

# Emergency point-of-care ultrasound applications

## Basic applications for the clinician performing bedside ultrasound.

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Clinicians who regularly manage critically ill and injured patients often lack the immediate clinical information that is essential to make correct clinical decisions. Emergency point-of-care ultrasound (EPCUS), performed by bedside clinicians, may provide some of this information, which will help in making the correct clinical decisions and improve overall patient outcomes.

Important points to remember:

- EPCUS is only an adjunct to your physical examination.
- EPCUS is not a formal radiological investigation.
- EPCUS should enhance your clinical examination, not replace it.
- EPCUS should be used to answer highly specific clinical questions, usually binary (example: is there a pneumothorax present? yes/no).

The following quote is pertinent for those who feel that EPCUS may be too complex an examination:

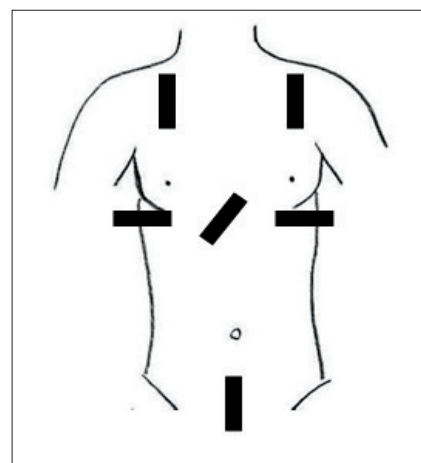
*'That it will never come into general practice, I am extremely doubtful because its beneficial application requires much time and gives a great deal of trouble both to the patient and the practitioner' – J Forbes 1823, Preface to Laennec's treatise on the stethoscope.*

**Table 1. Advantages of EPCUS**

- Compact: new laptop-size ultrasound machines
- Mobility: can be performed at the bedside without the need to move the patient
- Safety: no radiation exposure to patients and staff
- Non-invasive: patient comfort and risk
- Cost-effectiveness: minimal use of consumables
- Immediate: real-time results
- Repeatable: can compare trends of findings
- Trainable: evidence of training success of clinicians

EPCUS has many advantages (Table 1). However, its correct use and the interpretation of results are operator dependent. To make the best use of this technique there is a rigorous training curriculum available, as well as thorough credentialing and proper accreditation procedures. (Refer to the current EPCUS credentials and accreditation in the More About section of this issue.)

There are multiple uses for EPCUS by bedside physicians across all specialties and



*Fig. 1. The six views utilised in the EFAST examination.*

in general practice (Table 2). Choosing the correct module will depend on your scope of practice and patient composition.

Utilising peer EPCUS curricula from abroad, the College of Emergency Medicine of South Africa (CEMSA) formalised a local curriculum of core modules, each chosen for the technical ease of use and the impact on the patient. The current CEMSA core modules are discussed in more detail below.

### EFAST

Ultrasound in trauma patients (used by non-radiologists) was first introduced in the 1980s and subsequently led to the

## Ultrasound

Table 2. Uses of EPCUS (ACEP 2008)		Examples
Resuscitative	Ultrasound used directly related to an acute resuscitation	FEER – view below
Diagnostic	Ultrasound used in an emergent diagnostic imaging capacity	Deep-vein thrombosis
Symptom or sign-based	Ultrasound used in a clinical pathway based on the patient's symptoms or signs	ACES, 7-up or rush for shocked patients
Procedure guidance	Ultrasound used as an aid to guide a procedure	Central venous access or peripheral nerve blocks
Therapeutic and monitoring	Ultrasound used in therapeutics or in physiological monitoring	Caval index in intravenous fluid resuscitation

development of the focused assessment with sonography in trauma (FAST). The FAST examination was not designed to identify all sonographic detectable pathology, but rather as a bedside screening tool to detect free intrathoracic or intraperitoneal fluid. The additional evaluation for pneumothoraces led to the development of the extended FAST (EFAST) and can be used in abdominal (blunt) and chest (blunt and penetrating) trauma. The operator obtains six views to systematically evaluate the unstable trauma patient (Fig. 1).

**Ultrasound has the added advantage of confirming the catheter position, within the central vein, and excluding possible pneumothorax.**

Ultrasound uses no contrast media and is rapid, repeatable, portable, non-invasive, and accurate, which make it the preferred diagnostic modality in shocked patients, rather than diagnostic peritoneal lavage (DPL) and abdominal computed tomography (CT). On the other hand, CT offers more detailed and specific anatomical information and has the advantage of identifying alternative diagnoses. Important traumatic conditions causing minimal intra-abdominal bleeding (e.g. diaphragmatic rupture) may also be overlooked. Lastly,

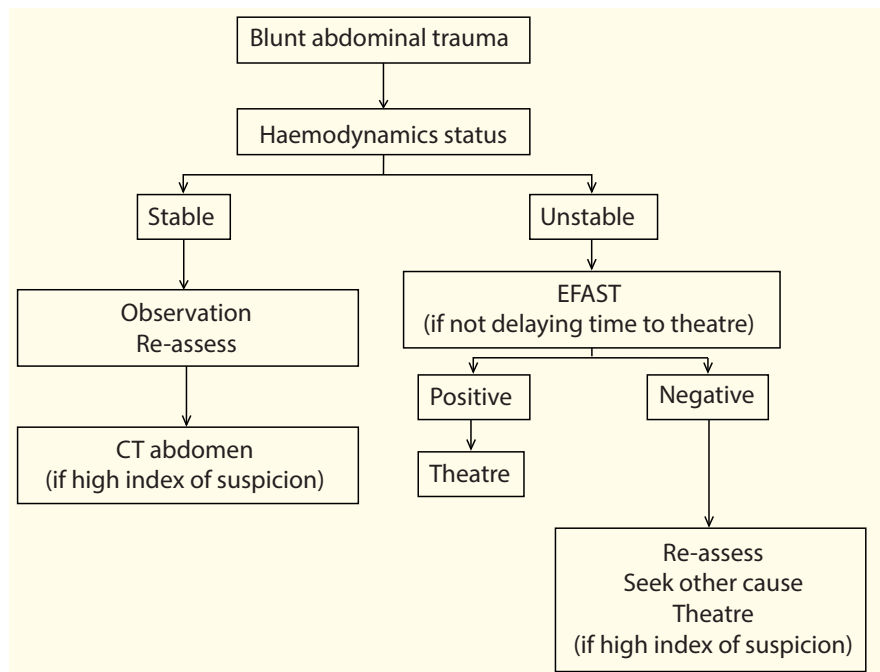


Fig. 2. The clinical application of EFAST in blunt abdominal trauma.

EFAST's utility in penetrating abdominal trauma and in the paediatric population is still unclear.

EFAST is not without limitations. It remains operator dependent, and certain conditions (e.g. bowel gas, obesity and subcutaneous emphysema) may result in sub-optimal examinations. In the acute setting, it is also nearly impossible to distinguish between different types of fluid such as urine, ascites and blood.

The use of EFAST as a bedside screening tool had shortened time to definitive surgical treatment and subsequently shortened

hospital stays and lowered hospital costs. In addition, fewer CT scans were ordered and patients had fewer complications.

Although EFAST has not improved mortality in blunt trauma, it has an important role in decision making in the unstable trauma patient (Fig. 2).

### Abdominal aorta aneurysm

Syncope, hypovolaemic shock and/or anaemia associated with abdominal or back pain are all possible presentations of abdominal aortic aneurysm (AAA). A thorough clinical examination is not sufficient to exclude the diagnosis. Although CT and MRI remain the

gold standard for AAA assessment, patients often present in a shocked clinical state and moving them out of the emergency centre for further diagnostic imaging is not ideal. EPCUS is the best diagnostic tool in this situation due to its high diagnostic accuracy, reproducibility and lack of contrast material administration. The positive finding of an AAA by ultrasound expedites the diagnosis and ensures the patient receives timely life-saving surgery.

The abdominal aorta is visualised from the diaphragmatic hiatus to the aortic bifurcation. Patients in whom AAA is identified are also assessed for the presence of free intraperitoneal fluid. The absence of free intraperitoneal fluid does not rule out acute AAA rupture, however. Most acute AAAs presenting to the EC do not have free peritoneal fluid as the aorta is a retroperitoneal structure. The presence of retroperitoneal haemorrhage cannot be reliably identified by EPCUS. It is most commonly used to evaluate for infrarenal AAAs, but the presence of suprarenal AAAs can also be detected.

EPCUS is not intended to identify all abnormalities or diseases of the aorta and its

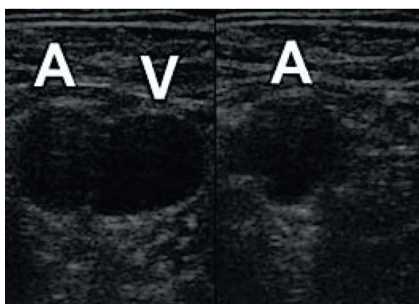


Fig. 3. Compressed right femoral vein to exclude DVT.

results should be interpreted in the context of the entire clinical picture. This focused assessment for AAA may be technically limited by abdominal tenderness, bowel gas and obesity.

### Deep-vein thrombosis

The use of bedside ultrasound to determine the presence of a deep-vein thrombosis (DVT) is common practice in many emergency care settings with access to bedside ultrasound.

### During cardiac arrest resuscitation peripheral pulses can be difficult to confirm using palpation or auscultation.

The patient presenting with a swollen lower limb usually undergoes clinical pre-test probability assessments to determine the risk of clot development, which will determine the relevant screening or diagnostic test. It is important to confirm the diagnosis because of the 10 - 50% rate of propagation from DVT to pulmonary embolism. Numerous formal diagnostic tests are available to identify DVT. Some of these include formal whole-leg ultrasonography that can be time consuming, expensive and can result in diagnostic delays. A large randomised controlled study in 2008 demonstrated that the use of 2-point compression ultrasound, performed by clinicians, versus formal

whole-leg ultrasound in D-dimer positive patients resulted in similar results in the detection of DVT.

The two areas compressed included the common femoral vein and the popliteal vein zones. A venous thrombosis is excluded when there is complete compression of the vein (Fig. 3). Any lack of complete obliteration of the venous lumen suggests the possibility of a clot and the patient should be managed with appropriate anticoagulant therapy.

Pitfalls of this technique include confusing an artery or a lymph node with a vein. A negative scan for a lower limb DVT does not rule out the diagnosis of a pulmonary embolism.

### Central venous access

There are many indications for the placement of central lines. Placing central lines has a high complication rate, especially in the hands of clinicians who do not perform the procedure regularly.

There are two well-known techniques that use ultrasound to assist in placing central lines:

- Identify and mark out the central vein prior to performing the procedure by using bedside ultrasound imaging. The central line catheter is then placed blindly.
- Ultrasound imaging is used during the procedure in real-time ultrasound-guided central line placement (Fig. 4). The physician may visualise the needle using the short-axis, long-axis or the combined approach. The combined technique has the lowest proven complication rate.

The three most common sites for ultrasound-guided central access are the internal jugular, femoral and brachial veins, due to their close proximity to the surface and reduced influence of acoustic artefacts from surrounding anatomical structures. The shortened distance from the surface allows use of a high-frequency ultrasound probe, which assures better image quality. This improves the view of the proceeding needle until correct placement can be confirmed by



Fig. 4. Ultrasound-guided central line access using the transverse approach.

withdrawing venous blood and by a real-time view of the needle tip's location within the central vein. When using these recommended sites, there are no vital structures between the surface and the vein that can be accidentally punctured, which reduces the risk of iatrogenic injury. Placement of catheters in the subclavian vein is less popular because of the acoustic shadow cast by the overlying clavicle.

Ultrasound has the added advantage of confirming the catheter position within

the central vein, and excluding possible pneumothorax. Unfortunately this does not eliminate the need for the standard post-procedure chest X-ray since the operator will still need to confirm the correct position of the catheter tip in relation to the right ventricle.

There are many local training courses available on ultrasound-guided central line placements. However, current evidence shows that the clinician's skill will linearly improve with the number of procedures performed and years of experience utilising bedside ultrasound.

### Focused echocardiography evaluation in resuscitation (FEER)

During cardiac arrest resuscitation peripheral pulses can be difficult to confirm using palpation or auscultation. The 2010 American Heart Association Advanced Life Support guidelines suggested that future research should focus on the role of ultrasound as a targeted intervention during cardiac arrest resuscitation. There are various clinical algorithms in which ultrasound is used during cardiac arrest to confirm asystole or pulseless electrical activity (PEA). Studies have shown that patients presenting to emergency centres with complete cardiac arrest have very little chance of survival. Emergency echocardiography is very useful to distinguish between asystole and PEA given the widely disparate clinical outcomes. The clinician can now utilise ultrasound to further diagnose possible causes of cardiac arrest, which include cardiac tamponade, tension pneumothorax, hypovolaemia and pulmonary embolism.

### Conclusion

The optimal use of EPCUS in clinical practice is still in its infancy. New EPCUS applications are added regularly to a rapidly growing list. Maintaining standards by assuring proper competency is the key, as EPCUS will become a core skill in the repertoire of the modern physician.

Further reading available at [www.cmej.org.za](http://www.cmej.org.za)

## IN A NUTSHELL

- EPCUS provides more and faster clinical information.
- All doctors can use EPCUS to enhance their clinical examination of patients.
- The key is proper training, credentialing and accreditation of EPCUS.
- There are many modules available to suit the different scopes of practice.
- Patients who are haemodynamically unstable with blunt abdominal trauma and a positive EFAST scan should receive immediate surgical laparotomy.
- A physician using a focused EPCUS DVT ultrasound examination can save substantial time by eliminating preceding screening tests.
- Real-time ultrasound-guided CVP insertion reduces patient complication rates.
- AAA screening of patients older than 50 years with suspicious symptoms is accurate, quick and effective.
- EPCUS can be used in cardiac arrest to determine the cause and to distinguish between asystole and PEA.

### Further reading

- Aggarwal S, Qamar A, Sharma V, Sharma A. Abdominal aortic aneurysm: A comprehensive review. *Exp Clin Cardiol* 2011;16(1):11-15.
- Andersen FA, Wheeler HB, Goldberg RJ, et al. A population-based perspective of the hospital incidence and case-fatality rates of deep vein thrombosis and pulmonary embolism. The Worcester DVT Study. *Arch Int Med* 1991;151:933-938.
- Andreatta P, Chen Y, Marsh M, Cho K. Simulation-based training improves applied clinical placement of ultrasound-guided PICCs. *Support Care Cancer* 2011;19(4):539-543.
- Bernadi E, Camporese G, Buller H, et al. Serial 2-point ultrasonography plus D-dimer vs whole-leg color-coded Doppler ultrasonography for diagnosing suspected symptomatic deep vein thrombosis: a randomised control trial. *JAMA* 2008;300:1653-1659.
- Blaivas M, Fox JC. Outcome in cardiac arrest patients found to have cardiac standstill on the bedside emergency department echocardiogram. *Acad Emerg Med* 2001;8:616-621.
- Blaivas M. Video analysis of accidental arterial cannulation with dynamic ultrasound guidance for central venous access. *J Ultrasound Med* 2009;28(9):1239-1244.
- Breitkreutz R, Walcher F, Seeger FH. Focused echocardiographic evaluation in resuscitation management: Concept of an advanced life support-conformed algorithm. *Crit Care Med* 2007;35(5) (suppl.):S150-S161.
- Calinas-Correia J, Phair I. Is there a pulse? *Resuscitation* 1999;41:201-202.
- Gillum RF. Pulmonary embolism and thrombophlebitis in the United States, 1970-1985. *Am Heart J* 1987;114:1262-1264.
- Goncalves IM, Costa Alves D, Carvalho A, et al. Tuberculosis and venous thromboembolism: a case series. *Cases Journal* 2009;2:9333.
- Goudie AM. Credentialing a new skill: what should the standard be for emergency department ultrasound in Australasia? *Emerg Med Australas* 2010;22(4):263-264.
- Hoffmann B, Bessman ES, Um P, Ding R, McCarthy ML. Successful sonographic visualisation of the abdominal aorta differs significantly among a diverse group of credentialed emergency department providers. *Emerg Med J* 2011;28(6):472-476.
- Hoffmann R, Pohlemann T, Wippermann B, Reimer P, Milbradt H, Tscherne H. [Management of sonography in blunt abdominal trauma]. *Unfallchirurg* 1989;92(10):471-476.
- Jehle D, Davis E, Evans T, et al. Emergency department sonography by emergency physicians. *Am J Emerg Med* 1989;7:605-611.
- Jorgensen H, Jensen CH, Dirks J. Does prehospital ultrasound improve treatment of the trauma patient? A systematic review. *Eur J Emerg Med* 2010;48(3):227-235.
- Kendall JL, Hoffenberg SR, Smith RS. History of emergency and critical care ultrasound: the evolution of a new imaging paradigm. *Crit Care Med* 2007;35(5 Suppl):S126-130.
- Kessel DO, Taylor EJ, Robertson I, Patel JV, Denton LJ, Perren TJ. Routine chest radiography following imaging-guided placement of tunneled central lines: a waste of time, money, and radiation. *Nutr Clin Pract* 2002;17(2):105-109.
- Ma OJ, Mateer JR, Ogata M, Kefer MP, Wittmann D, Aprahamian C. Prospective analysis of a rapid trauma ultrasound examination performed by emergency physicians. *J Trauma* 1995;38(6):879-885.
- Melniker LA, Leibner E, McKenney MG, Lopez P, Briggs WM, Mancuso CA. Randomized controlled clinical trial of point-of-care, limited ultrasonography for trauma in the emergency department: the first sonography outcomes assessment program trial. *Ann Emerg Med* 2006;48(3):227-235.
- Miller AH, Roth BA, Mills TJ, Woody JR, Longmoor CE, Foster B. Ultrasound guidance versus the landmark technique for the placement of central venous catheters in the emergency department. *Acad Emerg Med* 2002;9(8):800-805.
- Morrison LJ, Deakin CD, Morley PT, et al. Part 8: Advanced Life Support: 2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations. *Circulation* 2010;122[suppl 2]:S345-S421.
- Musselwhite LA, Sheikh V, Norton TD, et al. Markers of endothelial dysfunction, coagulation and tissue fibrosis independently predict venous thromboembolism in HIV. *AIDS* 2011;25(6):787-795.
- Plummer D. Principles of emergency ultrasound and echocardiography. *Ann Emerg Med* 1989;18:1291-1297.
- Rozycki GS, Ochsner MG, Schmidt JA, et al. A prospective study of surgeon-performed ultrasound as the primary adjuvant modality for injured patient assessment. *J Trauma* 1995;39(3):492-498; discussion 8-500.
- Scheiermann P, Seeger FH, Breitkreutz R. Ultrasound-guided central venous access in adults and children: Procedure and pathological findings. *Anaesthesist* 2010;59(1):53-61.
- Wells M, Bruijns S. College of Emergency Medicine of South Africa use of bedside emergency ultrasound in South African emergency departments. Part 2–Emergency Ultrasound Resource Document 2009 27 September 2011. [http://www.emergencymed.co.za/documents/CEM\(SA\)%20Emergency%20Ultrasound%20RESOURCE%20v3.pdf](http://www.emergencymed.co.za/documents/CEM(SA)%20Emergency%20Ultrasound%20RESOURCE%20v3.pdf). (accessed Aug 2012).