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The CAEP Emergency Ultrasound Curriculum – Objectives and Recommendations for Implementation in Postgraduate Training

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Executive Summary

Emergency Ultrasound (EUS) is now widely considered to be a ‘‘skill integral to the practice of emergency medicine (EM).’’ <1-4> In 2008, the Royal College of Physicians and Surgeons of Canada (RCPSC) included EUS as a core competency to its EM training standards, <5> and in 2010, the College of Family Physicians of Canada (CFPC) introduced EUS as a terminal training objective for CFPC-EM programs. <6> However, there is considerable heterogeneity in the scope of ultrasound training, curricula, and determination of proficiency. <7-9>

With this in mind, the CAEP Emergency Ultrasound Committee (EUC) formed the EUS Curriculum Working Group, consisting of EUS experts and educators from every EM training site in Canada. This group strives to combine best EUS evidence with contemporary curriculum design processes <10, 11> to create an implementable, evidence-guided core EUS curriculum for 2017 while also setting targets and recommendations for a second iteration in 2020.

The 35 members of the EUS Curriculum Working Group represent all major training institutions from across the country (see Appendix A). To determine Content of Learning (objectives and outcomes of training), the working group employed a modified Delphi method <12, 13> whereby 80% represented sufficient support for any given EUS application to be included in the core EUS curriculum. Items that received 60-79% support were then re-evaluated by working group members through online discussion and then widespread consultation with the CAEP EUC membership at CAEP16 (Quebec City, June 5, 2016). These applications were then voted on a second time for final consideration.

The following EUS applications met 80% support for inclusion in the core EUS curriculum: FAST, identification of AAA, identification of IUP by transabdominal approach, thoracic ultrasound, Focused Cardiac Ultrasound (FOCUS), and ultrasound-guided vascular access.

The proposed core EUS curriculum objectives lay a strong foundation for quality and growth of EUS in Canadian EM training programs. Similar to other established EUS curricula, this first iteration focuses on emergent and potentially life-saving applications. <14> This aligns well with the concept of Patient Zero, <15> where new graduates of either training stream should be skilled in acute resuscitation. The CAEP EUC has reviewed the proposed objectives of training and its members have voted in favor of their adoption as the foundation for a core EUS curriculum. Furthermore, the CAEP EUC endorses the following recommendations, as proposed by the Curriculum Working Group <16> and members of the CAEP EUC, as a means of moving forward with the core EUS curriculum project.

CAEP EUC Position Statement:

1) The Core EUS curriculum should include the following skills: FAST, identification of AAA, identification of IUP by transabdominal approach, thoracic ultrasound, Focused Cardiac Ultrasound (FOCUS), and ultrasound-guided vascular access.
2) The Royal College of Physicians and Surgeons of Canada and the College of Family Physicians of Canada should explore the adoption of these training objectives into the broader objectives and competency based assessment schemes within their EM residency training programs.

3) Residents of CCFP-EM programs should be introduced to EUS prior to their PGY3 year. This could be accomplished by encouraging all successful CFPC EM applicants to undertake EUS training immediately after receiving confirmation of their R3 match.
4) Training sites should share their teaching resources with regard to the above curriculum, in order to expedite adoption and minimize duplication. In such a partnership, all work would be attributed to the creators of the learning material (and their respective institutions).
5) Training sites should continue to advance patient care and push the boundaries of EUS beyond the core curriculum. This can be accomplished through addition of other EUS applications that are deemed important to the local context.
6) Future iterations of this position statement will need to be undertaken frequently to keep pace with the expanding set of EUS skills applicable to emergency care.

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Appendix A. CAEP Emergency Ultrasound Committee- Curriculum Working Group Members

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Appendix B. Objectives of Training for the Core Emergency Ultrasound Curriculum

Physics and Knobology

1. Describe the basic principles of the piezoelectric effect and the ability of ultrasound probes to both generate and detect sound waves
2. Understand the relationship between frequency, wavelength and resolution and its impact on an ultrasound image
3. Describe the ultrasound appearance of liquid, soft tissue, bone, and air
4. Understand gain and its effect on an ultrasound image
5. Select an appropriate probe for a particular ultrasound application
6. Describe and recognize common ultrasound artifacts (i.e. shadowing, refraction, posterior enhancement, mirroring)
7. Understand the difference between 2D and M-mode imaging
8. Understand color flow Doppler imaging
9. Describe safety and risk associated with ultrasound imaging

Abdominal Aorta

1. Describe the indications for performing an aorta scan
2. Select an appropriate probe for this scan
3. Identify key landmarks, including vertebral bodies, aorta, bifurcation into the iliac arteries, and IVC
4. Scan the aorta in short axis from the epigastrium to the bifurcation with visualization throughout
5. Describe methods to optimize visualization of the aorta if obscured by bowel gas
6. Demonstrate appropriate measurement of the maximal AP diameter of the aorta (outside wall to outside wall) and describe upper limit of normal diameter in cms
7. Appropriately and safely integrates findings of a negative, positive, or indeterminate scan into patient management

Focused Assessment with Sonography in Trauma

1. Identify free fluid in the abdomen and pelvis
2. Visualize and sweep the hepatorenal interface, splenorenal interface, sub-diaphragmatic space, and recto-uterine/recto-bladder space
3. Use ultrasound to identify ascites

Focused Cardiac Ultrasound

1. Generate the following cardiac views: subxiphoid, parasternal long axis, parasternal short axis, and apical 4 chamber
2. Identify cardiac standstill

3. Identify a pericardial effusion
4. Recognize that a plethoric IVC is an echo feature of cardiac tamponade
5. Assess gross left ventricular systolic function using visual estimation and E-point septal separation
6. Assess gross right ventricular function using visual estimation of RV size in relation to LV size
7. Generate images of the IVC

Thoracic Ultrasound

1. Generate images of the thorax and pleura
2. Identify pneumothorax
3. Identify pleural effusion and hemothorax
4. Identify alveolar-interstitial syndromes (B lines and their distribution/pattern)

Intrauterine Pregnancy

1. Identify an intrauterine pregnancy using a transabdominal approach in the patient presenting to the emergency department with symptomatic 1st trimester pregnancy
2. Identify a live intrauterine pregnancy
3. Identify an empty uterus
4. Identify an empty gestational sac
5. Identify free fluid/hemorrhage in the setting of ruptured ectopic pregnancy

Resuscitation

1. Integrate cardiac, thoracic and IVC ultrasound to assist in determining volume status and fluid tolerance
2. Integrate cardiac, thoracic and IVC ultrasound to differentiate between different types of shock (obstructive, cardiogenic, hypovolemic/distributive) and to guide patient management
3. Perform E-FAST as part of the primary survey

Central Venous Line Placement

1. Describe the indications and contraindications for inserting an ultrasound guided central venous catheter
2. Select an appropriate probe for guiding venous access
3. Describe the difference between the ultrasound appearance of an artery and a vein
4. Position the patient appropriately and accurately identify the internal jugular vein and carotid artery
5. Position the patient appropriately and accurately identify the common femoral vein and artery
6. Demonstrate sterile technique including the use of a sterile probe cover and sterile gel
7. Describe and demonstrate central venous catheter insertion using the Seldinger technique
8. Understand the difference between long axis (in plane) vs short axis (out of plane) ultrasound guidance

9. Understand the difference between the ultrasound appearance of the needle tip vs the needle shaft
10. Demonstrate clear visualization of the needle and needle tip on ultrasound at all times
11. Demonstrate clear visualization and guidance of the needle tip to a vascular target on an ultrasound phantom before attempting ultrasound guided central venous catheterization on an actual patient

Peripheral Intravenous Placement

1. Describe the indications and contraindications for inserting an ultrasound guided peripheral venous catheter
2. Position the patient appropriately and accurately identify the basilic vein, cephalic vein, and deep brachial veins
3. Select an appropriately sized catheter (i.e. adequate length) for ultrasound guided peripheral venous access

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Appendix C. Summary of Evidence for Core Emergency Ultrasound Applications

Extended Focused Assessment with Sonography in Trauma (E-FAST)

The Focused Assessment with Sonography in Trauma (FAST) exam has been used in blunt and penetrating trauma since the 1990's to identify the presence of hemopericardium and abdominal free fluid, which in the setting of trauma, usually represents hemoperitoneum from solid organ injury. [Rozycki 1993] More recently, the FAST has been extended (E-FAST) to include an evaluation of the chest for hemothorax and pneumothorax. [Kirkpatrick 2004, Ma 1997] Since all of these clinical entities have the potential to cause hemodynamic compromise, the FAST exam is part of the primary survey and resuscitation phase in the current ATLS guidelines. [ATLS 2013] In a meta-analysis of approximately 18,000 patients, the test characteristics of the FAST exam were a sensitivity of 78.9% and specificity of 99.2%. [Stengel 2005] The lung portion of the exam for pneumothorax and hemothorax has sensitivities of 90.9% and 96.2% with specificities of 98.2% and 100% respectively. [Alrajhi,2012, Ma 1997] Although patient-oriented outcomes data related to the extended portion of the FAST exam is lacking, use of the FAST exam proper results in clear patient benefits. Studies have demonstrated shorter delays to the operating room, fewer computed tomography (CT) scans, shorter hospital stays with fewer complications, and most importantly, increased survival. [Melniker 2006, Plummer 1992, Ma 2005.]

Thoracic

Thoracic ultrasound is used to evaluate the differing pleural surface artifacts that occur predictably with certain disease processes. These have been well described in the European literature since the 1990s [Lichtenstein 1997]. "A lines" are horizontal reverberation artifacts that occur consistently with air filled lungs, such as in normal or COPD patients. "B lines" represent interstitial fluid and are hyperechoic vertical lines that arise at the pleural surface and stretch at least 15 cm. When present diffusely and bilaterally, these represent interstitial syndrome, which encompasses pulmonary edema, pneumonitis and pulmonary fibrosis. [Volpicelli 2012] Recent meta-analyses have concluded that the presence of diffuse B lines has a sensitivity of 85-94% and a specificity of 92-93% for diagnosing acute decompensated heart failure (ADHF) [Martindale 2016, Al Deeb 2014]. A study of ED patients with undifferentiated dyspnea undergoing a combined cardiac and lung ultrasound protocol (LuCUS) showed that the US findings resulted in medication changes for almost half of the 50 patients in whom COPD and ADHF were initial diagnostic possibilities, and that the more tailored management plan was correct in all but 1 patient. [Russell 2015]. Thoracic ultrasound is relatively easy to learn to perform, but takes some practice to interpret [Volpicelli 2012]. In one study performed by physicians and medical students after 30 min of lecture and 2 hr of hands on training, the level of agreement with an experienced physician sonographer was a Cohen kappa of 0.82 [Liteplo 2009]

Abdominal Aortic Aneurysm

The purpose of the abdominal aorta scan is to detect the presence or absence of an abdominal aortic aneurysm (AAA). Patients with a ruptured AAA can present with a variety of nonspecific symptoms, contributing to a high rate of misdiagnosis [Marston 1992, Akkersdijk 1998]. In an unstable patient with symptoms suggestive of aneurysm rupture, the diagnosis of an AAA using POCUS can facilitate immediate surgical consultation and disposition directly to the operating room. Time to diagnosis and surgical management have a direct impact on mortality for this disease. [Harris 1991] A recent systematic review found that emergency physicians have a high accuracy for the detection of AAAs, with a combined sensitivity of 99% and specificity of 98%. [Rubano 2013] For patients presenting with a suspected AAA, the use of POCUS led to faster time to diagnosis, reduced time to operating room, and lower mortality compared with patients where POCUS was not used [Plummer 1998].

First Trimester Pregnancy

The purpose of first trimester pregnancy ultrasound is to rule in an intrauterine pregnancy (IUP) in patients presenting with symptoms concerning for a possible ectopic pregnancy. In this patient population, the finding of an IUP virtually rules out ectopic pregnancy, and allows for a safer and faster discharge from the emergency department [Shih 1997]. A systematic review of 10 studies found that emergency physicians have a sensitivity of 99.3% for ruling out ectopic pregnancy [Stein 2010]. Heterotopic pregnancy (simultaneous IUP and ectopic pregnancy) is rare, but should be considered for patients undergoing fertility treatment. For hemodynamically unstable patients with a positive beta-hCG, the POCUS findings of no definitive IUP in combination with free fluid in the peritoneum can facilitate transfer directly to the operating room (OR).

Emergency physician-performed POCUS is associated with a significantly shorter time to OR for patients presenting with ruptured ectopic pregnancy [Rodgerson 2001]. In symptomatic but stable pregnant patients, the presence of free fluid in the abdomen predicts the need for surgical intervention with a positive likelihood ratio of 112 [Moore 2007].

Cardiac Ultrasound

Cardiac POCUS can help facilitate diagnosis and guide management for a variety of patient presentations including cardiac arrest, shock, shortness of breath, and chest pain. The cardiac POCUS exam includes evaluation for left ventricular dysfunction, right ventricular dilation, and pericardial effusion. For patients in cardiac arrest, cardiac POCUS can help to distinguish between true pulseless electrical activity (PEA) and pseudo-PEA. Patients with true PEA or cardiac standstill have a very poor prognosis, with a negative likelihood ratio of 0.18 for achieving return of spontaneous circulation [Blyth2012]. In the appropriate clinical context, this finding may support termination of resuscitation. Conversely, cardiac arrest patients with electrical asystole or PEA may in fact have coordinated cardiac activity with a non-palpable pulse. In these patients, POCUS can help to identify reversible causes of cardiac arrest such as cardiac tamponade, pulmonary embolism, hypovolemia, and myocardial ischemia [Zengin 2016].

Patients with pericardial effusions often present with nonspecific and variable signs and symptoms. In one study, 13.6% of emergency department patients with unexplained dyspnea had an unsuspected pericardial effusion [Blaivas 2001]. Emergency physicians have been shown to have a sensitivity of 96% and specificity of 98% for detection of pericardial effusions [Mandavia 2001]. For patients with unexplained shock, the absence of a pericardial effusion on POCUS rapidly rules out cardiac tamponade. Cardiac POCUS is a standard component of the Focused Assessment with Sonography for Trauma (FAST) examination. For patients with penetrating cardiac injury, cardiac POCUS is associated with a reduced time to operating room and improved survival rates [Plummer 1992].

In patients with undifferentiated shock, determination of left ventricular function can be extremely valuable for determining diagnosis and guiding resuscitation. A poorly contracting left ventricle may lead to initiation of inotropes, whereas an empty and hyperdynamic left ventricle may lead to aggressive volume replacement. In stable patients, cardiac POCUS can help to identify patients with occult left ventricular failure presenting with nonspecific signs and symptoms. Qualitative estimation of left ventricular function by emergency physicians has been shown to be accurate and strongly correlates with quantitative measurements [Weekes 2011]. Emergency medicine trainees have been shown to have a high accuracy for determining left ventricular function after only three hours of proctored training [Bustam 2014].

Patients with massive pulmonary embolism have a high mortality rate and can present with shock or cardiac arrest without any prior symptoms. Early thrombolytic therapy has been shown to reduce mortality in these patients [Wan 2004]. In the right clinical context, a cardiac POCUS revealing a dilated right ventricle (RV:LV ratio >1) can lead to rapid diagnosis and treatment in patients too unstable to undergo a CT scan. Emergency physicians have a specificity of 98% for the identification of right ventricular strain when compared with comprehensive echocardiography [Taylor 2014]. In patients suspected of pulmonary embolism, the finding of right ventricular dilation on cardiac POCUS has a specificity of 98% [Dresden 2014]. The sensitivity of cardiac POCUS for pulmonary embolism is only 50%, therefore CT remains the gold standard for this diagnosis in stable patients.

Inferior Vena Cava

Ultrasound assessment of the inferior vena cava (IVC) can help to determine a patient's volume status and differentiate between categories of shock. In emergency department patients, a small IVC (<1-1.5cm) that demonstrates significant (>50%) collapse with inspiration is associated with low central venous pressure [Nagdev 2010]. In unstable patients, a small collapsing IVC points towards hypovolemia or distributive causes of shock. In contrast, a plethoric IVC points towards an obstructive or cardiogenic cause of shock. For patients with undifferentiated dyspnea in the emergency department, a plethoric IVC has a sensitivity of 84.4% and specificity of 92.9% for congestive heart failure [Yamanoulu 2015]. In pediatrics, a low IVC to aorta diameter ratio (<0.8:1) is associated with volume depletion [Chen 2010].

Central Venous Catheterization

Central venous catheterization (CVC) is associated with various complications, such as arterial puncture, pneumothorax, nerve injury, infection and unsuccessful placement [Nolan 2013]. The evidence for ultrasound guidance mitigating these complications is particularly strong for internal jugular vein cannulation, where it increases the likelihood of first pass success (OR 1.57) and reduces complications, including arterial puncture (OR 0.29). [Brass IJ 2015] Benefits in using ultrasound guidance have also been found for femoral vein insertion (increased first pass success rate, OR 1.73) and subclavian vein insertion (decreased arterial puncture, OR 0.21 and hematoma, OR 0.26.) [Brass Fem/SC 2015] In 2001, the Agency for Healthcare Research and Quality endorsed ultrasound guidance for central venous catheterization as a strongly encouraged patient safety practice based on the high quality of evidence in the literature. [Rothschild 2001] Since then, ultrasound-guided CVC has been further endorsed by the UK's National Institute of Clinical Excellence (NICE), the American Society of Echocardiography, the Society of Cardiovascular Anesthesiologists, and WINFOCUS [NICE 2002, Troianos 2011,Lamperti 2012] There is no clear consensus on how best to teach this skill. However use of a task trainer with repetitive, deliberate practice and feedback has been demonstrated to be superior to traditional teaching methods (see one, do one, teach one) with respect to skill acquisition and retention. [Lee 2009, Barsuk 2009, McGraw 2016]

Peripheral Intravenous Insertion

Peripheral IV insertion can often be challenging in the emergency department, with failure rates up to 26% in adults and 54% in pediatrics [Sabri 2013]. Failure of IV insertion often leads to more invasive procedures such as central venous catheters, and exposes patients to increased procedural risk and discomfort. Ultrasound guidance allows the identification and cannulation of non-palpable veins such as the basilic and cephalic veins of the upper arm. In a study of patients with difficult IV access, emergency physicians had higher success using ultrasound guidance compared with the blind approach (97% vs 33%) [Costantino 2005]. Ultrasound-guided IV insertion has also been shown to be faster, require fewer punctures, and leads to higher patient satisfaction than the blind technique. The use of ultrasound-guided peripheral IV insertion is associated with a reduction in central venous catheter use in the emergency department [Shokoohi 2013]

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