique. If a number of examinations for US-guided procedure is required, we would recommend 10 US-guided procedures examinations or completion of a module on ultrasound-guided procedures with simulation on a high quality ultrasound phantom. Learning curves in emergency ultrasound examinations have generally used an absolute number of examinations, but competency may have other equivalents than number of exams.[56-60] Examples include training in the setting of significant supervised training, experience with similar applications (eg, near-field, torso, procedural) or research with each application.

For general emergency ultrasound competency, a minimum of 150 total emergency ultrasound examinations (with a range of 150–250 cases) is required, depending on the number of core applications being used. For example, a department using greater than seven core applications may require more than 150 examinations. For rare abnormalities, the recognition of abnormal pathology using other means of competency testing may be used if the trainee is exposed to limited numbers of abnormal findings.

Finally, regarding non-core emergency ultrasound applications, a generally accepted number of 25-50 cases per application should follow didactic training, with variations (both smaller and greater in number) depending on the applications and technical aspects of the examination.

Continuing Medical Education

As with all aspects of emergency medicine, continuing medical education as defined below in emergency ultrasound is requisite, regardless of pathway. Continuing medical education (CME) specific to ultrasound must be achieved, combined with other CME topics, and can be done so in a wide variety of formats. The amount of CME required to maintain competency is related to the number of applications being utilized, the frequency of use, and other developments in emergency ultrasound and emergency medicine at large. In general, those in charge of ultrasound programs should have at least 10 hours of continuing medical educational credits pertaining to ultrasound activities per credentialing cycle (typically 2 years) including any of the following: Category 1 conference attendance, online educational activities, preceptorships, teaching, research, hands-on teaching, administration, quality assurance, image review, inservice examinations, textbook and journal readings, morbidity and mortality conferences inclusive of ultrasound cases, or others. Individual credentialed physicians should have 5 hours of the above continuing educational ultrasound activities per credentialing cycle. Educational sessions that integrate ultrasound into the practice of EM are encouraged, and do not have to be didactic in nature but can be participatory. Ultrasound quality improvement is an example of an activity that may be used for completion of the required ABEM Assessment of Practice Performance activities.[61]

Undergraduate Medical Student Education

Increasingly, medical students are being exposed to ultrasound in medical school education curricula.[62,63] The ability of medical students to master the fundamentals of ultrasound physics and probe manipulation may assist their focus on application in residency. The recommendation for a typical emergency medicine rotation and a dedicated emergency ultrasound rotation as an elective in the fourth year of medical school is listed in Appendix 5.

Ultrasound Preceptorships

A preceptorship with peers at other emergency ultrasound training sites or assistance from related imaging professionals within one's institution may be pursued. Preceptorships that have been successfully utilized to train community physicians may vary in duration, but typically last 1-2 weeks at another institution that is actively using emergency sonography. The review of clinically indicated studies should be performed by the credentialed staff at the bedside.

Fellowship Training in Educational Continuum of Emergency Ultrasound

The role of an emergency ultrasound fellowship is to train a generation of leaders in emergency ultrasound who will fill emergency ultrasound director and leadership positions in training programs and hospitals across the country.

Fellowship is not required for routine emergency physician use of core emergency ultrasound applications. During fellowship training, fellows should have the opportunity to consider more advanced ultrasound protocols or more deeply explore techniques, underlying principles and more advanced interpretative findings. In addition, fellowship training requires and promotes clinical research in emergency ultrasound in order to provide research support and evidence-based guidance to the continued evolution and universal incorporation of emergency ultrasound in clinical practice. Finally, fellowship training provides extensive exposure to the mechanics of running an emergency ultrasound program and includes training in image archiving, digital image management as well as all aspects of the administrative and financial responsibilities of an emergency ultrasound program director. (See ACEP Fellowship Guidelines.)[64]

SECTION 4: CREDENTIALING

Physician credentialing is the process of gathering information regarding a physician's qualifications for appointment to the medical staff. Credentialing defines a physician's scope of practice and the clinical services he or she may provide, and ensures that the physician provides services within the scope of privileges granted.

The American College of Emergency Physicians (ACEP) believes that the exercise of clinical privileges in the ED is governed by the rules and regulations of the department. The ED medical director or his/her designate (Emergency Ultrasound Director) is responsible for the periodic assessment of clinical privileges of emergency physicians. When a physician applies for reappointment to the medical staff and for clinical privileges, including renewal, addition, or rescission of privileges, the reappraisal process must include assessment of current competence by the ED medical director. The ED medical director will, with the input of department members, determine the means by which each emergency physician will maintain competence and skills and the mechanism by which each physician is monitored.

Pertaining to emergency ultrasound, the American Medical Association (AMA) House of Delegates in 1999 passed a resolution (AMA HR. 802) recommending hospitals' credentialing committees follow specialty-specific guidelines for hospital credentialing decisions related to ultrasound use by clinicians. This resolution provides clear support for hospital credentialing committees to grant emergency ultrasound (EUS) privileging based on the specialty-specific guidelines contained within this document without the need to seek approval from other departments. Furthermore, HR. 802 states that opposition that is clearly based on financial motivation meets criteria to file an ethical complaint to the AMA.

Implementing a transparent, high quality, verifiable and efficient credentialing system is an integral component of an emergency ultrasound program. An emergency ultrasound director, along with the department chairperson, should oversee

policies and guidelines pertaining to emergency ultrasound. The first principle is that the department should follow the specialty-specific guidelines set forth within this document for their credentialing and privileging process. Second, emergency medicine departments should either list emergency ultrasound within their core emergency medicine privileges, or as a single separate privilege for "emergency ultrasound" without further designation. Third, the ED should take responsibility to designate which core applications it will use, and then track its emergency physicians in each of those core applications. Fourth, to help integrate physicians of different levels of sonographic competency (graduating residents, practicing physicians, fellows and others), we recommend that the department of emergency medicine create a credentialing system that gathers data on individual physicians, which is then communicated in an organized fashion at predetermined thresholds with the institution-wide credentialing committee. This system focuses supervision and approval at the department level where education, training, and practice performance is centered prior to institutional final review. Finally, as new core applications are adopted, they should be granted by internal credentialing system within the Department of Emergency Medicine.

Eligible providers to be considered for privileging in emergency ultrasonography include emergency physicians who complete the necessary training as specified in this document via residency training or post-residency training (see Training Section). Board certification in emergency medicine is an excellent benchmark that should be considered when delineating clinical privileges. However, even with board certification, there will be those who need to complete the necessary training outlined in this document. Sonographer certification is not an expected or obligatory requirement for emergency ultrasound credentialing.

While the training guidelines in this document include a minimum number of examinations recommended to be performed, there are several qualifiers to this that merit attention. First, proficiency may not always be defined by numerical goals, and certain physicians may gain competency at varying rates or without numerical threshold but within structured educational experiences such as residency, preceptorships, and fellowships. Secondly, these examinations should be performed during patient encounters, ideally in the department of emergency medicine; however, approved training experiences with other imaging specialties, or other CME training in ultrasound is acceptable. Thirdly, pathologic findings should be present in a meaningful portion of cases submitted. More sophisticated sonographic techniques may require different credentialing requirements or modes of confirmation beyond the core or primary emergency indications.

At least every two years, hospitals are required to reappoint physicians and renew their clinical privileges. Hospitals and their medical staffs are legally obligated to credential and recredential those physicians who can demonstrate current clinical competence, skill, judgment, and technique. In order to remain competent, physicians must stay current with the literature and perform services delineated in their clinical privileging on a regular basis.[65] In addition to meeting the requirements for ongoing clinical practice set forth in this document, physicians should also be assessed for competence through the CQI program at their institution. (See QA/QI Section.) These suggestions are delineated in greater detail within other sections of this document, which exists as the standard for the initiation, integration, renewal and expansion of emergency ultrasound. In conclusion, specialty-specific credentialing in emergency ultrasound is an essential process that is supported by ACEP.

SECTION 5: EMERGENCY ULTRASOUND CONTINUOUS QUALITY MANAGEMENT

In order to ensure quality, facilitate education, and satisfy credentialing pathways, a plan for emergency ultrasound quality assurance and improvement program should be in place. This plan should be integrated into the overall plan of the EM department. The facets of such a program are listed below and summarized in Appendix 6.

Emergency Ultrasound Director

The emergency ultrasound director or coordinator is a board-prepared or certified emergency physician who has been given administrative oversight of the emergency ultrasound program from the EM director or group. In addition to coordination of education, machine acquisition and maintenance, the US director is responsible for developing, monitoring, and revising the QA process.

Documentation

Emergency ultrasound is different from consultative ultrasound in other specialties as the emergency physician not only performs but also interprets the ultrasound examination. In a typical hospital ED practice, ultrasound findings are immediately interpreted, and should be communicated to other physicians and services by written reports in the ED chart. Emergency ultrasound documentation reflects the nature of the exam which is focused, goal-directed, and performed at the bedside contemporary with clinical care. This documentation may be preliminary and brief in a manner reflecting the presence or absence of the relevant findings. Documentation as dictated by regulatory and payor entities may require more extensive reporting including indication, technique, findings, and impression. Documentation may be hand-written, transcribed, templated, or computerized. During out-of-hospital, remote, disaster, and other scenarios, US findings may be communicated by other methods as care is rendered within the constraints of the ongoing setting. Incidental findings should be communicated to the patient or follow-up provider. Discharge instructions should reflect any specific issues regarding US findings in the context of the ED diagnosis. Hard copy (paper, film, video, digital) ultrasound images are typically

saved within ED or hospital archival systems. Finally, documentation of emergency ultrasound procedures should result in a appropriate reimbursement for services provided. (See ACEP Emergency Ultrasound Reimbursement Guidelines.)[66,67]

Quality Assurance Process

Quality assurance systems are an integral part of any ultrasound program. The objective of the QA process is used to evaluate images for technical competence and interpretations for clinical accuracy and provide feedback to improve physician performance. The QA process is an integrated part of the educational, training, and credentialing processes of each department.

Parameters to be evaluated might include image resolution, anatomic definition, and other image quality acquisition aspects such as gain, depth, orientation, and focus. In addition, the QA system should compare the impression from the emergency ultrasound interpretation to the patient outcome measures such as consultative ultrasound, other imaging modalities, surgical procedures, or patient clinical outcome. In addition, direct supervision of physician performance of ultrasonography by expert emergency physician (sonologists) should be considered an ideal form of QA and practice performance activities. Any of these activities may be included in professional practice evaluation, practice performance, and other certification activities.

QA system design should strive to provide timely feedback to physicians. Balancing quality of review with provision of timely feedback is a key part of QA process design. Video review may be superior to still image review but is generally more time consuming, and may not be practical in some institutions. In addition, paper systems are more cumbersome that digital solutions, but may be easier to implement. Any system design should have a data storage component system that enables data and image recall.

All images obtained prior to a physician becoming credentialed should be reviewed, while images from credentialed physicians may be sampled during QA.

The general data flow in the QA system is as follows.

1. Images obtained by the physician are exported to some type of media (paper, tape, hard drive, flash drive, CD/DVD). These images may be still images, video clips.
2. Clinical information, ultrasound findings, and additional test results are documented on an electronic or paper QA data record.
3. These images and data are then reviewed by the ultrasound director or his/her designee.
4. Reviewers evaluate images for accuracy and technical quality and submit the reviews back to the physician.
5. Emergency ultrasound studies are archived and available for review later should they be needed.

QA systems currently in place range from thermal images and log books to complete digital solutions. Finding the system that works best for each institution will depend on multiple factors, such as machine type, administrative and financial support, and physician compliance.

US Machines and Maintenance

Dedicated US machines located in the ED for use by emergency physicians are expected equipment for optimal care in any hospital ED. Such units should be chosen to handle the rigors of the multi-user, multi-location practice environment of the ED. (See ACEP Emergency Ultrasound Section List of Optimal Characteristics for Emergency US Machines.) Other issues that should be addressed regarding emergency ultrasound equipment include: regular inservice of personnel using the equipment and appropriate transducer care, stocking and storage of supplies, adequate cleaning of external and endocavitary transducers with respect to infection control, upkeep and maintenance of US machines by clinical engineering or others, and efficient communication of equipment issues.[68]

Risk Management

Ultrasound is an excellent risk reducing tool by 1) increasing diagnostic certainty, 2) shortening time to definitive therapy, and 3) decreasing complications from blind procedures that carry an inherent level of complications.[69] An important step to managing risk is ensuring that physicians are properly trained and credentialed according to national guidelines such as those set by ACEP. Proper quality assurance and improvement programs should be in place to identify and correct substandard practice. Lastly, the standard of care for emergency ultrasound is the performance and interpretation of ultrasound by a credentialed emergency physician within the limits of the clinical scenario. Physicians performing ultrasound imaging in other specialties or in different settings have different goals, scope of practice, documentation requirements, and consequently should not be comparable to those practicing emergency medicine. As emergency ultrasound is a standard emergency medicine procedure, it is included in any definitions of the practice of emergency medicine in regards to insurance and risk management.

SECTION 6: CLINICAL ULTRASOUND RESEARCH

Our healthcare system has moved towards evidence-based medicine in an effort to achieve optimal cost-effective and efficient patient care outcomes. The medical literature demonstrates that emergency ultrasound has the ability to reduce the economic and human costs of unnecessary procedures, and to improve patient outcomes and experiences through early detection and better treatment options.

A key element of answering this challenge is outcome assessment research. In this case, the assessment of the outcome of emergency ultrasound in comparison to other sources of information (ie, other types of diagnostic testing) which, where appropriate, may be used to assess the validity of the conclusions

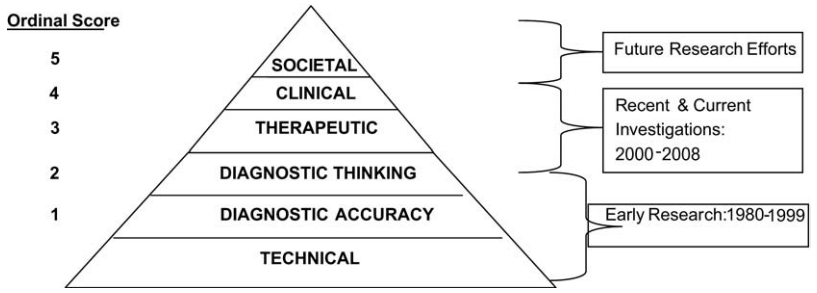

Figure 3. Fryback-Pearl hierarchical model of effectiveness assessment: clinical sonography.

Established Applications	Newer Applications
AAA: 3	Deep Venous Thrombosis: 2
Cardiac: 4	Thoracic: 2
US guided Central access: 4	Musculoskeletal: 1
FAST: 4	Ocular: 1
Pregnancy: 3	Procedural: 1
Shock: 3	

Figure 4. Emergency ultrasound applications graded in the Fryback-Pearl hierarchical model of effectiveness assessment: clinical sonography.

reached on the basis of the ultrasound examination. Outcomes research programs may be designed to assess the effectiveness of emergency ultrasound in a manner akin to the Fryback-Pearl hierarchical model.[70-72] See Figure 3.

The first two echelons of assessment are technical and diagnostic accuracy effectiveness, which address the ability to create an image of interpretative quality and the ability to test how well the image obtained compares to an established "gold standard." These levels of effectiveness assessment regarding primary applications of emergency ultrasound have been addressed in the literature since the 1990's. The middle strata of the assessment hierarchy are diagnostic thinking and therapeutic effectiveness. These levels have been the focus of the current primary application research. They assess whether a test facilitates the practitioner's ability to make a diagnostic decision and whether a test leads to improved treatment, ie, better therapy or more rapid provision of an established therapy.

The highest level of the pyramid addresses clinical effectiveness, ie, whether the test improves patient outcomes, such as reducing morbidity and, societal effectiveness, ie, whether the test can positively influence outcomes at the population level, eg, enhancement of quality of life and overall societal cost-effectiveness. The emergency ultrasound research community has the goal of addressing the highest level possible on this pyramid.

Based on a recent review of the literature, the highest ordinal scores of the level of assessment for established and newer clinical sonography applications are as follows in Figure 4.

Another key element of the research effort is the assessment of scientific evidence traditionally presented as classes:

– Class I Evidence: Randomized controlled trials (RCTs) are the gold standard

– Class II Evidence:

A. Data collected prospectively

B. Retrospective analyses from clearly reliable data

– Class III Evidence: Most studies based on retrospectively collected data

Using this system of ranking, some Class I evidence exists for ultrasound-assisted central venous cannulation and the FAST examination, but most publications are Class II (both A & B) evidence. Published literature for clinical sonographic evaluation of other established applications, including abdominal aortic aneurysm, cardiac tamponade and global inotropy, early intrauterine pregnancy confirmation, and shock states are Class II (both A & B) and Class III evidence. For the newer applications, some Class II data exist, but the majority of the literature remains Class III evidence.

Finally, after completing an assessment of the scientific evidence, the confidence in recommending the use of clinical sonography can be rendered and presented as levels:

– Level 1: Convincingly justifiable based on the available scientific information alone

– Level 2: Reasonably justifiable by available scientific evidence and strongly supported by expert opinion

– Level 3: Supported by available data but adequate scientific evidence is lacking

Currently, a Level 1 recommendation for use of clinical sonography may be assigned to ultrasound-assistance of central venous cannulation: no negative data has been published and it is formally recommended by the Agency for Healthcare Research and Quality. All other core applications reviewed may carry a Level 2 recommendation based on the available published information.

In conclusion, research in emergency ultrasound has given us the basis for these guidelines. The above template will continue to provide a guide for future research in emergency ultrasound.

SECTION 7: FUTURE ISSUES

Emergency ultrasound is a rapidly growing subspecialty within emergency medicine but has roots and branches to all other disciplines, especially within clinical ultrasound. Several international and national ultrasound organizations have been interested and collegial in the development of this field.[13,74] Our leaders will continue to lead and liaison with other

specialties interested in the use of ultrasound for clinical care, especially allied with the concept of clinical bedside ultrasound.

In education, the integration of ultrasound will begin at the undergraduate medical education level by incorporating ultrasound into basic sciences such as anatomy, and into clinical care in specialties such as EM, critical care, surgery, and family practice. At the residency training level, further coordination and standardization of the curriculum will take place. Emergency ultrasound training for community physicians will evolve as more physicians mature in their ultrasound practice, and seek new and more sophisticated techniques. A culture of expecting the performance of emergency ultrasound will gradually seep into the dynamics of emergency medicine practice. Fellowships' and preceptorships' focus will shift with more research and collaboration with other similar specialties such as critical care.

Technological advances including specialized transducers, miniaturization, signal manipulation, and machine format will all evolve to become more congruous with emergency medicine practice and information systems. The continued improvement in ultrasound resolution may allow further adaptation in EM practice with a reduction in the use of ionizing radiation.

As emergency ultrasound goes forward, issues such as including subspecialty development, practice designation, integration of other applications, and continued research in the field will need to occur. A vigorous, participatory, and professional involvement in all these endeavors by emergency physicians will allow the continued growth and appropriate use of ultrasound in the emergency care of patients in our EDs.

SECTION 8: CONCLUSION

Emergency medicine specialty-specific guidelines have been extensively updated and advanced to reflect current practice since the original publication in 2001. Emergency physicians or those who practice in emergency settings should utilize these guidelines for the initiation, development, training, credentialing, and future growth of their practice. Some physicians and programs may surpass many of these recommendations, while local circumstances may require modifications of these guidelines based on staffing, education, equipment, and facilities. New research and knowledge will give impetus to revised guidelines for emergency ultrasound. Emergency physicians and EDs should continue to adopt, maintain, and expand their use of ultrasound during this exciting period.[34,38,48,49,73,96,108,118]

ACEP endorses the following statements on the use of emergency ultrasound:

1. Emergency ultrasound performed and interpreted by emergency physicians is a fundamental skill in the practice of emergency medicine.
2. The scope of practice of emergency ultrasound can be classified into categories of resuscitation, diagnostic, symptom or sign-based, procedural guidance, and monitoring/therapeutics in which a variety of emergency ultrasound applications, including the below listed core applications, can be integrated.
3. Current core applications in emergency ultrasound include trauma, pregnancy, abdominal aorta, cardiac, biliary, urinary tract, deep venous thrombosis, thoracic, soft-tissue/musculoskeletal, ocular, and procedural guidance.
4. Dedicated ED ultrasound equipment is requisite to the optimal care of critically ill and injured patients.
5. Training and proficiency requirements should include didactic and experiential components as described within this document.
6. Emergency ultrasound training in emergency medicine residency should begin early and be fully integrated into patient care.
7. Emergency physicians after initial didactic training should following competency guidelines as written within this document.
8. Credentialing standards used by EDs and health care organizations should follow specialty-specific guidelines as written within this document.
9. Quality assurance and improvement of emergency ultrasound is fundamental to the education and credentialing processes.
10. Emergency physicians should be appropriately compensated by payors in the provision of these procedures.
11. Emergency ultrasound research should continue to explore the many levels of clinical patient outcomes research.
12. The future of emergency ultrasound involves adaptation of new technology, broadening of education, and continued research into an evolving emergency medicine practice.

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APPENDIX 1. EVIDENCE FOR CORE EMERGENCY ULTRASOUND APPLICATIONS.

Trauma

The use of ultrasound in trauma patients is typically for the detection of abnormal fluid or air collection in the torso. This application applies to both blunt and penetrating trauma in all ages. Perhaps the first bedside ultrasound technique studied in the hands of non-radiologists was the focused assessment with sonography in trauma (FAST) examination. First demonstrated in Europe and by surgeons, the technique was later adopted by emergency physicians.[83] In one early prospective study, FAST was 90% sensitive and 99% specific in detecting peritoneal bleeding in blunt trauma, and 91% sensitive and 100% specific in penetrating trauma.[84] A retrospective review of patients with penetrating thoracic trauma demonstrated 100% sensitivity for the detection of pericardial effusion and more rapid diagnosis and management when ultrasound was employed in their assessment.[85] Recently, a prospective randomized controlled study assessed 262 blunt trauma patients managed using the FAST exam as a diagnostic adjunct vs. no FAST exam. Patients randomized to the FAST exam group had more rapid disposition to the operating room, required fewer CT scans, and incurred shorter hospitalizations, fewer complications, and lower charges than those in whom the FAST was not performed.[86]

Pregnancy

Use of emergency ultrasound in pelvic disorders centers on the detection of intrauterine pregnancy (IUP), detection of ectopic pregnancy, detection of fetal heart rate in all stages of pregnancy, dating of the pregnancy, and detection of significant free fluid. Bedside pelvic ultrasound during the first trimester of pregnancy can be used to exclude ectopic pregnancy by demonstrating an intrauterine pregnancy. Studies of emergency physician-performed ultrasound in this setting have demonstrated sensitivity of 76-90% and specificity of 88-92% for the detection of ectopic

pregnancy.[87,88] In one study, emergency physicians were able to detect an intrauterine pregnancy in 70% of patients with suspected ectopic pregnancy (first trimester pregnancy with abdominal pain or vaginal bleeding).[87] When intrauterine fetal anatomy was visualized at the bedside, ectopic pregnancy was ruled out with a negative predictive value of essentially 100%. When bedside ultrasound evaluation was incorporated into a clinical algorithm for the evaluation of patients with suspected ectopic pregnancy, the incidence of discharged patients returning with ruptured ectopic pregnancy was significantly reduced.[89]

Abdominal Aortic Aneurysm (AAA)

The use of emergency ultrasound of the aorta is mainly for the detection of AAA, though aortic dissection may occasionally be detected. Although CT scan and MRI often serve as the criterion standard for AAA assessment, ultrasound is frequently used by radiology departments as a screening modality as well. In the ED, bedside ultrasound demonstrates excellent test characteristics when used by emergency physicians to evaluate patients with suspected AAA. One study of 68 ED patients with suspected AAA demonstrated sensitivity, specificity, positive and negative predictive values of 100%.[90] In another, 125 patients were assessed by emergency physicians. Sensitivity was 100%, specificity 98%, positive predictive value 93% and negative predictive value 100% in this study.[91] In both studies, CT scan, radiology ultrasound, MRI, and operative findings served as a combined criterion standard.

Emergent Echocardiography

Emergent cardiac ultrasound can be used to assess for pericardial effusion and tamponade, cardiac activity, a global assessment of contractility, and the detection of central venous volume status. One early study of bedside echocardiography by emergency physicians demonstrated 100% sensitivity for the detection of pericardial effusion in the setting of penetrating chest trauma. In this series, patients evaluated with ultrasound were diagnosed and treated more rapidly when ultrasound was employed in their assessment.[85] Test characteristics of emergency physician-performed echocardiography (when compared to expert over-read of images) for effusion include sensitivity of 96-100%, specificity 98-100%, positive predictive value 93-100% and negative predictive value 99-100%. The prognostic value of emergency physician-performed bedside echocardiography has been well-established.[92] In one study of 173 patients in cardiac arrest, cardiac standstill on ultrasound was 100% predictive of mortality, regardless of electrical rhythm (positive predictive value of 100%).[93] In the assessment of patients with undifferentiated hypotension, emergency physician assessment of cardiac contractility correlated well with blinded review by cardiologists (correlation coefficient $R=0.86$). This was similar to the inter-observer correlation among cardiologists in reading the same images ($R=0.84$).[31]

Hepatobiliary System

The use of emergency ultrasound for hepatobiliary disease has centered on biliary inflammation and biliary obstruction. Although many sonographic criteria for acute cholecystitis exist (including gallstones, thickened gallbladder wall, pericholecystic fluid, sonographic Murphy's sign, and common bile duct dilatation), gallstones are present in 95-99% of acute cholecystitis cases. This finding is quite accessible to the emergency physician using bedside ultrasound, and may be placed into the context of an individual patient's clinical picture (presence of fever, tenderness, laboratory evaluation, etc). The test characteristics for gallstone detection by bedside ultrasound are: sensitivity 90-96%, specificity 88-96%, positive predictive value 88-99% and negative predictive value 73-96%.[94,95] A retrospective review of 1252 cases of suspected cholecystitis demonstrated that bedside emergency physician ultrasound vs radiology ultrasound evaluation decreased length of stay by 7% (22 minutes) overall, and up to 15% (52 minutes) when patients were evaluated during evening or nighttime hours.[99]

Urinary Tract

The use of emergency ultrasound in the urinary tract is for detection of hydronephrosis and bladder status. The detection of hydronephrosis on bedside ultrasound, when combined with urinalysis and clinical assessment, may be helpful in differentiating patients with acute renal colic. Bedside renal ultrasound by experienced emergency physicians has demonstrated sensitivity of 75-87% and specificity of 82-89% when compared with CT scan.[97,98]

Deep Venous Thrombosis (DVT)

The use of emergency ultrasound for detection of DVT has centered on the use of multilevel compression ultrasound on proximal veins, especially in the lower extremity. A number of ED studies have examined the test characteristics of emergency physician-performed limited venous compression sonography for the evaluation of DVT. A recent systematic review of six studies, (with a total of 132 DVTs in 936 patients) found a pooled sensitivity and specificity of 95% and 96%, respectively.[28] One study demonstrated more rapid disposition for patients undergoing bedside ultrasound for DVT assessment compared with radiology department DVT assessment (95 vs. 225 minutes).[99]

Soft tissue/musculoskeletal

The use of emergency ultrasound in soft-tissue has focused on soft-tissue infection, foreign bodies, and cutaneous masses. Although a host of musculoskeletal applications of bedside ultrasound have been studied by emergency physicians, among the most common and best described is the assessment of cellulitis and abscess at the bedside. Ultrasound has been shown to improve the clinical assessment of patients with cellulitis and possible abscess in several studies. In one study of 105 patients with suspected abscess, ultrasound demonstrated sensitivity of 98%, specificity 88%, positive predictive value 93% and negative predictive value 97% compared with needle aspiration.[16] Another study demonstrated that bedside ultrasound altered the management of patients with cellulitis (and no clinically obvious abscess) in 56% of

cases.[100] These patients were found to have abscesses or require surgical evaluations which were not evident on clinical examination alone. Fractures have been identified in series and prospective studies with good accuracy.[101] Tendon injuries and joint effusions have been studied with excellent clarity.[102-107]

Thoracic

The use of emergency ultrasound in the thorax has been for the detection of pleural effusion and pneumothorax, and possibly inflammatory disorders. Bedside ultrasound for the evaluation of thoracic disorders was described in the 1990s in European critical care settings. Since then, emergency physicians have utilized the technology for the detection of pneumothorax and other acute pathology. In the setting of blunt thoracic trauma, emergency physician-performed ultrasound demonstrated sensitivity of 92-98%, specificity 99%, positive predictive value 96-98% and negative predictive value 99% compared with CT scan or air release during chest tube placement.[27]

Ocular

The use of emergency ultrasound in the eye has been used for the detection of posterior chamber and orbital pathology. Specifically, ultrasound has been described to detect retinal detachment,[107] vitreous hemorrhage, and dislocations or disruptions of structures. In addition, the structures posterior to the globe such as the optic nerve sheath diameter may be a reflection of other disease in the CNS.[109-112]

Procedural Guidance

Ultrasound guidance has been studied as a useful adjunct to many common ED procedures, including venous access, thoracentesis, paracentesis, joint aspiration, and others.[107,113-117] Studies since the early 1990s have demonstrated the efficacy of ultrasound guidance for central venous cannulation, and the use of this technology has been advocated by the United States Agency for Healthcare Research and Quality as one of the top 11 means of increasing patient safety in the United States.[17] Recently, a randomized controlled study of 201 patients undergoing central venous cannulation demonstrated higher success rates with dynamic ultrasound guidance (98% success) when compared with static ultrasound guidance (82%) or landmark-based methods (64%).[118]

APPENDIX 2. EMERGENCY ULTRASOUND CURRICULUM.

Introduction

- Define limited, goal-directed emergency ultrasound
- List the primary emergency applications
- Describe position statements of various organizations affiliated with emergency ultrasound (eg, ACEP, SAEM, AMA, ABEM)
- Define terms training, proficiency, credentialing as it applies to limited, goal-directed ultrasound

Physics & Instrumentation

- Understand role of physics in modern ultrasound
- Define necessary terms to include:
  piezoelectric effect
  frequency
  resolution
  attenuation
  echogenicity
  Doppler

- Understand the role of instrumentation in image acquisition
  Image mode
  Gain
  Time gain compensation
  Focus
  Dynamic range
  Probe types

- Understand types of ultrasound artifacts and their role in image acquisition
  Reverberation
  Side lobe
  Mirror
  Shadowing
  Enhancement
  Ring-down

Trauma

- Describe the indications, clinical algorithms, and limitations of bedside ultrasound in blunt and penetrating thoracoabdominal trauma.
- Define the relevant local anatomy including the liver, spleen, kidneys, bladder, uterus, pericardium, and lung bases.
- Understand the standard ultrasound protocol required when evaluating for hemoperitoneum, hemopericardium, hemothorax, and pneumothorax.
- Recognize the relevant focused findings and pitfalls related to the detection of hemoperitoneum, hemopericardium, and hemothorax.
- Describe how volume status can be evaluated and monitored by evaluating left ventricular function and inferior vena cava compliance.

First-Trimester Pregnancy

- Describe the relevant local anatomy including the uterus, cervix, adnexa, bladder and cul-de-sac.
- Describe the indications and limitations of focused sonography in first-trimester pregnancy pain and bleeding.

- Understand the standard ultrasound protocol including transabdominal and endovaginal views when performing focused pelvic ultrasound in early pregnancy.
- Understand the role of ultrasound and quantitative β-hCG in a clinical algorithm for first-trimester pregnancy pain and bleeding.
- Understand the differential diagnosis of early pregnancy including intrauterine pregnancy, embryonic demise, molar pregnancy, ectopic pregnancy, and indeterminate classes.
- Recognize the relevant focused findings and pitfalls when evaluating for early intrauterine pregnancy and ectopic pregnancy.
  Early embryonic structures
  Location of embryonic structures in pelvis
  Findings of ectopic pregnancy
  Pseudogestational sac
  Adnexal masses

Abdominal Aortic Aneurysm

- Describe indications and limitations of focused ultrasound in the evaluation of abdominal aortic aneurysms.
- Define the local relevant anatomy including the aorta with major branches, inferior vena cava, and vertebral bodies.
- Understand the standard ultrasound protocol required when evaluating for abdominal aortic aneurysms.
- Recognize the relevant focused findings and pitfalls when evaluating for abdominal aortic aneurysms.
- Types of aneurysms
- Measurement technique

Echocardiography

- Describe the indications and limitations of focused emergency echocardiography.
- Define the relevant cardiac anatomy including cardiac chambers, valves, pericardium, and aorta.
- Understand the standard ultrasound windows (subcostal, parasternal, and apical) and planes (four chamber, long and short axis) necessary to perform focused echocardiography when evaluating for cardiac activity and pericardial effusions.
- Recognize the relevant focused findings to detect cardiac activity and pericardial effusions with or without tamponade.
- Estimate qualitative left ventricular function.
- Estimation of central venous pressure through examination of inferior vena cava compliance.
- Understand how ultrasound can allow the examiner to estimate cardiac function and central venous pressure to guide resuscitation in patients with cardiopulmonary instability.
- Recognize a dilated aortic root and/or descending thoracic aorta. Understand clinical relevance and potential pitfalls.

Biliary Tract

- Describe the indications and limitations of focused biliary tract ultrasound.
- Define the relevant local anatomy including the gallbladder, portal triad, inferior vena cava, and liver.
- Understand the standard ultrasound protocol when performing focused biliary ultrasound.
- Recognize the relevant focused findings and pitfalls when evaluating for cholelithiasis and cholecystitis.

Urinary Tract Ultrasound

- Describe the indications and limitations of focused urinary tract ultrasonography.
- Define the relevant local anatomy including the kidneys and collecting systems, bladder, liver, and spleen.
- Understand the standard ultrasound protocol when performing focused urinary tract ultrasound.
- Recognize the relevant focused findings and pitfalls when evaluating for hydronephrosis, renal calculi, renal masses, and bladder size.

Deep Venous Thrombosis

- Describe the indications and limitations of focused ultrasound for the detection of deep venous thrombosis.
- Understand the standard ultrasound protocol when performing a focused exam for the detection of deep venous thrombosis of the upper and lower extremities.
  Vessel identification
  Compression
  Augmentation

- Define the relevant local anatomy associated with ultrasonic detection of deep venous thrombosis in the upper and lower extremities.
  Develop an understanding of Doppler physics and instrumentation to include:
  Color Doppler
  Power Doppler imaging

- Recognize the relevant focused findings and pitfalls when evaluating for deep venous thrombosis.

Soft Tissue & Musculoskeletal

- Describe the indications and limitations of focused ultrasound of soft tissue and musculoskeletal structures.
- Define the relevant local anatomy associated with ultrasonic evaluation of soft tissue and musculoskeletal structures to include:

Skin
Soft-tissue
Bones
Muscle
Tendon
Lymph Nodes

- Recognize the relevant focused findings and pitfalls when evaluating the following:
  Soft tissue infections
  Abscess versus cellulitis
  Foreign body location and removal
  Fractures
  Tendon injury (laceration, rupture)
  Joint identification
  Upper extremity
  Lower extremity
  Subcutaneous fluid collection identification

Thoracic Ultrasound

- Describe the indications and limitations of focused ultrasound of thorax.
- Define the relevant local anatomy associated with ultrasonic evaluation of thoracic structures.
- Understand the standard ultrasound protocol when performing a focused exam for the detection of:
  Pleural effusion
  Pneumothorax

- Recognize the relevant focused findings and pitfalls when evaluating for thoracic pathology

Ocular Ultrasound

- Describe the indications and limitations of focused ultrasound of the ocular structures and orbit.
- Define the relevant local anatomy associated with ultrasonic evaluation of eye and orbit structures.
- Understand the standard ultrasound protocol when performing a focused exam for the detection of:
  Posterior chamber hemorrhage
  Retinal detachment
  Other structural disruption

- Recognize the relevant focused findings and pitfalls when evaluating for ocular pathology.

Procedural Ultrasound

- Describe the indications and limitations when using ultrasound to assist in bedside procedures.
- Understand the 2D approaches of transverse and longitudinal approaches to procedural guidance with their advantages and disadvantages.
- Define the relevant local anatomy for the particular application.
- Understand the standard protocols when using ultrasound to assist in procedures. These procedures may include:

Vascular access-central and peripheral
Pericardiocentesis
Paracentesis
Thoracentesis
Foreign body detection removal
Bladder aspiration
Arthrocentesis
Pacemaker placement and capture
Abscess identification and drainage

- Recognize the relevant focused finding when performing ultrasound for procedural assistance.

APPENDIX 3. EMERGENCY MEDICINE RESIDENCY ULTRASOUND EDUCATION GUIDELINES.

Introduction

1. It is recommended that all emergency medicine residency programs identify a full-time faculty member specifically as its Emergency Ultrasound Director/Coordinator with the institutional support and skill sets capable of implementing all aspects of the educational program as described below. In addition to the EMUS Director/Coordinator it is recommended that a minimum of fifty percent of the required number of "Core Faculty" members at all emergency medicine residency programs be designated as "Core Ultrasound Faculty" and should be credentialed by the host institution in the use of ultrasound. For example, if a program has a core faculty requirement of 12, then a minimum of 6 Core Ultrasound Faculty should be designated. This may be inclusive of the EM Ultrasound Director/Associate Director. Each program should develop, demonstrate, and retain performance measures for the Core Ultrasound Faculty. This faculty group should be available to supervise and educate its residents in emergency ultrasound and teaching the *core* applications.
2. All EM residency training programs should provide access to appropriate ultrasound equipment (systems with adequate array of transducers, imaging resolution) and these ultrasound systems should be available during a resident's clinical experience 24/7. All emergency medicine residency programs should hold textbooks covering at least emergency ultrasound and ultrasound physics in their respective libraries. In addition, residents shall be exposed to the current and historical literature concerning all emergency ultrasound applications and faculty should make every attempt to involve the residents in any current or future research projects.

Educational Program

1. All EM residents shall be provided introductory instruction in emergency ultrasound early in their EM training programs. This training should include both didactic and hands-on sessions covering critical emergency ultrasound examinations/procedures and interpretation as well as basic ultrasound physics and knobology. It is recommended that this orientation be given in the form of a 1-day course. During residency, a minimum of 2 weeks in a dedicated emergency ultrasound rotation, or an equivalent of 80 hours, should be completed. Ideally, a portion of this time would come in the first year of residency training. The residents should be offered educational sessions and hands-on workshops in addition to scanning time in the ED with active patients.
2. Recommendations for the rotation experience include:

- Didactic sessions covering basic and advanced emergency ultrasound applications.
- Scheduled reading assignments in preferred textbooks or journals.
- Access to other educational modalities including CD/DVD/Web-based educational products.
- Access to question bank on emergency ultrasound applications.
- Scheduled shifts devoted to performing ultrasound examinations and procedures. A significant portion of these shifts should be done with a qualified faculty member to provide direct instruction on scanning technique.
- Either direct or indirect review of a majority of the residents' images by qualified faculty to provide feedback on scanning technique, image acquisition and interpretation.
- Educational sessions aimed specifically at helping the resident to incorporate ultrasound into their daily clinical practice should be included.
- Components of ultrasound education should be spread over the entire course of residency training. A single block rotation with no integration into routine clinical practice is not sufficient.

3. It should be noted that competency assessment can be performed using several methods; however, most experts recognize that the performance of at least **150** ultrasound examinations in "critical" or "life-saving" scenarios promotes a minimum acceptable level of exposure. While the completion of this set number of examinations does not, in and of itself, delineate competency, residency programs should dedicate hours and rotations with the intent of meeting this level of experience to allow residents the best opportunity to achieve competency.
4. A system will be in place at all EM residency training programs where a portion of the examinations performed by EM residents will be reviewed (via still images or video capture) by faculty members to provide quality assurance AND timely feedback to the residents in training. Information regarding total ultrasound examinations completed and educational progress should be made available to residents on a regular basis.
5. It is recommended that emergency ultrasound education be incorporated into the core educational program for all EM residency programs. In addition to the introductory training, longitudinal didactic and hands-on instruction should be provided to EM residents throughout their residency training. This may include scheduled sessions during normal EM conference hours. It is felt that a minimum of 20 hours of scheduled educational sessions should be given over the course of a 3- or 4-year EM residency training program.

Competency Assessment

The goal of competency assessment in emergency ultrasound is to ensure that each individual emergency medicine resident has a basic set of skills to allow for integration of ultrasound into their daily clinical practice after residency training is completed. The following methods are recommended tools for competency assessment in emergency ultrasonography during emergency medicine training:

1. Assessment of Ultrasound Technique -A practical exam consisting of a direct assessment of the skills necessary to obtain and record appropriate ultrasound images for the appropriate studies. The practical exam should include assessment of proper machine settings, probe positioning, image acquisition and documentation. Ultrasound images obtained during the practical exam should be assessed for technical merit and not interpretative merit including but not limited to image quality, image framing, identification of landmarks, and completeness of imaging protocol. The practical exam can be performed on actual ED patients (recommended) and/or in a simulation setting. The practical exam may include various methods to assess for adequacy of skill including but not limited to:

- OSCE- Objective Structured Clinical Examination
- SDOT- Standardized Direct Observation Tool
- Videotape of person performing ultrasound examination for later review

2. Assessment of Image Interpretation -Each EM residency training program should have an educational program established providing either static image or dynamic video review (preferred method) to assess competency of residents in both performing and interpreting focused emergency ultrasound examinations. This will allow faculty members to evaluate a resident's ability to perform

these examinations during their clinical exposure. This can be a tool to evaluate ultrasound technique as well as image interpretation as examinations can be examined for completion of scanning protocols, identification of both anatomic and sonographic landmarks, and recognition of normal and pathologic findings. The medical decisionmaking process following these examinations can also be followed.

3. A standardized multiple choice question exam as a nationwide question bank that may be accessed (in a secure manner) by the Ultrasound Director/Coordinator at each emergency medicine residency program. This test will also be used as a tool to assess resident competency in clinical decisionmaking based on the interpretation of images and video.
4. ACEP suggests that the above mentioned competency assessment tools be utilized (at a minimum) at the end of each ultrasound rotation and in the last year of residency training. Different aspects of competency assessment may be performed at separate intervals to allow better integration of ultrasound education into the overall emergency medicine residency education schedule. Ultrasound skills may degrade over time and competency assessment may be repeated for an individual in situations where either a significant time period has elapsed (resident on other rotations where ultrasound is not used or encouraged), or deficiencies are identified which indicate a deterioration of skill.

APPENDIX 4. SUGGESTED OPTIMAL GUIDELINES FOR IMPLEMENTATION OF AN INTRODUCTORY EMERGENCY ULTRASOUND COURSE FOR EMERGENCY PHYSICIANS.

1. Resources: Training courses in emergency ultrasonography require a substantial resource commitment and significant advance planning. Below are the basic components necessary for emergency ultrasound courses.

a. Instructors: Instructors should have expert knowledge in the material being taught and ideally should be trained emergency physicians. Substitution with other allied specialty physicians may be appropriate depending on the lecture material being taught. Because of the focused and clinical nature of emergency ultrasonography, it is recommended that a trained emergency physician be the course director.

b. Ultrasound laboratory: Appropriate machines and transducers will be necessary. To maximize the hands-on component no more than 5 participants per machine should be allowed and at least one instructor should be present at each station to assist in training.

c. Ultrasound models: Normal models and patients should be part of the training laboratory with at least one model necessary at each training station. Appropriate patient models include those with pericardial effusions, cholelithiasis, aortic aneurysms and chronic ambulatory peritoneal dialysis (CAPD) patients (to simulate hemoperitoneum). Private areas for endovaginal ultrasound are necessary. Full informed consent should be obtained from all models and a signed waiver of responsibility is recommended.

d. Syllabus: A syllabus or standard text is recommended for all courses. The material supplied should supplement the lecture presentations and meet the goals and objectives of each lecture.

e. Site: The ideal site will have 2 separate rooms to accommodate the lecture and laboratory stations without disassembly. Audiovisual equipment will be needed and will include 35-mm slide projectors, LCD projectors, and video display capability.

2. Didactic content: The standard 2-day course will include the following topics and primary applications taught in a focused manner over an 8-hour period. With the addition of new core emergency ultrasound applications, a 3-day period would be required to cover all 11 applications in one course. In a single application course, the didactics should be taught over a 3- to 4-hour period and should include introduction, physics/knobology, and the emergency indication. The following are the goals and objectives of a core curriculum are listed in Appendix 2.
3. Hands-on training: The technical laboratory is an integral component of any ultrasound course. The comprehensive 2-day format should have a minimum of 6 to 8 hours of skills laboratory. A single application will require at least 2 to 4 hours of laboratory training. In either format, the optimal ratio should be no more than 5 students per instructor per station. An instructor should demonstrate the proper application protocol for the emergency indication. Inclusion of special skills assessments stations at the end of the course can be a valuable teaching tool.

APPENDIX 5. MEDICAL SCHOOL EMERGENCY ULTRASOUND EDUCATION.

General emergency medicine one-month clerkship:

General EM clerkships should include an introduction to emergency ultrasound that may entail a single dedicated emergency ultrasound shift with direct faculty supervision, a 1-day EUS course, or simply case-by-case incorporation of emergency ultrasound into patient care in the ED. Students should strive to become familiar with a single emergency ultrasound application such as the FAST exam, and should be exposed to additional emergency ultrasound exams over the course of the clerkship. Emergency ultrasound literature and selected textbook chapters should be made available for student review.

Dedicated emergency ultrasound rotation recommendations:

1. Emergency ultrasound rotations should include instruction in the following areas:

Physics/Instrumentation, Biliary, Renal, Aorta, FAST, Cardiac, Procedures, Pelvic (including endovaginal ultrasound), Deep Venous Thrombosis, Skin/Soft Tissue/Musculoskeletal.

2. Didactic education should be delivered in electronic, preferably online, format in an attempt to maximize hands-on education in the clinical area. Course directors may choose to utilize the emergency ultrasound didactic materials available on the ACEP Web site.
3. Assessment should include an online pre-test including still image/video interpretation and case-based applications of EUS. To assess their progress, students will complete the test again at the end of the rotation.
4. Each student should obtain approximately 100 scans over the course of a 4-week rotation, or approximately 75 scans over the course of a 2-week rotation. Dedicated shifts may include evenings or weekends to maximize exposure to pathology and interesting emergency ultrasound cases. Students should generate a personal log of EUS exams on which to build during their postgraduate education.
5. All student-performed scans should be directly supervised by emergency ultrasound credentialed faculty or recorded for subsequent quality assurance review with the rotation director.
6. Students should complete the reading of one emergency ultrasound textbook or viewing of an online curriculum over the course of the rotation. In addition, students should identify a current publication relevant to emergency ultrasound and discuss their findings with the rotation director.

APPENDIX 6. ACEP EMERGENCY ULTRASOUND QUALITY AND ACCREDITATION CRITERIA.

Each health care provider who performs emergency ultrasound must have an active state medical license in good standing, must train in accordance with ACEP ultrasound guidelines and then meet ACEP ultrasound guidelines for credentialing. They must participate in appropriate continuous quality management (CQM) standards as described below.

Each health care provider must perform and interpret minimal ultrasound examinations per credentialing cycle as designated by the ACEP Ultrasound guidelines. Health care providers who do not meet this number requirement must have their studies overread by a qualified health care provider (see US Director).

A practice should have a designated physician Ultrasound Director or coordinator who is responsible for the CQM of the program including, but not limited to, machine maintenance, education, and monitoring of staff.

As a component of CQM:

- There must be a process in place, where an appropriate number of the examinations performed in the practice are reviewed continuously.
- There must be a process in place that ensures a patient and/or a patient's consulting or follow-up physicians are made aware of any pathological or incidental findings.
- Routine correlation between ultrasound and other imaging modalities and surgical pathology should be conducted to ensure accuracy of findings.

Ongoing education must be obtained by each health care provider and the appropriate certificates filed for easy reference and retrieval. (See ACEP Section on Training and Proficiency - CME.) These educations hours may include any of the following: formal continuing medical education, other CME subjects that include ultrasound, readings, online training, departmental in-services programs, and practice performance programs.

All ultrasound equipment must meet state and federal guidelines. The machines must be kept in good condition and undergo routine calibration and servicing at least once a year. If any defect or problem is identified during utilization, the equipment must be marked out of service and taken out of the department. Routine cleaning and monitoring of the equipment must be ensured. A policy must be in place for infection control and transducer disinfection following national standards.

The practice must perform peer review to ensure all members are performing and interpreting ultrasound examinations in a quality manner. Periodic review of each physician should be performed. If deficiencies are discovered, a remediation policy must be in place.

A report must be generated for all examinations performed, including the indication for the study. The report should be part of the medical record and easily accessible.

Image retention and record keeping must be assured for the minimum number of years as set forth by the state. Document storage may be on a variety of media including thermal paper, VHS, super-VHS, hard drive, DVD, and/or PACS or similar. Document storage and reporting must follow the guidelines set forth by ACEP. Patient confidentiality and HIPAA guidelines must be respected at all times.

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