Echocardiography in acute medicine: a clinical review

As a result of developments in portable and hand-held devices, transthoracic echocardiography can now be brought to the patient. There is the opportunity for acute physicians to exploit the benefits of echo in the assessment and management of acutely unwell patients in a variety of settings.

Transthoracic echocardiography can be an extremely powerful tool in the armoury of the acute medical physician; it can be used to aid assessment of patients with chest pain, shortness of breath, unexplained hypotension or even in cardiopulmonary arrest. It is safe, non-invasive and provides instant results to the assessing clinician which can be incorporated into the overall evaluation of the patient. Transthoracic echocardiography has the potential to provide important information over and above that already available from a detailed history, thorough examination, basic investigations and other readily accessible imaging modalities.

Portable machines have become more sophisticated and cheaper; equipment has advanced to a level where the technical limitations of portable machines are no longer a significant problem. There will be an increasing number of emergency departments and acute medical units which contain a portable echo machine. Before this occurs, it is important to reflect on the evidence for the use of bedside echo beyond the traditional scenarios and by non-experts. This article describes the current situation with regard to echo in acute medicine and reviews evidence for its use in this setting.

Background

Since its introduction in the 1950s, echocardiography has aided the cardiologist in the diagnosis and surveillance of cardiovascular disease. Traditionally, transthoracic echocardiography has only been available in an 'echo lab', and the images recorded, interpreted and reported by a trained sonographer (cardiologist or physiologist). Transthoracic echocardiography has been somewhat unreachable by the acute physician, usually because of the training necessary to become proficient in echo. This also limits the availability of the imaging modality, especially out of hours.

New developments

In the last 10 years the sophistication, size and cost of components of an echo machine has improved dramatically. This has led to the introduction to the market of laptop and handheld-size echo machines. Some devices are now available which are truly 'pocket-sized' and no larger than a smartphone. These are being marketed for use in acute and emergency medicine, to improve and aid diagnosis in these situations. The advantage of the portability of these machines was seen early, and investigators were quick to begin to study the quality and utility of these systems. This has led to the increasing use of point-of-care echocardiography in a wide range of fields including the intensive care unit, acute medical unit and emergency department.

The British Society of Echocardiography, the group which aims to promote the study and development of echo, has published a position statement on the subject (Fox et al, 2008). This welcomes the expansion of echocardiography outside the traditional fields and aims to encourage the development of bedside echo in the acute, emergency and critical care fields. It is creating an accreditation pathway for echo in critical care with pilot exams starting in autumn 2010. The FEEL-UK group has recently been set up to advance the use of echo in a peri-arrest setting (see below).

On an international level, in 2006 the World Interactive Network Focused On Critical UltraSound (WINFOCUS) was developed. This group, made up of international experts, aims to increase education and research into the use of echo in critical care. Its goal is the use of echo in all critical in-hospital and out-of-hospital settings.

Proficiency and safety

The route to demonstrating competence in echo in the UK is to undertake the British Society of Echocardiography accreditation process. To complete this, a log book of 250 reported cases covering a range of pathologies along with five fully recorded studies must be submitted. Before this can be done, a written exam must be passed. This is currently the only option in the UK for echocardiographers to gain a recognized qualification of proficiency. There are differing accreditation pathways for community and transoesphageal echo (and soon, critical care). It also requires the 'sponsorship' of an experienced echocardiographer to oversee the log book. Gaining full accreditation takes a significant personal investment of time and energy and can be

Dr Andy Potter *is ST2 GP Trainee, Bedford Hospital NHS Trust, Bedford MK42 9DJ*

very difficult to achieve for clinicians with limited access to a cardiology department (often a problem for acute medical trainees).

To expect every acute or general physician wishing to practice echo at the bedside to gain the British Society of Echocardiography accreditation would be unrealistic and could retard the development of echocardiography in acute medicine. However, the importance of maintaining standards of competence cannot be overestimated. The potential for misuse of a skill which is so heavily reliant on the observer's ability and experience is considerable and could lead to harm to the patient and render the practitioner open to litigation. A balance must be sought whereby interested physicians are encouraged to develop the skill, along with the support of the British Society of Echocardiography, initially in a structured and limited way and within a safe framework. Using a logbook or portfolio should be encouraged as evidence of the clinician's competence.

Focussed, diagnosis-driven echocardiography

A key development in the emerging field of echo in settings outside specialized cardiology units was the recognition that a focused, protocol-based framework was needed. This would concentrate on the diagnosis of a limited number of important conditions in specific circumstances in the emergency department, acute medical unit or intensive care unit to allow non-experts to practice echo safely and act as a foundation on which to build skills and expertise. To maximize its uptake, it was also vital that the necessary skills could be taught in a brief time frame to novices and could be used in daily practice to maintain skill level. The development of two different goal-orientated protocols has provided the interested acute physician with an introduction to the skill and the security of practicing it within a safe, evidence-based structure with defined competences.

The more motivated clinician could potentially study for full accreditation. Although these two protocols are not designed specifically for the acute medical unit per se, they provide an excellent entry point to echocardiography for the interested physician who is commonly confronted by these situations.

The FEEL (Focused Echo Evaluation in Life Support) protocol was designed for use in the peri-arrest setting (Breitkreutz et al, 2007). It describes a very clear pathway for echo in cardiopulmonary resuscitation or other emergency situations. This protocol is necessarily very different from that of a full non-urgent transthoracic echocardiogram. It uses the subcostal approach initially as it is often the most easily available area; if adequate images cannot be demonstrated after a few seconds, the assessor should move on to the parasternal then apical views. It is designed to sit alongside current advanced adult life support practice and stresses the importance that echo in resuscitation situations should not interfere with circulatory and respiratory support. Its main aim is to rule out certain reversible causes (such as cardiac tamponade) during pauses from basic life support. The authors claim it can be taught to non-experts in a 1-day teaching session (Breitkreutz et al, 2007) (*Table 1*).

A second echo-in-the-critically-ill protocol began its development in the late 1990s and was published in 2004 (Jensen et al, 2004). It was developed primarily for use in the intensive care unit. It advocates the use of its focus assessed transthoracic echo (FATE) protocol to exclude obvious pathology, assess wall thickness and chamber dimensions, assess contractility and image the pleura (*Table 2*). It was devised to aid the assessment of the haemodynamically unstable patient in intensive care unit and seems to do this effectively (Jensen et al, 2004). It is suggested by the authors that it can be taught in 2 days.

The skills taught using FATE could be transferred to the acute medical unit, especially those which involve the more unwell and unstable patients (i.e. level II care). Indeed, other similar 'rule-in, rule-out' protocols have been assessed and do seem to be accurate and useful, when used by intensivists, after limited training (Vignon et al, 2007).

Beyond FEEL and FATE

These frameworks are the only two to have been designed and tested for use of echo in the critically ill by non-experts. They do have the potential to be perfected for the acute medical unit or the emergency department and could significantly improve patient care. However, without further development, echo in acute medicine will only have a limited role which will greatly restrict its clinical usefulness and attraction to the medical trainee.

Echocardiography has the potential to benefit a much wider patient group, in a number of clinical scenarios, and the goal for many acute physicians would be the

Table 1. The FEEL (focused echo evaluation in life support) protocol

To be used in cardiopulmonary resuscitation situations or emergency setting
Three echo 'windows', subcostal first (most accessible position)
To look for cardiac activity and pericardial collections
1-day training course

From Breitkreutz et al (2007)

Table 2. The FATE (focussed assessed transthoracic echocardiography) protocol

For use in intensive care unit to aid haemodynamic assessment
Includes the pleura (pleural effusions)
2-day teaching session

From Jensen et al (2004)

ability to use the skill in multiple situations on a busy unselected medical take. It could be invaluable in situations when assessment of left ventricular function, myocardial wall motion abnormalities, and presence of a pericardial collection would aid diagnosis (*Table 3*). However, indiscriminate use of transthoracic echocardiography could have pitfalls, especially if over-relied upon despite conflicting clinical information. The scenario which must be avoided is when important clinical decisions are made based on inaccurate scans used in inappropriate situations. Indeed, this must be the underlying principle for the development of echo in acute and emergency medicine.

Is there evidence for non-experts to practice echo in settings outside the FEEL or FATE protocols? Beyond this, can non-experts perform scans which can provide other useful information in everyday practice in the emergency department or acute medical unit? There are certainly advocates for this (Duvall et al, 2003). In spite of this, the specific issue has not been investigated but several clinical studies could provide answers to these questions (see below).

Table 3. The views and potential abnormalities which can be detected – specifically relating to emergency echo

Location/view	Potential abnormalities
Parasternal long axis: 2nd/3rd rib space, left lateral sternal edge	Left ventricular wall motion abnormalities
	Right ventricle function
	Left ventricular chamber size
	Mitral valve
	Aortic valve
	Pericardial collection
Parasternal short axis: 2nd/3rd rib space, left lateral sternal edge (probe rotated 90° clockwise)	Aortic valve – dissection flap (aortic level)
	Left ventricular wall motion abnormalities (mid-left ventricular level)
	Right ventricle function
	Right ventricle overload (septal abnormalities)
Apical four-chamber view: 5th/6th intercostal space, mid-clavicular line	Left ventricular size and function
	Right ventricle size and function
	Left ventricular wall motion abnormalities
	Mitral and tricuspid valve
	Clot
	Ventricular aneurysm
	Inter-ventricular septum
	Inter-atrial septum
	Pericardial collection
Apical two-chamber view: 5th/6th intercostal space, mid-clavicular line (probe rotated 90°)	Left ventricular function and wall motion abnormalities
Subcostal view: just below distal end of sternum	Pericardial collection
	Left ventricular and right ventricle function
	Right ventricle pressure (indirectly from inferior vena cava)

Training time and skill level

Several small clinical trials have compared the diagnostic value of novice echocardiographers to skilled technicians. For example, 20 internal medicine trainees received a 3-hour tutorial on a focused transthoracic echocardiography study looking for a limited number of gross pathologies. With comparison to 'gold standard' transthoracic echocardiography (a full study by experienced and qualified sonographers), the negative predictive value for left ventricle dysfunction, mitral regurgitation, limited aortic valve disease and pericardial effusion performed by these beginners was 85%, 89%, 95% and 99% respectively (Alexander et al, 2004). Other studies have investigated the effectiveness of point-of-care echo but with slightly longer training periods (Hu et al, 1996; Bruce et al, 2002; DeCara et al, 2003).

Based on the outcomes of these limited studies it appears realistic to train the acute physician in focused echo concentrating on the detection of left ventricle dysfunction, pericardial collection and gross cardiac activity and that the quality of study would be acceptable (Moore et al, 2002; Fedson et al, 2003; Randazzo et al, 2003; Pershad et al, 2004). It is important to note that in all of these studies the echo findings were not equal to a full examination. This is the common finding in all the studies but the aim is not to complete a full examination, but to be able to rule in or rule out certain disease processes.

The issue of training period is an important one, especially as the training time of acute medical trainees is severely limited. Researchers have investigated the training periods for the recognition of common abnormalities (Hellmann et al, 2005). The accuracy improved significantly with every ten scans performed, after a short introduction to echo and ultrasound. As all studies were supervised this requires a considerable input from echo trainers, which is a rate-limiting step in the development of a similar programme.

Wider applications

As the use of echo by an acute physician develops, the skill level improves. Many clinicians will naturally look to widening its application to clinical situations where rapid information on the functioning of the heart (or great vessels) would significantly improve diagnostic accuracy. There are a number of scenarios where a certain level of doubt regarding the diagnosis exists and patients are potentially put at risk when treated with risky therapies based on inaccurate or incomplete information. The use of transthoracic echocardiography by experts, at the patient's bedside in the acute presentation of several disease processes has been studied and could revolutionize their management in the urgent setting.

Acute coronary syndromes

All doctors working in acute medicine will have experience of the assessment and management of patients presenting with chest pain presumed to be the result of acute myocardial ischaemia. The standard assessment of these patients includes a thorough history, clinical examination, electrocardiograms and cardiac enzyme measurements. Despite all this information, it can be difficult to accurately risk stratify a patient and determine if it is safe to discharge him/her home. Could transthoracic echocardiography be used to provide evidence of acute ischaemia?

Rest echocardiography can detect left ventricle regional wall motion abnormalities. These can be caused by acute ischaemia but there are also other causes (Pierard and Lancellotti, 2009). In its absence, it can help to rule out ischaemia, but not to the level that it can be completely relied on (Weston et al, 2004). If present, it can provide some information on prognosis, albeit less than contrast echo (Senior and Ashrafian, 2005). Although the use of bedside echo in this scenario is very attractive, it is probably not applicable to routine acute care.

Acute aortic syndromes

An extremely important cause of acute chest pain presenting to hospital is aortic dissection. Incorrectly treating a patient with an aortic dissection with antiplatelet agents and anticoagulants can be catastrophic. When the clinical picture is classic, echo is probably not indicated as it is not as accurate as contrast computed tomography; its sensitivity and specificity being 59% and 83% respectively (Nienaber et al, 1993). If transthoracic echocardiography is performed immediately and a dissection is found it can lead to rapid management and avoidance of potentially harmful treatments. However, if it is not found and suspicion remains high, further imaging modalities will be indicated.

Pulmonary embolism

Patients whom present with pulmonary emboli are a diverse group. Clinical suspicion must always remain high in order not to miss this important diagnosis. Transthoracic echocardiography can be used in this setting to guide acute management. There are a number of signs which can be used to indirectly detect a pulmonary embolism but their absence does not rule out the diagnosis (Pierard and Lancellotti, 2009). The detection of certain signs of right ventricular overload may also be used to identify patients who may benefit from thrombolytic therapy, even if there is no systemic arterial hypotension (Konstantinides et al, 2002), although this is contentious. Transthoracic echocardiography is probably not accurate enough to make or rule out the diagnosis.

Hypotension

Transthoracic echocardiography can also be useful in the assessment of patients presenting with hypotension, without obvious cause from clinical examination and basic investigations routinely available. It can reveal a number of reversible pathologies such as pericardial effusion (*Figure 1*), left or right ventricular dysfunction, or even pleural causes.

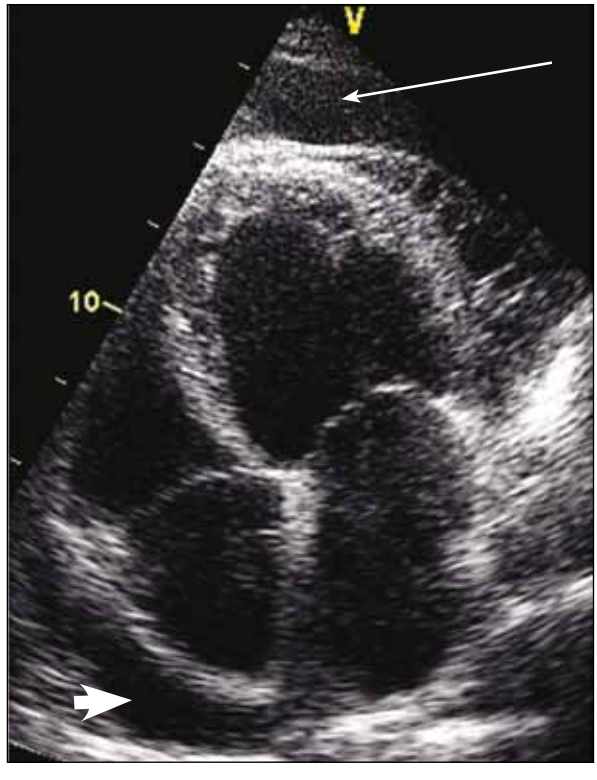
Limitations

As outlined above, the potential benefit of transthoracic echocardiography to acute and emergency medicine is considerable. The main drawback to echo is its reliance on skill and subsequent inter-observer variability. This can, to some extent, be mitigated by teaching and practise. However, there are specific situations which are inherent in assessing the ill patient which are significant barriers to the use of echo in these scenarios. A good echo scan relies heavily on patient cooperation; the patient needs to be able to position him-/herself into a potentially uncomfortable posture for several minutes. Ill patients often are unable to do this which will substantially reduce the quality of the study.

The future

The British Society of Echocardiography is supporting the development of echo in new areas, and acute medicine as a speciality must embrace this. As the British Society of Echocardiography develops protocols and new accreditation schemes, all trainee doctors in acute medicine should be given the opportunity to train in echo. The attraction of such a skill to the potential acute medical trainee must not be underestimated. This often requires an enthusiastic and flexible cardiology depart-

Figure 1. An apical four-chamber view revealing an anterior (white arrow) and posterior (white arrow head) pericardial effusion.



ment and acute medical departments must be proactive in establishing links for this reason. Also, there are also a number of short study courses which provide focussed training.

There are advocates who believe the skills are mandatory and essential for the management of acutely ill patients (Ashrafian et al, 2004). Indeed the WINFOCUS group believe echo should be used in the assessment of all patients presenting with critical features, either inpatients or in the pre-hospital setting.

Conclusions

Transthoracic echocardiography can be used to great effect in acute and emergency medicine and its use should be expanded, as supported by professional societies. It offers considerable benefit in the assessment of acutely ill patients and could drastically improve patient care. There is an evidence base collecting to support its use outside the traditional 'echo lab' and the acute medical unit and emergency department are ideal areas to expand its use. It can aid in the diagnosis of cardiac tamponade, left ventricle and right ventricle dysfunction, valve and great vessel abnormalities, as well as non-cardiac structures such as the pleura. It could also have a role in the cardiopulmonary setting.

More advanced practitioners can use it in the evaluation of patients presenting with symptoms suggesting myocardial ischaemia or pulmonary embolism. However, its benefits must not blind us; it could cause significant morbidity if used indiscriminately.

Finally, as many procedures previously performed at the bedside by the medical team are now performed in the interventional radiology suite, it is vital that acute trainees have the opportunity to develop practical skills. Also, the dexterity, understanding and ability to perform echocardiography could be transferrable to other ultrasound modalities and ultrasound-guided procedures. The huge opportunities that portable echo brings should be seized by acute physicians and developed to allow echo to be as ubiquitous as the stethoscope and chest X-ray. **BJHM**

KEY POINTS

- Echocardiography can provide important and valuable information to the assessing physician for patients presenting with a wide variety of acute medical illness.
- Advanced portable echo machines offer the opportunity for excellent image quality by the bedside.
- The British Society of Echocardiography encourages the expansion of echo to acute, emergency and critical care fields.
- Non-cardiologists can accurately recognize gross cardiac abnormalities with limited training.
- Specific echo protocols for the resuscitation and critical care settings exist; these could be transferred to the acute medical unit.
- It is essential that echo is only used within the practitioner's level of competence.
- The expansion of echo in acute medicine could attract trainees to the speciality.

Figure 1 *is reproduced from Stoodley et al (2008) by kind permission of Oxford University Press.*

Conflict of interest: none.

Alexander JH, Peterson ED, Chen AY et al (2004) Feasibility of point-of-care echocardiography by internal medicine house staff. *Am Heart J* **147:** 476–81

Ashrafian H, Bogle R, Rosen S et al (2004) Portable echocardiography. *BMJ* **328:** 300–1

Breitkreutz R, Walcher F, Seeger FH et al (2007) Focused echocardiographic evaluation in resuscitation management: Concept of an advanced life support–conformed algorithm. *Crit Care Med* **35**(5 Suppl): S150–S161

Bruce CJ, Montgomery SC, Baily KR et al (2002) Utility of hand-carried ultrasound devices used by cardiologists with and without significant echocardiographic experience in the cardiology inpatient and outpatient settings. *AmJ Cardiol* **90:** 1273–5

DeCara JM, Lang RM, Koch R et al (2003) The use of small personal ultrasound devices by internists without formal training in echocardiography. *Eur J Echocardiogr* **4:** 141–7

Duvall WL, Croft LB, Goldman ME (2003) Can hand-carried ultrasound devices be extended for use by the noncardiology medical community? *Echocardiography* **20**(5): 471–6

Fedson S, Neitharrdt G, Thomas P et al (2003) Unsuspected clinically important findings detected with a small portable ultrasound device in patients admitted to a general medicine service. *J Am Soc Echocardiogr* **16:** 901–5

Fox K on behalf of a Collaborative Working Group of the British Society of Echocardiography (2008) A position statement: echocardiography in the critically ill. *J Intensive Care Soc* **9:** 197–8

Hellmann DB, Whiting-O'Keefe Q, Shapiro EP, Martin LD, Martire C, Ziegelstein RC (2005) The rate at which residents learn to use hand-held echocardiography at the bedside *Am J Med* **118**(9): 1010–18

Hu BS, Saltiel F, Popp RL (1996) Effectiveness of a limited training in echocardiography for cardiovascular diagnosis. *Circulation* **94:** I–253

Jensen MB, Sloth E, Larsen KM et al (2004) Transthoracic echocardiography for cardiopulmonary monitoring in intensive care. *Eur J Anaesthesiol* **21:** 700–7

Konstantinides S, Geibel A, Heusel G et al (2002) Heparin plus alteplase compared with heparin alone in patients with submassive pulmonary embolism. *N Engl J Med* **347:** 1143–50

Moore CL, Rose GA, Tayal VS et al (2002) Determination of left ventricular function by emergency physician echocardiography of hypotensive patients. *Acad Emerg Med* **9:** 186–93

Nienaber CA, von Kodolitsch Y, Nicolas V et al (1993) The diagnosis of thoracic aortic dissection by noninvasive imaging procedures. *N Engl J Med* **328:** 1–9

Pershad J, Myers S, Plouman C et al (2004) Bedside limited echocardiography by the emergency physician is accurate during evaluation of the critically ill patient. *Pediatrics* **114:** 667–71

Pierard LA, Lancellotti P (2009) Echocardiography in the emergency room. *Heart* **95:** 164–70

Randazzo MR, Snoey ER, Levitt A et al (2003) Accuracy of emergency physician assessment of left ventricular fraction and central venous pressure using echocardiography. *Acad Emerg Med* **10:** 973–7

Senior R, Ashrafian H (2005) Detecting acute coronary syndrome in the emergency department: the answer is in seeing the heart: why look further? *Eur Heart J* **26:** 1573–5

Stoodley PW, Costa RJ, Richards DA, Thomas L (2008) Acute myocardial infarction complicated by LV free wall rupture: the benefits of echocardiography. *Eur J Echocardiogr* **9**: 188–9

Vignon P, Dugard A, Abraham J et al (2007) Focused training for goal-oriented hand-held echocardiography performed by noncardiologist residents in the intensive care unit. *Intensive Care Med* **33**(10): 1684–6

Weston P, Alexander JH, Patel MR, Maynard C, Crawford L, Wagner GS (2004) Hand-held echocardiographic examination of patients with symptoms of acute coronary syndromes in the emergency department: the 30-day outcome associated with normal left ventricular wall motion. *Am Heart J* **148**(6): 1096–101