

# ACEP Policy Statement

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## *Emergency Ultrasound Guidelines*

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Approved by the ACEP Board  
of Directors June 2001

### **Section 1: Introduction**

The clinical application of ultrasonography by emergency physicians has greatly expanded over the past decade.<sup>1-5</sup> Emergency physicians have adopted ultrasound to advance the timely and accurate evaluation and treatment of the acute patient.<sup>1,6,7</sup> Ultrasound provides critical information to emergency physicians at the bedside by rapidly and non-invasively defining critical anatomic structures and function, providing guidance for difficult procedures, and identifying pathologic conditions as well as localizing sources of pain. As ultrasound utilization has grown in emergency medicine, emergency physicians in all practice settings have looked for guidance on appropriate use and adoption of this emergency modality.<sup>8</sup>

In 1994, the first emergency medicine ultrasound curriculum by Mateer et al<sup>1</sup> was published. This document remains the standard curriculum for most emergency physicians in training and practice today. It is a broadly written document that divides ultrasound into abdominal, pelvic, and cardiac applications and describes many of the uses of ultrasound in emergency practice. Since then, emergency ultrasound has grown and matured, and updated recommendations are needed.

The American College of Emergency Physicians (ACEP) has firmly supported the concept of emergency ultrasound.<sup>8</sup> ACEP has recognized the need for emergency ultrasound imaging on a 24-hour basis and that emergency physicians should perform such examinations. ACEP has recommended that training and credentialing guidelines be created for such examinations, and advocated research into the uses of emergency ultrasound. ACEP also has suggested that performance and interpretation of ultrasound imaging studies be included in emergency medicine curricula for residency training. Since then, more than 70% of emergency medicine residencies have added or now have formal education in ultrasound in their curriculum. Most recently, the American Board of Emergency Medicine (ABEM) has generated a Scope of Training Task Force to gain consensus for the requirement of emergency ultrasound for emergency medicine residency programs.<sup>9</sup>

In 1999, the American Medical Association (AMA) House of Delegates approved a resolution recommending hospital credentials' committees follow specialty specific guidelines for hospital credentialing decisions

involving the use of diagnostic ultrasound.<sup>10</sup> This resolution then requires specialties that use ultrasound in clinical evaluation to specify their unique guidelines.

To that end, the authors describe the scope of practice of emergency ultrasound as currently used in the United States, training and proficiency recommendations for emergency medicine, specialty specific credentialing guidelines, quality improvement and documentation issues, and future applications of emergency ultrasound in this document.

## **Section 2: Scope of Practice**

The emergency ultrasound examination performed by emergency physicians is distinctly different from the evaluations of other specialties.<sup>6,7</sup> It is usually performed at the bedside simultaneously with the clinical examination, resuscitation or procedure. It has been typically described as an extension of the palpating hand and a “visual” stethoscope during the physical examination, providing both anatomic and functional information complementary to the routine physical examination.<sup>6,11,12</sup> The bedside examination that can be performed by the emergency physician usually attempts to answer a single focused clinical question within minutes. This is analogous to the use of ECG, point-of-care laboratory assays, naso-laryngoscope, and the slit lamp examination in the hands of emergency physicians, which have expanded and enhanced the emergency evaluation.

Primary applications in emergency ultrasound are uses that have been defined in the medical literature and are used by emergency physicians. Procedural applications include applications of ultrasound that have been used by emergency physicians or other specialists to noninvasively aid the successful completion of the procedure. Future and novel uses will be described in Section 6.

### **Primary Applications for Emergency Ultrasound**

**Trauma ultrasound.** The use of ultrasound for traumatic torso injury started in Europe and spread

to North America in the 1990s.<sup>13</sup> Trauma ultrasound has mostly eliminated the initial use of diagnostic peritoneal lavage at many trauma centers in the United States. Physicians from many specialties have successfully used ultrasound for trauma with high sensitivity and specificity.<sup>14-18</sup>

Indications for trauma ultrasound include blunt or penetrating trauma to the torso where there is suspicion of intraperitoneal hemorrhage, pericardial tamponade, and hemothorax.<sup>19</sup> The minimum 4-view trauma ultrasound should include the right flank to visualize the hepatorenal space, left flank to include the perisplenic anatomy, subcostal to visualize the pericardium, and pelvis to visualize retrovesical or retrouterine fluid views. The flank views also visualize the spaces above and below the diaphragm.<sup>20</sup> Other views include the bilateral paracolic gutters, the apical and parasternal views of the heart (described later), and Trendelenburg positioning with the flank views.<sup>21-23</sup> These views assume the trauma patient is in supine position in spinal protocol with multiple other procedures required or taking place simultaneously. Limitations of trauma ultrasound include the inability to identify injury to specific viscera (contained lacerations/contusions of the spleen/liver), bowel, or retroperitoneal structures and hemorrhage.<sup>24</sup> Additionally pathologic air or patient anatomy may make the examination technically difficult, and require alternative imaging modalities.

**Emergency ultrasound in pregnancy.** The incidence of ectopic pregnancy has been rising in this country over the past several decades.<sup>25</sup> Most current algorithms for the evaluation of the ectopic pregnancy include the use of pelvic ultrasound with quantitative human chorionic gonadotropin (hCG) as needed.<sup>26</sup> With the need to incorporate ultrasound into the standard evaluation of the symptomatic first-trimester patient with bleeding or pain, pelvic ultrasound for intrauterine pregnancy has become a natural application in emergency ultrasound.<sup>27-30</sup>

Indications for first-trimester pelvic ultrasounds include establishment of the location of the pregnancy and fetal heart rate in the symptomatic

first-trimester pregnant patient with pain, bleeding, near syncope, or shock or the asymptomatic pregnant patient with risk factors for ectopic pregnancy.<sup>28-31</sup> The pelvic ultrasound is typically performed after a pelvic exam by transabdominal ultrasound or endovaginal ultrasound. An additional right upper quadrant view can be used to detect large amounts of intraperitoneal fluid suggestive of ruptured ectopic pregnancy.<sup>32</sup> The real-time examination typically views all segments of the uterus and contents for a gestational sac with an appropriate decidual mantle and a yolk sac or an appropriately large fetal pole to confirm intrauterine pregnancy. The cul-de-sac and adnexa should be visualized for masses or fluid collections. Limitations include the non-visualization of the early gestation in the first 4 to 5 weeks of pregnancy, lack of visualization of ectopic pregnancies, and sonographic intrauterine abnormalities such as fibroids or intrauterine devices that may alter the acoustic characteristics of the pelvis.

Second- and third-trimester ultrasound by emergency physicians is focused on the detection of fetal cardiac movement and the evaluation of the pregnant trauma patient.<sup>33</sup> The same transabdominal techniques used in first trimester ultrasound for detection of fetal heart rate are applicable. Limitations include nonvisualization of the fetus by anatomic abnormalities or lack of heartbeat in a fetal demise. The technique for trauma ultrasound evaluation of the pregnant patient is not altered from standard techniques.

**Emergency echocardiography.** The evaluation of cardiac arrest and shock mandates assessment for the presence of cardiac activity and pericardial effusion.<sup>34-36</sup> Pulseless electric activity may actually be a low myocardial flow state, amenable to therapy.<sup>37</sup> Signs and symptoms for significant pericardial effusion, or tamponade, such as Beck's triad are often nonspecific or lacking in critical patients. There is no alternative test to emergency echocardiography for either cardiac mechanical activity or pericardial effusion. In penetrating chest trauma, the use of emergency echocardiography can improve morbidity and mortality.<sup>38</sup>

Indications for emergency echocardiography include suspicion of pericardial effusion or the detection of cardiac activity, usually in the hemodynamically unstable or symptomatic patient. Usually performed by the transthoracic method, common views include the subcostal, apical 4 chamber, and parasternal long and short views.<sup>39</sup> The 4 chambers and surrounding pericardium of the heart are visualized for global function and abnormal fluid collections. Two-dimensional echocardiographic signs of tamponade physiology in the presence of pericardial effusion include right atrial collapse, right ventricular diastolic collapse, and non-collapsible inferior vena cava and hepatic veins. Pacing leads and mechanical pacing capture can be visualized with the same techniques.<sup>40-42</sup> Abnormal findings should be confirmed by several views. Limitations of the technique include the inability to visualize because of patient body habitus, pathologic air collections around the chest, and cardiac and mediastinal structures imaged best by transesophageal methods.

**Abdominal aortic aneurysm.** As the older segment of our population has increased in demographic proportion, the incidence of abdominal aortic aneurysm (AAA) may increase as well.<sup>43</sup> For the unstable patient, the presence of an aneurysm on ultrasound will confirm the decision to proceed to laparotomy.<sup>44-46</sup> The detection of an aneurysm in the hemodynamically stable patient can allow appropriate monitoring, consultation, and, if appropriate, follow-up. Early detection of such an aneurysm can reduce the potential mortality rate associated with rupture and emergency operation. Indications for ultrasound of the abdominal aorta to detect AAA included the presence of syncope, shock, hypotension, abdominal pain, abdominal mass, flank pain, or back pain especially in the older population. The abdominal aorta is visualized real-time in 2 planes (transverse and sagittal) continuously from diaphragm to bifurcation.<sup>47</sup> The inferior vena cava (IVC) and spine should be noted to support correct identification of the aorta, and the size of the aorta should be measured in both planes. Detection of AAA may spur operative management or further imaging.<sup>48,49</sup> The presence of bowel gas or large

body habitus can make the ultrasound examination technically difficult. Limitations include the inability to reliably demonstrate dissection or rupture into the retroperitoneum.

**Biliary ultrasound.** Cholecystitis and cholelithiasis, common differential diagnoses for pain in the epigastrium, are best imaged with ultrasound. Time in the department for such patients can be saved with emergency ultrasound of the gallbladder.<sup>50</sup> Indications for biliary ultrasound include the suspicion of a biliary etiology for epigastric, abdominal, flank or right shoulder pain. The gallbladder is visualized to detect echogenic material that may produce shadowing, gallbladder wall diameter, and presence of fluid around the gallbladder. The abnormal size of the common bile duct and the presence of a sonographic Murphy's sign should also be noted.<sup>51</sup> This procedure may be performed separately or as a view of the upper abdomen in combination with other indications noted. Limitations include contracted gallbladder, non-visualization due to bowel gas, difficulty imaging common bile duct stones, and other pathology in the local right upper quadrant anatomy (liver, lung, or ribs).

**Renal ultrasound.** The symptoms of renal tract obstruction can require long or costly imaging procedures.<sup>52,53</sup> Ultrasound images the kidneys well and may judge the degree of obstruction.<sup>54</sup> Use of renal tract ultrasound can be a sensitive bedside test for hydronephrosis.<sup>55</sup> Indications for the ultrasound of the renal tract include the detection of hydronephrosis manifested by costovertebral pain, flank pain, or abdominal pain with vomiting. Both kidneys should be visualized from upper to lower pole in coronal/long and transverse planes for detection of hydronephrosis and echogenicity suggestive of stones with or without shadowing. Both kidneys can be imaged to exclude urethral obstruction. Limitations include inability to detect the cause of the obstruction or degree of renal function. Dehydration or early imaging may result in false-negative examinations, and the sensitivity of the examination is improved with hydration and serial imaging.<sup>54</sup>

**Procedural ultrasound.** Ultrasound can be a helpful adjunct to the performance of a wide variety of procedures. Ultrasound can assist the emergency physician when there are issues of localization of abnormalities, localization of normal structures, absence of body landmarks attributable to habitus, condition, or ongoing care. Sonographic guidance can improve the speed and accuracy of performance of procedures in addition to reducing associated complications. Ultrasound may localize the percutaneous insertion/incision site before the procedure, or may provide real-time guidance of the procedure with needle, catheter, or other device. The common emergency ultrasound procedures are described in Table 1.<sup>41-42, 56-62</sup>

There are a multitude of other indications for procedural emergency ultrasound that are currently performed or being investigated.<sup>62-65</sup> While not precluding those, the previously mentioned procedures were felt to have clinical application by emergency physicians and agreement by experts in the field of emergency ultrasound. Educational and proficiency issues related to these and other ultrasound applications are discussed later.

### **Section 3: Training and Proficiency**

Ultrasound is a unique diagnostic modality for the emergency physician because it requires proficiency in both a cognitive (indication and interpretation) and psychomotor (hands-on) skill. Training in both image acquisition and image interpretation must be provided through curriculums that include didactic lectures, demonstrations, and technical skill laboratories.<sup>1</sup> Both the cognitive and psychomotor skill components have minimum content requirements that are necessary for meeting the educational objective for training in emergency ultrasound. This section presumes understanding, recognition, and management of emergency medical conditions consistent with residency training in emergency medicine.<sup>66,67</sup> Pathways for residency-based and practiced-based training will be described later and summarized in the Figure.

## Initial Training

The most practical method of instruction is with special ultrasound courses focusing on the primary emergency applications. Many successful formats have been used and their length will vary depending on the number of primary applications being taught.<sup>68</sup> A 2-day comprehensive course format covering all primary applications over 16 hours has been used extensively and provides a foundation for emergency ultrasonography.<sup>69</sup> For those learning one (eg, trauma) or a limited number of applications, a single-day course format including introduction, physics, knobology (the operation of ultrasound controls to improve the image) and the application protocol is an effective method.<sup>70,71</sup>

Numerous educational methods can be used to present the cognitive component including lectures, syllabi, textbooks, video, Web-based, and computer-assisted learning. The Appendix lists the essential curriculum for an introductory ultrasound course. The psychomotor component requires proctored hands-on experience within a laboratory setting. These sessions involve scanning of live models, which may include those with known pathology.<sup>72</sup> Objective structured clinical examinations and computer simulations of sonography can be useful additions in teaching and assessing the psychomotor component.<sup>73</sup> Table 2 lists the suggested optimal guidelines for the implementation of an introductory course in emergency ultrasound for emergency physicians.

## Pathways for Completion of Training

A residency-based pathway should be the primary mode for emergency medicine residents to attain competency in emergency ultrasonography during their 36- to 48-month ACGME-approved program.<sup>69,74,75</sup> Program directors, responsible for training in emergency ultrasound, will have the flexibility to present the previously mentioned content over the duration of the residency period. Optimally, committed faculty given the responsibilities of emergency ultrasound coordinator or director should organize the training of emergency medicine residents. Emergency medicine faculty should have

experience or obtain emergency ultrasound experience through the following guidelines in order to supervise emergency medicine residents. An ultrasound machine should be available for emergency medicine residents and faculty to use during emergency medicine rotations. Rotations in other specialties that use ultrasound may be useful if cooperative, hands-on experience is allowed. The experiential component of ultrasound training following didactics should follow the guidelines.

A practice-based pathway for physicians who have completed their residency training without emergency ultrasound training should include initial training in either a 16-hour (or longer) course covering the previously mentioned topics in the primary applications or a series of 1-day, single-application format courses. Subsequent to the introductory course(s), practice-based physicians should return to perform emergency ultrasound in a case-control manner, which then requires confirmatory testing for each patient with emergency ultrasound.<sup>1,76,77</sup> This experience, as with residency training, requires the presence of an appropriate ultrasound machine. Each department or individual should develop a plan during this experiential training phase of having each emergency ultrasound reviewed by trained peers or by quality assurance review process.

The experiential component for both pathways integrates psychomotor and the cognitive components of emergency ultrasound, and significantly improves with practice and overlap in the learning curves of the different primary applications. Thus, experience in one abdominal application leads to better technique and interpretation of other similar applications. After didactic content, emergency physicians should obtain experience using the ultrasound before presenting cases for formal recognition. This period can be viewed as a training, proctoring, or provisional privileging period. Ultrasounds performed during this period should be reviewed for technique, image acquisition, and outcome (see Sections 4 and 5). If without an emergency medicine colleague at one's specific institution with ultrasound training or credentials, requests of peers at related institutions with emergency ultrasound or assistance from related imaging

professionals within one's institution may be pursued. Whether by experience, proctoring, or quality review, the emergency physician should be able to incorporate emergency ultrasound into emergency care with gradually improving skills during this training period.

At the end of this period, we recommend that at least 25 documented and reviewed cases be obtained in each of the following primary applications. Because of the difficulty in assigning numerical goals to individuals of different abilities and practice settings, we have included numerical ranges of ultrasound examinations that generally allow attainment of proficiency in Table 3.

Procedural applications are a unique area of emergency ultrasonography in that in most instances, the physician is already trained and credentialed in that technique. Thus, no further minimum number of ultrasound guided procedures is recommended but rather the physician should be competent in the basic use of ultrasound demonstrated by completed training in at least another single application.

### **Continuing Medical Education and Proficiency**

As part of continual training and in concert with our organizations' and ABEM's efforts to promote continual education, emergency physicians who perform ultrasound examinations should continue to obtain continuing medical education (CME) in ultrasound after the initial training phase.<sup>78</sup> Not only is ultrasound a learned specialty, but it also requires maintenance of skills and familiarity with technology. The amount of CME and the frequency will depend on the number of applications used and developments in emergency ultrasound. This education can be inclusive of journal club, conference lectures, morbidity and mortality conferences, hands-on training courses, or other CME-established formats.

After the initial phase of training, continuous use of the ultrasound technology is advised to maintain skills. The frequency of experience with emergency ultrasound should continue at a steady if not increasing rate in the years after the initial

training. This frequency would maintain comfort with imaging skills and yet account for individual practice settings, which may vary.

### **Section 4: Credentialing**

Implementing a quality and verifiable credentialing system should be an integral component of an emergency ultrasound program.<sup>76,79</sup> An emergency ultrasound coordinator or director and the chair of the department of emergency medicine for each institution or health care organization should primarily oversee policies and guidelines regarding emergency ultrasound. While credentialing occurs at the local hospital level, requirements should be specialty and application specific.

The ultrasound credentialing system should perform at a minimum the following 3 criteria: identify eligible providers, specify training or experience requirements, and specify the emergency ultrasound privileges.<sup>76</sup> Optional but desirable criteria for the credentialing process include outlining a training curriculum, specify documentation requirements for the emergency ultrasound, define levels of credentialing (if desired), and define the ED emergency ultrasound continuous quality improvement process.

Eligible providers to be considered credentialed by the department of emergency medicine to perform emergency ultrasounds include emergency (staff) physicians or faculty and eligible providers who complete the credentialing guidelines as specified by this document.

### **Training Experience**

The recommended training experience suggested for emergency credentialing are listed in Table 3, consistent with ranges of proficiency varying between 25 to 50 documented and reviewed ultrasound examinations per primary application. Emergency physicians desiring general emergency ultrasound privileges (application not specific) should perform a minimum of 150 examinations.

There are several qualifiers to the aforementioned recommendations. First, proficiency may not always be defined by numerical goals, and certain physicians may gain competency at lower or higher thresholds. Secondly, these examinations should be performed during patient encounters in the department of emergency medicine, approved training experiences with other imaging specialties, or other CME training in ultrasound. Thirdly, all cases should not be normal and some pathologic findings should be present in a portion of cases submitted. (eg, hemoperitoneum for trauma ultrasounds, gallstones for biliary ultrasound, aortic aneurysm in AAA scanning). More sophisticated sonographic techniques may require different credentialing requirements or modes of confirmation beyond the primary emergency indications.

### Confirmation of Results

All studies to be used for the credentialing process will have to fulfill the following criteria: performed by the provider listed, contain an interpretable image, and contain quality assessment information on an appropriate ultrasound data collection form. After obtaining the ultrasound examination, each ultrasound study should be reviewed by the ED ultrasound coordinator or other qualified personnel. Several methods of confirming outcome and competence exist including direct supervision of the emergency ultrasound, overread of static or video images, confirmatory testing via other imaging procedures (ultrasound, computed tomography [CT], magnetic resonance imaging [MRI], or surgical procedure), or confirmation of patient clinical outcome. After review, a copy of the review should be returned to the physician. On completion of credentialing guidelines, the physicians will receive documentation of completion of the ultrasound credentialing guidelines and undergo local hospital privileging approval.

Credentialing levels should be considered an optional system for departments of emergency medicine to bridge the gap from novice to expert emergency ultrasonographer. One such system is described in Table 4. Advantages to such a system

are that there is a preexisting “ladder” and definition of the capabilities of each emergency physician using ultrasound. The disadvantage is that there may be a period of “unevenness” when different levels of providers are present in the department. Eventually, however, emergency physicians should seek the highest competency offered by their department.

Recommendations for hospital departmental requirements for emergency ultrasound credentials should include: satisfactory completion of introductory course, satisfactory completion of training ultrasound examinations, and participation in department lectures and case review (as applicable).<sup>76,80</sup> For those individuals who apply to join the ED staff after the initial credentialing requirements are set forth, ultrasound privileges may be provided if prior suitable training equal to or in excess of the previously mentioned training guidelines is documented.

### **Section 5: Issues Relating to Documentation and Quality Improvement in Emergency Ultrasound**

The emergency ultrasound has different roles in different clinical settings, thereby complicating record keeping. It may be a diagnostic device (similar to a stethoscope or slit lamp), diagnostic test (similar to an ECG), and a pictorial record (over time) of the patient’s progress.<sup>6</sup> To communicate with other physicians and services, all ultrasound examinations performed in the ED that are used to facilitate patient-care decisions should have the results documented on the ED chart. These examinations are to be documented as “emergency ultrasound.” Examination documentation should only include information specific to the intended goal of the examination. The ED chart and any ultrasound data collection sheet should document the course of action to be taken regarding the emergency ultrasound examination findings.

Beyond the need for a written note, formal reports of the emergency ultrasound may be required for other purposes including quality assurance, regulatory, and billing purposes. These could take one of several forms including: immediate

transcription or computer-generated formal reports; a brief written note at the conclusion of the emergency ultrasound examination, pending a formal transcribed report; and if formal printed reports are not available, a more detailed hand-written note describing the significant positive and negative findings.

Standards relating to documentation often refer to the Joint Commission on Accreditation of Healthcare Organizations' (JCAHO) and Medicare guidelines. JCAHO's handbook for hospital accreditation includes information sections, that suggest the need to include documentation that "support the diagnosis, justify the treatment, promote continuity of care among health care providers, and provide instructions for follow-up care."<sup>80</sup> The Medicare guidelines for procedural documentation include: indicating medical necessity, producing a written interpretation and report for each test performed, recording the procedural report in the medical record, and providing documentation of the procedure, results, and report on hard-copy that is available for review.<sup>81,82</sup> These national statements suggest that hand-written notes of the emergency ultrasound procedure may need to be supplemented by a written, transcribed, or computer-generated report.

Although emergency ultrasound is generally a limited focused examination, it is recognized that incidental findings will occur (eg, gallstones seen on a FAST examination). Such findings should be noted in the medical record, and the patient informed of them verbally, and, if applicable, on the discharge instruction sheet.

On discharge, patients should be given instructions indicating that emergency ultrasound is a focused examination. In addition to routine follow-up instructions we recommend a synopsis of the emergency ultrasound findings to facilitate the patient's continuing care, as well as any additional advice mandated by the emergency ultrasound.

### Quality Review and Quality Improvement

Quality review of emergency ultrasound examinations should function for 2 purposes. First, it is a tool for education and feedback for physicians in training (see

Section 3) who are in the process of completing a stipulated minimum number of supervised scans for basic proficiency. Quality review is needed for 100% of such examinations during the post- didactic training period. Secondly, it is a tool to monitor ongoing performance in physicians who have completed their training in emergency ultrasound. In this situation, it may be adequate to review a certain percentage of scans.

There are a number of performance criteria amenable to quality review including static image review, videotape, digital image review, imaging or procedural "gold standards," and clinical outcomes. Although one or many of these may be used to assess the quality of scans, caution must be taken in accounting for the limits and timing of the performed ultrasound. Both the technical aspects of the image and the outcome can be assessed.

### Equipment Quality Assurance and Management

Ultrasound machines require periodic maintenance and cleaning after each patient encounter. Although beyond the scope of this document, standards (manufacturer, local and national) for mechanical and electrical output, calibration of measurement, and infection control should be followed. Suggestions for such processes include: assigning responsibility of quality assurance to a designated faculty member, daily log of function and cleansing, and clinical engineering assistance on biomedical machine issues. All transducers, but especially intracavitary transducers, must be cleansed per appropriate hospital infection control methods to pathogens carried by blood and bodily secretions.

### Section 6: Future Directions

The future of emergency ultrasound will be shaped by research and clinical adoption of new applications by emergency physicians. A number of research lines are currently being studied in emergency ultrasonography including studies of improved patient outcome, ultrasound cost-effectiveness, and learning curves. Future research into the clinical applications of emergency ultrasound including resuscitation, trauma, shock,

vascular, procedural, and acute pain states is strongly supported by ACEP.<sup>8</sup>

Although the initial studies that appeared in the literature were often retrospective reviews, a concerted effort is ongoing to perform prospective, randomized studies and multicenter trials. The Sonography Outcomes Assessment Program is such an interdisciplinary, multicenter research program investigating outcomes with emergency ultrasound.<sup>83</sup>

Important aspects of research into emergency ultrasound include use of standard and accepted ultrasound terms as well as imaging planes that will help others understand the authors' research better. Delineation of the equipment capability including advanced capabilities will indicate the level of resolution available to the researchers. Investigators should have a basic level of training to perform ultrasound examinations effectively and efficiently. Important in the evaluation of ultrasound research is the concept of time of procedure, as ultrasound is a "snapshot" in time and may offer a continual picture of evolving pathology if used sequentially.

Limitations are similar to those faced by emergency physicians in acute care research efforts. They include funding, protected time, informed consent, and patient safety. Although there may be additional limitations by institutional or specialty concerns, collaborative research efforts across departments and specialties may enhance research efforts and ultimately improve patient care.

### **Integration of Sonographic Research Into Clinical Practice**

One of the most exciting aspects of emergency ultrasonography is its continued growth and adaptation of new applications. New applications will need to meet several criteria before gaining broad acceptance by emergency ultrasonographers including: being applicable to the emergency setting, utility in local situation, ability of the emergency physician to gain proficiency in the potential application, ability of the application to be performed in a timely manner, support by local

demographics and ultimately whether it improves patient care and outcome. Table 5 lists current examples of new emergency ultrasound applications that show considerable promise for the future use by skilled emergency physicians in ultrasound.<sup>62,65,84-90</sup>

### **Out-of-Hospital Use of Ultrasound**

This topic is currently being investigated in air and ground out-of-hospital medical systems.<sup>91</sup> Out-of-hospital use will clearly need to show improved outcome before widespread training of out-of-hospital personnel. At this time, out-of-hospital use by non-physicians should be interpreted by a telemedicine connection to ED.

Potential locations for out-of-hospital use by emergency physicians include patient evaluation in remote land, water and aerospace situations. Examples of civilian situations include isolated clinics in mountainous areas, remote islands, polar regions, and cruise ships. The military and NASA, sources of funding for portable ultrasound technology, have multiple settings for ultrasound use including the battlefield, military surface ships, submarines, aeromedical evacuation, and spacecraft.<sup>92-94</sup>

### **Medical Student Education**

Integrating medical students into the advantages of clinical applications of ultrasound is a progressive method of integrating basic science and clinical technology. Medical student ultrasound education can occur at emergency medicine rotations at facilities that use ultrasound on a regular basis. All programs that are able to offer away rotations in emergency ultrasonography to medical students should consider eligibility for their rotations.

### **Telemedicine**

The reality of ultrasound use requires the performing physician to know about anatomy, pathology, and image acquisition, so that the physician can usually make the diagnosis before sending the image remotely. However, difficult pathology or remote locations may allow for

telemedicine applications between physicians or hospitals.<sup>95</sup>

### **New Ultrasound Technologies in Emergency Ultrasound**

Currently, ultrasound machines are getting smaller, more portable, and sophisticated at the entry level of emergency ultrasound.<sup>96-98</sup> Integral to the advancement of emergency ultrasound is the migration of many technologies to machines aimed at the emergency ultrasound role. Newer ultrasound applications and technologies, such as tissue harmonic imaging, color and power Doppler modes, 3-dimensional ultrasound, and contrast agents, currently used in other settings, are spreading into the emergency ultrasound setting.

### **Emergency Ultrasound, the Ultrasound Community, and the Public**

Emergency physicians' relationships with other imaging professionals and organizations will evolve to include mutual interests and cooperative ventures in basic ultrasound research, clinical applications, and new technology.<sup>99,100</sup> As the growing needs of the American public for immediate medical care challenges all medical professionals, emergency ultrasound will become an indispensable tool in the effort for optimal emergency care.

### **Section 7: Conclusions and Limitations**

Specialty-specific guidelines for the application of ultrasound by emergency physicians have been described. Physicians and programs that lead the specialty in ultrasound may greatly surpass many of these recommendations. Other local situations will suggest modifications of these guidelines based on staffing, education, equipment, and facilities. During the next 5 to 10 years, new research and knowledge will give impetus to revised guidelines for emergency ultrasound. Emergency physicians, regardless of practice location or type, should be encouraged to adopt this extraordinarily useful modality in this leading decade of the 21<sup>st</sup> century.

ACEP endorses the following recommendations from this paper on the application of emergency ultrasound:

1. Emergency ultrasound performed by emergency physicians is an accepted modality within emergency medicine.
2. The scope of practice for emergency ultrasound includes, but is not limited to, the primary applications of first trimester pelvic and pregnancy related, trauma, emergency echocardiography, AAA, biliary, renal, and procedural ultrasound.
3. Training and proficiency requirements should include the didactic and experiential components for each emergency physician, whether in residency training or practice.
4. Credentialing standards used by EDs and health care organizations should follow specialty specific standards.
5. Emergency physicians should obtain at a minimum 25 ultrasounds per primary indication or 150 ultrasounds for general emergency ultrasound privileges before credentialing or independent use.
6. Emergency ultrasound documentation should include written notes and reports in compliance with local departmental policy.
7. Quality assurance and review includes hard copy appraisal regarding imaging quality and patient outcome.
8. Future applications of emergency ultrasound can be expected to provide patients and emergency physicians more effective emergency care into the 21<sup>st</sup> century.

**Table 1. Common procedural uses of emergency ultrasound.**

<b>Procedural Application</b>	<b>Strengths and Uses</b>	<b>Limitations</b>
Intravenous lines	Body habitus, anticoagulation, lack of anatomic or palpable landmarks	Vessels may be difficult to visualize without Doppler technology
Bladder size and aspiration	Avoid dry “taps” Avoid urethral catheterization	
Abscess location and aspiration	Soft tissue infection without clear fluctuance	Other sonolucent structures
Thoracentesis and paracentesis	Localization of fluid and avoidance of viscera in the candidate without clear findings	
Foreign body localization, including pacemaker visualization, intrauterine device location, soft-tissue foreign bodies	Excellent visualization in fluid and uniform surrounding tissue	Small foreign bodies in extremities may be difficult to identify Sterile technique should be used when appropriate

**Table 2. 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. The 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. Registered sonographers can be used to assist teaching during the laboratory session. 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. 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 goals and objectives of a core curriculum are listed in the Appendix.
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.

**Table 3. ACEP recommended training and proficiency numerical goals per emergency ultrasound application.**

Primary Application	Minimum	Range of Documented and Outcome Reviewed Ultrasound Needed for Proficiency
Trauma	25	25-50
IUP	25	25-50 25 Endovaginal (if only doing EV) 25 Transabdominal (if only doing TA)
Emergency cardiac	25	25-50
AAA	25	25
Biliary	25	25-50
Renal	25	25

**Table 4. Examples of levels of proficiency (if desired).**

Level I This level is for the practitioner who has completed the introductory training.

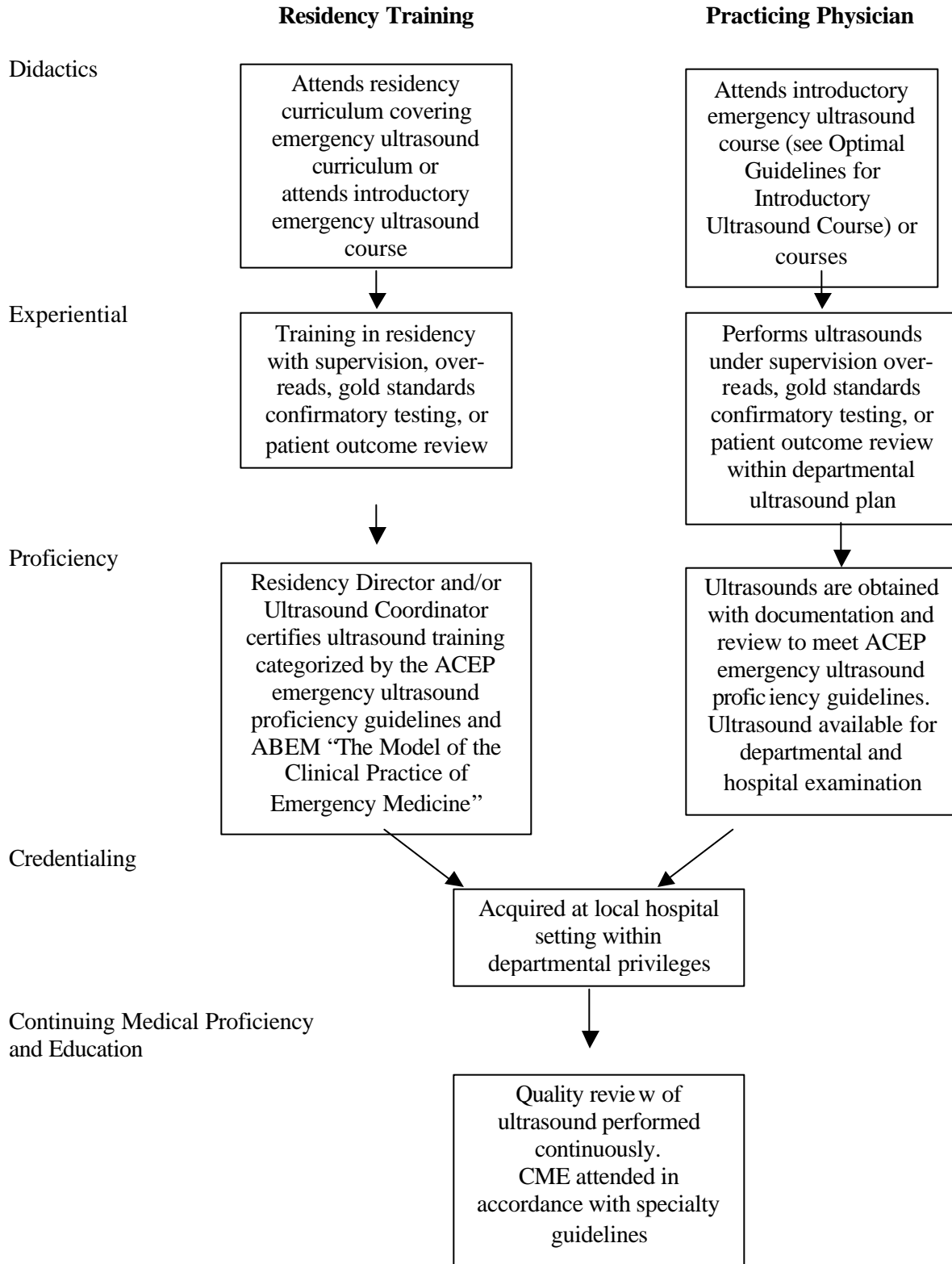
Level II This level is for the practitioner who is in the process of completing credentialing examinations. Credentialing examinations must be recorded and contain follow-up documentation. Each examination is to be reviewed by the ED ultrasound coordinator. Straightforward examinations may be used in some clinical situations if reviewed by a Level III sonographer. In general, these examinations will not be used to make patient care decisions unless reviewed by a Level III sonographer.

Level III This level is for the practitioner who is approved to use emergency ultrasound in the ED for patient-care decisions. This physician may supervise Level I and II examiners.

**Table 5. Future potential applications of emergency ultrasound.**

Application	Rationale
Musculoskeletal	Musculoskeletal injuries Arthrocentesis Fracture detection Fracture reduction guidance
Deep venous thrombosis	Detection of deep venous thrombosis
Airway	Intubation detection in the apneic patient
Head and neck	Peritonsillar abscess detection and drainage
Testicular ultrasound	Rule out torsion
Cardiac (transthoracic)	Use for left ventricular function and hypotension
Orbital ultrasound	Orbital hematoma and retinal detachment
Transesophageal	Cardiac function and aortic disease
Obstetric second- and third-trimester bleeding	Placenta previa

**Figure. Pathways for emergency ultrasound training.**



## Appendix. 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).
- Define terms training, proficiency, credentialing as it applies to limited, goal-directed ultrasound.

### Physics/Knobology

- 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
    - 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, and hemothorax.
- Recognize the relevant focused findings and pitfalls related to the detection of hemoperitoneum, hemopericardium, and hemothorax.

### 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 right upper quadrant ultrasound.
- Recognize the relevant focused findings and pitfalls when evaluating for cholelithiasis and cholecystitis.

### First-Trimester Pregnancy

- Describe the indications and limitations of focused sonography in first-trimester pregnancy pain and bleeding.
- Understand the role of ultrasound in a clinical algorithm for first-trimester pregnancy pain and bleeding.
- Primary focus on intrauterine pregnancy identification and free intraperitoneal fluid.
- Role of quantitative  $\beta$ -hCG.
- Describe the relevant local anatomy including the uterus, cervix, adnexa, bladder and cul-de-sac.
- Understand the standard ultrasound protocol including transabdominal and endovaginal views when performing focused pelvic ultrasound in early pregnancy.
- Recognize the relevant focused findings and pitfalls when evaluating for early intrauterine pregnancy and ectopic pregnancy.
- Early embryonic structures.
- Pseudogestational sac.
- Adnexal masses.

### Abdominal Aortic Aneurysm

- Describe indications and limitations 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.

### Renal Ultrasound

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

### Procedural Ultrasound

- Describe the indications and limitations when using ultrasound to assist in bedside procedures.
- 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
- Recognize the relevant focused finding when performing ultrasound for procedural assistance.

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