Echocardiography and the non-cardiac anaesthetist

Echocardiography is destined to revolutionize perioperative and intensive care medicine, as it has already in cardiac anaesthesia. This article reviews the evidence underlining why now is the time for general anaesthetists to get involved in this rapidly evolving field.

There is currently a groundswell of interest throughout the UK from intensive care medicine trainees and consultants alike to learn transthoracic echocardiography as they have witnessed the dramatic impact that point-of-care ultrasound has had on other aspects of clinical practice. In trained hands bedside echo is capable of rapidly ruling in or out key life-threatening diagnoses on the ward, in theatre or recovery and even in cardiac arrest. It will undoubtedly become a core skill for intensivists of the future but is within the reach of all practitioners of perioperative medicine. So what is all the fuss about and how might focused echo benefit the non-cardiac anaesthetist?

Preoperative echo: demand and supply

'Hypotension or haemodynamic instability of uncertain or suspected cardiac aetiology' carries the strongest indication for echo in the acute setting (scoring 9/9) (Douglas et al, 2011) and yet in most UK hospitals emergency echo is currently not a 24-hour service.

As modern medicine becomes increasingly risk-averse and reliant on imaging to inform major clinical decisions, the demand for echo in some areas risks outstripping supply. An example of this is preoperative echo for proximal femoral fracture surgery, which is time-critical, emergency surgery performed commonly in almost every hospital nationwide. This patient group is elderly with a 39% prevalence of aortic stenosis (8% moderate or severe, many of whom have no audible murmur) and can spend potentially deleterious time waiting for preoperative echo (Loxdale et al, 2012).

It is unlikely that comprehensive transthoracic echocardiography could be learned within a usual training programme but anaesthetic trainees have been taught to perform certain aspects of transthoracic echocardiography. After only a 1-hour lecture and 1-hour hands-on teaching to evaluate aortic valve stenosis (using two-dimensional imaging and peak aortic velocity), five senior house officers performed 20 preoperative cases each and their interpretation reached complete concordance with a blinded cardiac anaesthetist, experienced in echo (Cowie and Kluger, 2011).

Preoperative cardiac assessment is a cornerstone of good perioperative care and will become increasingly important as the UK surgical population is destined to become even older and present with additional comorbidities for ever more emergent procedures. Alongside cardiopulmonary exercise testing, it would be desirable for echocardiography to be embedded in the preoperative assessment clinic for high-risk cases. A recent transthoracic echocardiography study of 100 patients over 65 years of age with suspected cardiac disease performed by an anaesthetist in the preoperative assessment clinic demonstrated a 'step-down' in planned perioperative care in 34% of cases including the avoidance of cancelling surgery, cardiology referral, invasive monitoring, vasopressors and booking of a postoperative high dependency unit bed, which would have obvious advantages to patient flow, efficiency and bottom-up cost (Canty et al, 2012).

Focused echo in the emergent setting

Comprehensive transthoracic echocardiography is not an easy skill to acquire and, done properly, takes years to learn. Echo training and service provision has historically been within the domain of cardiology. However, 'focused', 'bedside' or 'hand-held' echo is rapidly gaining momentum worldwide. It is widely accepted by echo societies across Europe and North America that non-cardiologists can learn to perform certain (largely two-dimensional) aspects of transthoracic echocardiography to answer specific, goal-directed questions in acutely ill patients such as 'is there a pericardial effusion?' or 'is there severe right ventricular dilatation?' (Price et al, 2008) (*Figures 1* and *2*).

Focused echo in cardiac arrest

In advanced life support, reversible causes of cardiac arrest (known as 'the 4Hs and 4Ts') are considered mainly on the antecedent clinical history but once in established cardiac arrest these are clinically indistinguishable. Focused echo can rapidly rule most of these out at the scene (Price et al, 2010) and has repeatedly demonstrated that patients with no cardiac motion (regardless of the presenting rhythm) are extremely

Dr MJE Peck *is Consultant in Anaesthesia and Intensive Care Medicine, Frimley Park Hospital NHS Foundation Trust, Frimley, Surrey GU16 7UJ (marcus.peck@lineone.net)*

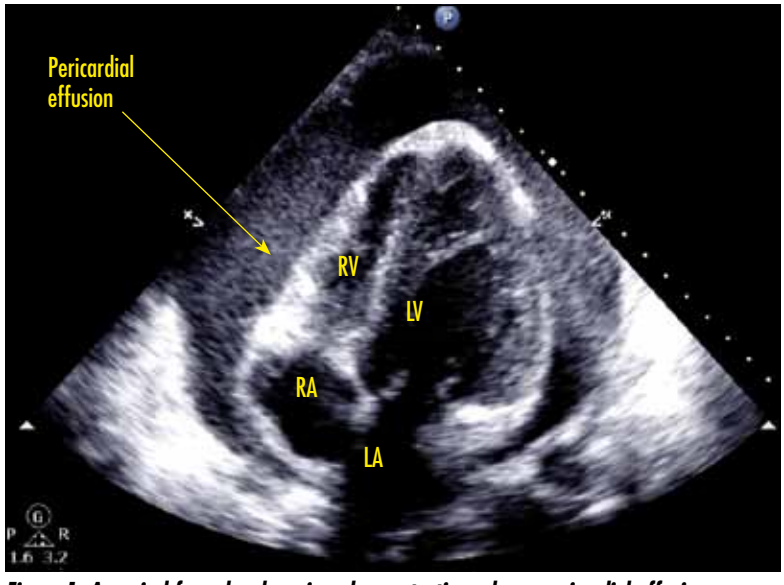


Figure 1. An apical four-chamber view demonstrating a large pericardial effusion. The diagnosis of tamponade is a clinical one but this echo finding in the context of hypotension would strongly suggest it. LA = left atrium; LV = left ventricle; RA = right atrium; RV = right ventricle.

unlikely to survive (Blavias and Fox, 2001). In contrast, it is common to find cardiac wall motion in pulseless electrical activity arrest (known increasingly as 'pseudo-pulseless electrical activity') and this is highly associated with return of spontaneous circulation (Salen et al, 2005).

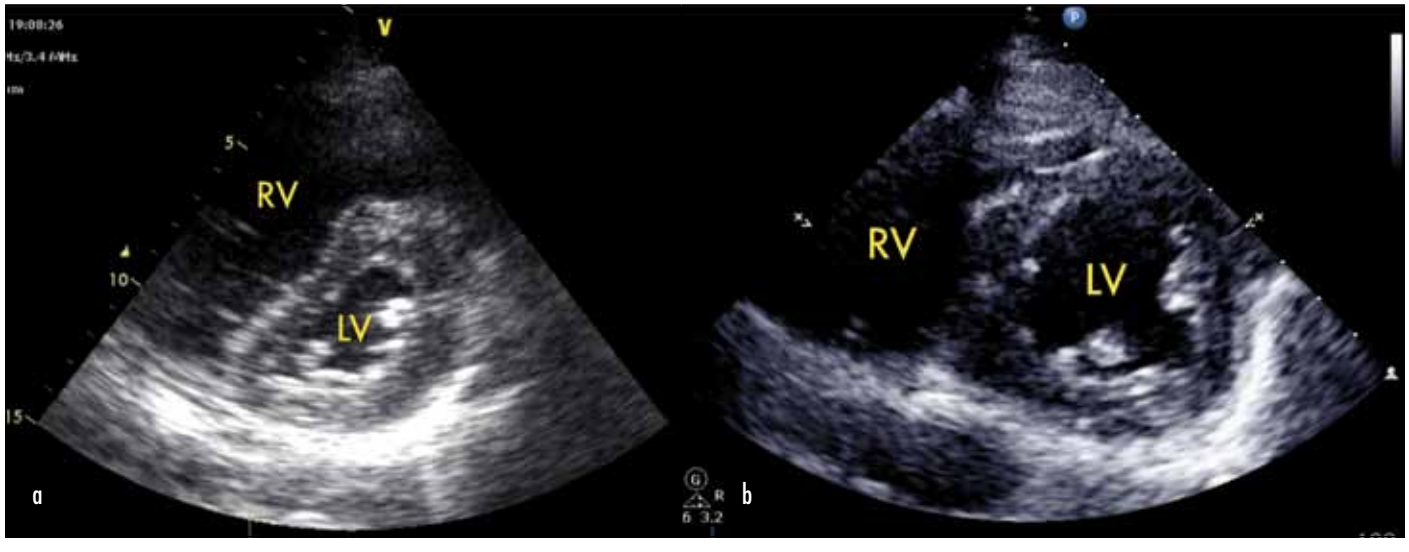
Emergency surgery in the 'high-risk' patient: a clinical challenge

Consider the case of a 72-year-old woman with an acute abdomen, booked on the emergency list for an emergency laparotomy. Her past medical history included heavy smoking, widespread rheumatoid arthritis, hypertension and non-insulin-dependent diabetes mellitus. Her accompanying GP letter reported that she had been progressively breathless on minimal exertion and had lost 2 stone in weight over the previous 6 months. An echocardiogram performed 2 years ago demonstrated good left ventricle systolic function and mild/moderate mitral regurgitation but this was not followed up.

Preoperatively she was drowsy, tachypnoeic and shocked with a significant metabolic acidaemia and a lactate level of 4 mmol/litre. An electrocardiogram demonstrated non-specific ST-T changes but it was not possible to arrange a preoperative echo. She arrived in theatre partially resuscitated but at induction became profoundly hypotensive and remained vasopressor-dependant. Invasive monitoring was established and her initial central venous pressure was 22 cmH_2O. She remained anuric and fluid-unresponsive throughout the case and her lactate and oxygen requirement rose steadily throughout the case. An adrenaline infusion was commenced and a large intravenous bolus of furosemide was given with no significant response.

It is a common dilemma in anaesthesia to site a central venous catheter and find a high central venous pressure associated with systemic hypotension. The differential for the case above is long and could include dilated cardiomyopathy, severe mitral regurgitation with pulmonary hypertension, acute myocardial ischaemia, submassive pulmonary embolus with acute right ventricle pressure or volume overload cardiac tamponade and even tension pneumothorax, the treatments of which are all completely different and potentially antagonistic. Detailed knowledge of the patient's comorbidities and clinical examination may shorten the differential but this information is often limited in the context of emergency surgery.

Figure 2. a. A parasternal short-axis view demonstrating gross right ventricle (RV) dilatation, which is compressing the left ventricle (LV) into a D-shape instead of its normal circle. If acute, this right ventricle pressure and volume overload would be consistent with a pulmonary embolus. b. A normal parasternal short-axis view. Note the circular shape and relative size of the left ventricle cavity, which is usually the same or larger than the right ventricle.



Echo in the non-cardiac theatre

The heart is not just a black box with an input and an output that can be reliably driven by increasing doses of fluid and inotropes. It is a remarkable organ that meets the metabolic needs of the body in health but in sickness it fails in different ways. Knowing how can make the difference between life and death.

The diagnosis of haemodynamic instability (as in the case above) clearly informs whether one should fluid challenge or diurese, vasoconstrict or vasodilate, use a specific inotrope or avoid inotropes altogether and whether or not further imaging or remedial interventions are indicated. Echo can make this diagnosis and without it these major intraoperative decisions are made on best guess alone and can be flawed. Echo will not replace cardiac output monitoring but combined these provide true understanding of the problem.

Transthoracic echocardiography has obvious limitations once the patient is draped on the operating table but is not impossible, given enough access. Transoesophageal echo has maximum utility in this setting and has become integral to modern cardiac surgery. However, transoesophageal echocardiography is used increasingly in major non-cardiac surgery for patients at risk of ischaemia or haemodynamic disturbance. It impacts significantly on vasoactive and fluid therapy with most benefit seen in unstable patients (Hofer et al, 2004).

The most extreme on-table cardiac instability is cardiac arrest and in a series of 22 such cases where transoesophageal echocardiography was performed during cardiopulmonary resuscitation it allowed a definitive diagnosis in 19 cases (nine thromboembolic, six acute myocardial ischaemia, two hypovolaemia and two tamponade) and directed additional surgical procedures in 14 (including four pulmonary embolectomies, three emergency coronary artery bypass grafts, two vascular explorations and several intra-aortic balloon pumps) (Memtsoudis et al, 2006). It is doubtful that this would have been possible without the information which was provided by on-table echocardiography. Of this cohort of patients 14 left theatre alive and seven survived to leave hospital.

Echo in recovery and critical care

Intensive care unit echo specialists are important because critically ill patients have different systemic pathology and cardiac loading conditions compared with those in the outpatient department. Physiology is dynamic, clinical interventions are frequent and there is a need for serial echo examinations in the intensive care unit, which cannot realistically be met by cardiologists or sonographers. For it to be effective the critical care echo practitioner needs to understand both.

One must ask the right questions and correctly interpret the right images at the right time. In this regard intensivist-performed transthoracic echocardiography images were found to be adequate in 84% of ventilated patients and had a therapeutic impact in over 50% of cases (Orme et al, 2009).

New UK critical care echo training programme

Echo is expanding rapidly into anaesthetic and critical care literature. As equipment has become ever cheaper and more available, critical care echo's limitation has been a lack of structured training and qualified trainers experienced in both echo and anaesthesia or intensive care medicine. This is about to change.

The British Society of Echocardiography and the Intensive Care Society have collaborated to produce an excellent accreditation process in critical care echo, backed by robust governance, and are currently in the process of establishing a national training network at both focused and advanced levels. Focused Intensive Care Echo (FICE) is designed to be achievable within a 6-month period and appropriate for all anaesthetists. The advanced intensive care unit echo accreditation is on a par with the British Society of Echocardiography transthoracic echocardiography process, will take 24 months to complete and is likely to be a post-CCT (Certificates of Completion of Training) achievement. Information about these opportunities can be found on the Intensive Care Society website (Bruemmer-Smith et al, 2012).

Cardiac anaesthetists have taken ownership of perioperative transoesophageal echocardiography because they are experts in the physiological interactions between patient and surgeon and it is important for general anaesthetists and intensivists to do the same. Now is the time to get involved with this exciting and rapidly evolving field. **BJHM**

Conflict of interest: none.

Blaivas M, Fox JC (2001) Outcome in cardiac arrest patients found to have cardiac standstill on the bedside emergency department echocardiogram. *Acad Emerg Med* **8**: 616–21

KEY POINTS

- Hypotension or haemodynamic instability of uncertain or suspected cardiac aetiology carries the strongest indication for echo.
- The demand for echo in some clinical areas risks outstripping supply and emergency echo is not always readily available.
- Echo has major impact on preoperative, intraoperative and postoperative clinical decision-making in high-risk non-cardiac surgery.
- Echo is expanding rapidly into anaesthetic and critical care literature and learning to practice focused transthoracic echocardiography is within the reach of all anaesthetists and intensivists.
- A new British Society of Echocardiography/Intensive Care Society critical care echo accreditation process is about to be launched in the UK at both focused and advanced levels.

Bruemmer-Smith S, Colebourne C, Fletcher N (2012) *Advanced Notice - Echocardiography Accreditation: Focused and Advanced.* Joint British Society of Echocardiography (BSE) and Intensive Care Society (ICS) Committee for Critical Care Echocardiography and Committee for Focused Intensive Care Echocardiography (FICE). www.ics.ac.uk/Meetings_Seminars/ics_modules/fice_bse_echo_accreditation (accessed 25 July 2012)

Canty DJ, Royse CF, Kilpatrick D, Williams DL, Royse AG (2012) The impact of focused transthoracic echocardiography in the pre-operative clinic. *Anaesthesia* **67**(6): 618–25

Cowie B, Kluger R (2011) Evaluation of systolic murmurs using transthoracic echocardiography by anaesthetic trainees. *Anaesthesia* **66**(9): 785–90

Douglas PS, Garcia MJ, Haines DE et al (2011) ACCF/ASE/AHA/ASNC/HFSA/HRS/SCAI/SCCM/SCCT/SCMR 2011 Appropriate Use Criteria for Echocardiography. *J Am Soc Echocardiogr* **24**: 229–67

Hofer CK, Zollinger A, Rak M et al (2004) Therapeutic impact of intra-operative transoesophageal echocardiography during noncardiac surgery. *Anaesthesia* **59**: 3–9

Loxdale SJ, Sneyd JR, Donovan A, Werrett G, Viira DJ (2012) The role of routine pre-operative bedside echocardiography in detecting aortic stenosis in patients with a hip fracture. *Anaesthesia* **67**: 51–4

Memtsoudis S, Rosenberger P, Loffler M et al (2006) The usefulness of transesophageal echocardiography during intraoperative cardiac arrest in noncardiac surgery. *Anesth Analg* **102**: 1653–7

Orme RML'E, Oram MP, McKinstry CE (2009) Impact of echocardiography on patient management in the intensive care unit: an audit of district general hospital practice. *Br J Anaesth* **102**(3): 340–4

Price S, Via G, Sloth E et al (2008) Echocardiography practice, training and accreditation in the intensive care: document for the World Interactive Network Focused on Critical Ultrasound (WINFOCUS). *Cardiovascular Ultrasound* **6**(6): 49

Price S, Uddin S, Quinn T (2010) Echocardiography in cardiac arrest. *Resuscitation* **16**(3): 211–15

Salen P, Melniker L, Chooljian C et al (2005) Does the presence or absence of sonographically identified cardiac activity predict resuscitation outcomes of cardiac arrest patients? *Am J Emerg Med* **23**: 459–62