Review Article

An overview of emergency ultrasound in the United States

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BACKGROUND: As emergency ultrasound use explodes around the world, it is important to realize the path its development has taken and learn from trials and tribulations of early practitioners in the field.

METHODS: Approaches to education, scanning, documentation, and organization are also described.

RESULTS: Machines have reduced in price and once purchased further material costs are low. Staffing costs in terms of training, etc have yet to be assessed, but indications from elsewhere are that these are low. Length of stay in the emergency department dramatically decreases, thus increasing patient satisfaction while maintaining an even higher standard of care.

CONCLUSION: Emergency screening ultrasound is now a nationally accepted tool for the rapid assessment of the emergency patient.

KEY WORDS: Emergency ultrasound; United States

World J Emerg Med 2012;3(2):85-90

DOI: 10.5847/wjem.j.issn.1920-8642.2012.02.001

INTRODUCTION

Ultrasound has long been recognized as a powerful tool for use in the diagnosis and evaluation of many clinical entities. Before the development of real-time ultrasound, the complexity of acquiring images prevented the practical application of ultrasound for most injured or emergency patients and was an absolute barrier to use at the bedside. Significant time and effort was devoted to improving ultrasound devices throughout the 1980s and 1990s. This resulted in the units being smaller, faster, and more portable. Other technological advancements included the trans-vaginal transducer, multi-frequency probes, and color Doppler. These improvements accelerated the movement of technology from the domain of a specific specialty to the bedside, where clinicians could use it for the immediate evaluation of their patients.

From the late 1980s through the mid 1990s, significant investigations were conducted in Japan and

other Asian countries, the United States, and Germany to evaluate the utility of ultrasound in trauma patients, specifically for the detection of hemoperitoneum and hemopericardium. This research culminated in the description of the Focused Assessment with Sonography for Trauma, or the FAST examination.^[1-8] In most trauma centers, the FAST examination has replaced diagnostic peritoneal lavage as the preferred method of initial evaluation and been fully integrated into Advanced Trauma Life Support (ATLS). Consequently, the FAST examination is the initial ultrasound examination for trauma victims performed by trauma surgeons and emergency physicians and is the prototype of emergency ultrasonography.

Ultrasound is no longer limited to radiology but is being utilized by at least 8 different specialties. One specialty which has contributed new research regarding ultrasound's multiple clinical applications is emergency medicine. The attraction of immediate

bedside sonographic examinations in the evaluation of specific emergent complaints makes it an ideal tool for the emergency specialist.

The social and economic pressures to triage, diagnose and rapidly treat patients have fueled ultrasound's use as a primary screening tool in the emergency department. Most institutions now utilizing emergency screening ultrasounds report faster turn around times and more expedient diagnosis of potential life-threatening emergencies such as internal hemorrhage following blunt trauma, abdominal emergencies, ectopic pregnancy, pericardial tamponade, and aortic aneurysms. With the use of emergency physician-performed pelvic ultrasound, the length of stay was decreased in the emergency department by a median of 120 minutes.^[9] In response to this demand, most emergency medicine residencies now train their residents in emergency screening ultrasound as part of their standard curriculum. The individual endorsement statements from both the American College of Emergency Physicians and the Society for Academic Emergency Medicine continue to support these advancements.^[10,11]

Incorporation of ultrasound into the emergency department has often been fraught with misunderstanding. Emergency ultrasound is a highly focused, limited, goal directed exam with the expressed purpose of answering a select set of questions. Ultrasound in emergency medicine in the United States acts as a clinical decision support tool and does not replace formal imaging. Only in rare instances will these initial screens not be followed by a formal complete radiographic study in the next 1-2 days. There are other uses of ultrasound including foreign body localization, musculo-skeletal imaging, and assistance in performing procedures. However, in all situations emergency ultrasound remains a specific, goal directed, focused examination employed to answer a single question, rather than fully evaluating a specific

system. Comprehensive imaging of systems remains the domain of radiologists and will not be reduced by the implementation of specific ultrasound within the emergency department.

PRIMARY INDICATIONS

Focused assessment with sonography for trauma (FAST)

Focused assessment with sonography for trauma has been widely evaluated.^[12,13] This allows a timely examination, takes less than five minutes, and can be performed during resuscitation.^[14] It is readily repeatable and noninvasive and has replaced diagnostic peritoneal lavage as the primary assessment of blunt abdominal trauma. It will not replace other radiological procedures, such as computed tomography, but will more effectively triage patients to the operating room, further investigation, or observation. FAST employs a 4 view scan of the abdomen and pericardium purely for the purpose of detecting free fluid. The standard views are: Morison's pouch (Figure 1), pericardial (Figure 2), perisplenic space (Figure 3), and supra-pubic windows (Figure 4). Of these, the most useful single view is of Morison's pouch, but adding other views increases sensitivity and specificity.^[15,16] Limitations of the technique include obesity, subcutaneous emphysema, and previous abdominal scars. In a series of studies with FAST performed by surgeons, sensitivities ranged from 81.5% to 99% (mean 90.1%), and specificity from 95.0% to 99.7% (mean 97.7%).^[17-21] Initially pioneered in the US by trauma surgeons, there is increasing evidence that emergency physicians can perform the scan with similar sensitivity and specificity. There is as yet no consensus as to the minimum training required for performance of FAST. Recent studies have indicated a consistently steep learning curve and as few as 15 ultrasound scans may

Figure 1. Morison's pouch.

Figure 2. Pericardial effusion.

be required for clinician ultrasonographers to become competent in the FAST examination.^[14]

Abdominal pain and hypotension

Aortic dimensions can be measured easily and although active bleeding cannot be assessed, the presence of a dilated aorta in patients with circulatory instability significantly speeds up diagnosis of a leaking abdominal aortic aneurysm (AAA) and referral to the vascular team (Figure 5). The time to diagnosis of abdominal aortic aneurysm is consistently less than 10 minutes with routine use of bedside ultrasound in unstable patients with abdominal pain.^[22]

Ectopic pregnancy

Clinical assessment alone is inadequate in the management of symptomatic women in the first trimester and the early use of endovaginal ultrasound scanning is becoming the accepted standard of care.^[23,24] In emergency medicine the goal of the examination is to identify a viable intrauterine pregnancy. Endovaginal scanning allows visualization of intrauterine structures between one and two weeks earlier in gestation than transabdominal scans (Figure 6).^[25] In one study, six emergency physicians underwent 10-12 hours

of didactic teaching followed by 10-12 patients and a sensitivity of 99% and a specificity of 93% were found for ectopic pregnancy.^[26] In another study, when ultrasound was performed by emergency physicians, there was a significant reduction in length of stay among patients with a viable intrauterine.^[27] These studies indicate the clear benefit in the early use of both transabdominal and endovaginal ultrasonography in the expedient management of the complicated first trimester pregnancy.

Echocardiography

The two primary indications for emergency department echocardiography are the diagnosis of pericardial tamponade (Figure 2) and the confirmation (or refutation) of pulseless electrical activity (electromechanical dissociation). Ultrasound also allows the distinction between "true" electromechanical dissociation (EMD) and "clinical" EMD. True EMD is seen as organized electrical ventricular activity in the absence of visual evidence of myocardial contraction and carries a prognosis similar to asystole, and stopping resuscitation is usually justified. Clinical EMD is diagnosed when myocardial contraction is visualized on ultrasonography and is usually associated with a

Figure 3. Perisplenic fluid.

Figure 4. Suprapubic free fluid.

Figure 5. Abdominal aortic aneurysm.

Figure 6. Intrauterine pregnancy.

Figure 7. Hydronephrosis.

Figure 8. Gallstones.

potentially treatable cause.^[28] The correct identification of ventricular fibrillation masquerading as asystole has also been described and the use of ultrasound allows early defibrillation as part of successful resuscitation.^[29]

Renal colic

Ultrasound is used in the assessment of patients with renal colic to detect hydronephrosis^[30] (Figure 7). The use of early renal ultrasonography by emergency physicians allows a progressive protocol for management of patients presenting with renal colic and so reduces the need for radiological imaging with its associated risks and inevitable time delays.

Gall stones

Ultrasound is the primary diagnostic modality used to confirm the presence of gallstone disease and it has been shown that emergency physicians can produce accurate results. A combination of two or more of the following features is highly suggestive of acute gallbladder disease: the sonographic Murphy's sign (the point of maximal tenderness to transducer pressure is localized to the sonographically visualized gall bladder), a thickened gallbladder wall, gallbladder sludge, or pericholecystic fluid (Figure 8).^[31]

Deep venous thrombosis (DVT)

The place of ultrasound in the diagnosis of DVT is well established but radiographic studies are often available during office hours, while patients attend emergency departments 24 hours a day. In one study by emergency physicians using color Doppler the emergency department examination was 100% sensitive and 75% specific.^[32] In a study on emergency duplex ultrasound by Theodoro et al^[33], the mean time from triage to EP disposition was 95 minutes and the mean time from triage to radiology disposition was 220 minutes.

Central venous catheter insertion

Ultrasound technology decreases the number of attempts required to cannulate a central vein and will decrease the amount of time required to cannulate the vein. These results are especially true for those patients considered to have difficult vascular access.^[34]

TRAINING

The initial providers of the service will be trained through a combination of dedicated courses and cooperation with their local radiology departments or teaching hospitals. Suitably trained emergency department personnel will then provide further training in-house.

One of the most controversial areas is the training required for emergency physicians in this country to practice ultrasound. The studies cited above show wide variation in the length of formal training and numbers of examinations. Even with brief training periods respectable sensitivities and specificities have been achieved. The Society for Academic Emergency Medicine has developed a model curriculum suggesting the adequate training of emergency physicians in the use of ultrasound. This recommends 40 hours of teaching and 150 examinations (at least 50% of these should be clinically indicated patient studies) across the range of indications.^[35] Concerns exist regarding skill maintenance and retention once trained. This has not been adequately investigated and remains an area for further evaluation. However, multiple studies have shown the steep learning curve of non-radiologists in performing scans concluding that as few as 10 scans may provide competence.^[14,32,33] These findings suggest that skill maintenance is reasonable but this does require formal evaluation. The combination of primary indications should mean that ultrasound is used regularly

Figure 9. ACEP 2008 scopes of practice.

and routinely in patient assessment and even in smaller departments skill decay should be minimal.

SUMMARY

In June 2001 the American College of Emergency Physicians (ACEP) approved the first specialty-specific comprehensive guidelines for use of ultrasound in emergency medicine,^[36] which was revised in 2008.^[37] 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 (Figure 9).

Emergency screening ultrasound is now a nationally accepted tool for the rapid assessment of the emergency patient. Machines have reduced in price and once purchased further material costs are low. Staffing costs in terms of training, etc have yet to be assessed, but indications from elsewhere are that these are low. The ability to perform these focused studies will allow for a more expedient and safer disposition of patients. Length of stay in the emergency department dramatically decreases, thus increasing patient satisfaction while maintaining an even higher standard of care. The requirement for carefully monitored ultrasound use within emergency departments is common sense.

Funding: None.

Ethical approval: Not needed.

Conflicts of interest: The authors have no financial or other conflicts of interest regarding this article.

Contributors: Jeremy A. Michalke drafted the manuscript. The author read and approved the final manuscript.

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Received January 10, 2012

Accepted after revision May 20, 2012