Transothoracic Echocardiography and Anaesthesia

MICHAEL VELTMAN, FANZCA
Director of Anaesthesia, Joondalup Hospital; Cardiac Anaesthetist, Royal Perth Hospital, Perth

Dr Veltman is the Director of Anaesthesia at Joondalup Hospital, and is a cardiac anaesthetist at Royal Perth Hospital. He teaches echocardiography at Sir Charles Gairdner Hospital in Western Australia and holds an appointment as a senior fellow with the University of Melbourne in association with the postgraduate diploma course in critical care echocardiography.

INTRODUCTION

Ultrasound imaging is dramatically changing the practice of a number of critical care specialties, including anaesthesia and intensive care. As an imaging modality it offers portability, speed of data acquisition, high resolution imaging, with little or no risk to patients.

Within anaesthesia, ultrasound was used for general imaging purposes by a few pioneers in the 1980s[1], and it established a role for vascular access in the early 1990s[2, 3]. At around the same time early pioneers in cardiac anaesthesia began using transoesophageal echocardiography (TOE) for cardiac surgery. Transoesophageal echocardiography has now become a standard of care for cardiac surgery. This has occurred despite TOE being considered to have a "limited" role in review articles as recently at eight years ago[4]. More recently, ultrasound imaging has been used to facilitate nerve or plexus blocks[5].

Although most cardiac imaging in anaesthesia has used TOE, transthoracic echocardiography (TTE) has been the main ultrasound imaging mode used by the cardiologists for several decades. There is now a growing recognition that TTE may have an even greater role than TOE in many areas of critical care medicine, including anaesthesia, and that this change is inevitable[6].

TRANSTHORACIC ECHOCARDIOGRAPHY IN ANAESTHESIA

The role of TOE is now well established in relation to cardiac surgery, and TOE is being used increasingly in other areas of anaesthesia. The use of TTE has been reported less often in the anaesthetic[7] and intensive care[8] literature. Nevertheless, editorials are now appearing in mainstream anaesthesia journals[9] indicating a growing recognition that TTE may also find a role in anaesthetic practice.

There are many reasons for developing TTE skills within anaesthesia. The use of TTE in the peri-operative setting may improve the quality of the pre-operative cardiac assessment. In one study (using trained physicians with board certification in echocardiography), 43% of major cardiovascular findings were missed during physical examination, compared with 21% of major findings being missed using a point of care (POC) ultrasound examination[10]. Although neither technique was as good as the 'gold standard' of a full outpatient echocardiogram, POC ultrasound was clearly superior to clinical examination, given adequate training. The quality of information is likely to be useful throughout the perioperative period.

There is evidence that all physicians can obtain useful information using TTE. For example it has been shown that even medical students can obtain useful information with limited training[11]. The use of TTE in anaesthesia is part of the increasing role of ultrasound as a POC tool by clinicians generally.

Transthoracic Versus Transoesophageal Echocardiography

Increasingly, the primary decision in cardiology is whether to use echocardiography, Cardiac CT or MRI imaging for cardiac assessment in the stable outpatient. Within the critical care setting, echocardiography remains the primary imaging modality, and the choice is between TTE and TOE. The advantages of TTE include:-

Minimal risk to patient
Rapid delivery of information
Repeatability
Better assessment of ventricular and valvular function

Because TTE is essentially a risk free procedure and avoids the known complications of TOE. The complications of TOE are uncommon but significant, and the published incidence ranges from 0.2%[12] to 5.6%[13]. Perforation of a viscus is estimated at around 0.03%[14]. Mortality is a rare but documented complication[15] with probe insertion. With TTE, as there is no need to insert a probe, the information is available more quickly. This is particularly notable when attending emergencies, cardiac arrests, or where multiple patients are being imaged. TOE probe cleaning times are typically 20 minutes or more. As TTE carries little risk, it is easy to repeat assessments as required. To do this with TOE requires repeated risks of trauma with each examination, or leaving the TOE probe in situ.

Transthoracic echocardiography is the better imaging modality for ventricular function. The apex is poorly seen with TOE. This is why the standard 16 segment model for TOE does not include the apex, whereas the standard assessment model for TTE is a 17 segment model, that includes the true apex. For doppler assessment, the ability to use multiple windows compared to TOE allows better doppler angles to be obtained for flow assessment across valves.

Transoesophageal echocardiography is indicated primarily for the following reasons, often when TTE has been unhelpful, and these indications are identical for cardiology and anaesthesia:
Assessment of 2D valve morphology for valve repair or endocarditis.
Assessment of atrial related structures (atrial septal defects, atrial appendage thrombus, pulmonary veins).
Assessment of thoracic aortic disease (dissection, rupture).
Where TTE is not possible or provides inadequate images.

Where a choice between TOE and TTE is available, the use of TOE to look at 2D appearances of structures that are close to the oesophagus allows better resolution, mostly due to the higher frequency of TOE. This improves the resolving power of TOE and markedly improves the chance of detecting small lesions[i] such as endocarditis, dissection flaps and small septal defects[17].

Training and Accreditation in Echocardiography

Formal accreditation in echocardiography requires substantial training. According to the ACC/AHA Clinical Competence Statement on Echocardiography[18] training is categorised into three levels. Level one training is suggested for all cardiologists but would not be considered enough to formally report echocardiographic examinations. Level two echocardiography is the minimum for full diagnostic echocardiography, and consists of 150 examinations performed and 150 further examinations reviewed. At this level the practitioner is competent to practise independently and considered sufficiently skilled to know when to refer to a level three practitioner for complex cases. In the setting of full diagnostic echocardiography in anaesthesia, this would be a reasonable standard to aim for as a minimum. Level three training is sufficient to run an echocardiography laboratory, and consists of 700 examinations in total, of which the clinician should perform 300, and another 400 cases reviewed.

Standard Transthoracic Echocardiography

Formal TTE has a fairly standard structured examination. This attempts to obtain as much information as possible from the four main echo windows. Each window has a series of views, and within each view each structure is assessed using 2D, M-Mode, Colour and Spectral Doppler. All views are recorded, generally in a structured sequence, and a formal report is generated. Typically between 30 to 45 minutes of time is allocated per examination.

Given the training requirements and time constraints, it is unlikely that a significant number of anaesthetists will adopt standard TTE examinations in their routine practice. Formal TTE assessments would be appropriate where there is a high clinical suspicion of cardiac disease, and where there is sufficient time to perform a full examination. This would include a full assessment of critically ill patients in intensive care, and assessment of cardiac pathology that is detected in the outpatient clinic for the first time. However, this could be achieved by referral to a cardiologist if necessary.

Limited or Directed Transthoracic Echocardiography Examinations

The alternative to a full TTE assessment is a limited or directed examination. A large number of limited examination models have been put forward for point of care echocardiography. The interest in these limited examinations has risen sharply with the availability and the reduction in cost of portable equipment for POC assessment.

It must be stated clearly at the outset that limited or directed examinations are not a substitute for formal accredited TTE assessments. Rather they are designed for situations where limited information is sought, generally in relation to left ventricular function and filling. Some limited examination formats also assess basic valve function to exclude significant pathology. Training is focussed on these areas and can generally be achieved in a much shorter period than accreditation for full independent diagnostic echocardiography. In general, directed examinations mostly utilise 2D, and to a lesser extent colour flow doppler. The use of spectral doppler is very limited or absent in a directed examination, in comparison to a full assessment.

In anaesthesia, the directed examination has great potential to supplement or replace the stethoscope. In this role, using the existing clinical skills of the anaesthetist, the likely cause of clinical signs and symptoms could be identified for appropriate acute management. In the outpatient setting the directed POC examination would allow selective and appropriate referral of pathology for ongoing management.

DIRECTED EXAMINATION MODELS

There have been several models for limited cardiac assessment such as the FATE[19] examination in intensive care, or the BLEEP[20] examination in paediatrics. The FATE examination is supported by the British Society of Echocardiography (BSE) as a method of screening for cardiac pathology. Despite its use in one of the most difficult settings for echocardiography, the imaging quality was sufficiently good to be of value in 97% of ICU cases. Even though the FATE examination only assessed LV function and the pleura, it provided clinically important and decisive information in approximately 25% of cases.

The University of Melbourne has developed a new limited echocardiography examination known as the HEART scan (Haemodynamic Echocardiographic Assessment in Real Time) and provides hands on training workshops in its use. The HEART scan has two components to it: the Haemodynamic and the Echo Assessments. The haemodynamic component is an assessment of ventricular filling, function and pressures, and is repeatable as required to allow for dynamic changes (eg intraoperatively). The echocardiographic assessment component is a screening test that will allow identification of significant pathology of the aortic, mitral and tricuspid valves plus the pericardium. It is not a full diagnostic procedure, but is designed to allow rapid (5-10 minute) screening of valves to identify any significant pathology that might explain a murmur.

ACCREDITATION IN DIRECTED EXAMINATIONS

At present, there is no formal accreditation or certification in any directed examination. Whilst the BSE supports FATE certification, it requires active support from an approved cardiology department, and FATE can be practised only with support from that cardiology department in that hospital. Less than a handful of hospitals in the UK support this, and the requirement for cardiology support does not appear to be a successful model at this stage. The Australian Society for Ultrasound medicine (ASUM) has a directed examination certificate (CCPU), but excludes anaesthetists currently on the basis of speciality. The University of Melbourne does not yet offer certification in directed examinations, although this is being considered for their recently introduced HEART examination.

TRAINING IN ECHOCARDIOGRAPHY

There is no formal requirement to sit any examinations in order to practice echocardiography in Australia or New Zealand. The Cardiac Society of Australia and New Zealand recommends that cardiology trainees interpret 450 examinations, of which 150 should be performed personally. No guidance is given for other specialities.

In anaesthesia in Australia and New Zealand, guidelines have been developed for accreditation in perioperative TOE (ANZCA PS46), but these do not cover TTE. ANZCA is currently considering what standards would be appropriate for TTE.

For those seeking formal qualifications to demonstrate competence, three main routes exist:

University of Melbourne

The University of Melbourne offers a Diploma in Perioperative and Critical Care Echocardiography. This is currently listed as an acceptable standard for TOE in ANZCA document PS46. It is not confined to TOE, however, and covers both TTE and TOE fairly equally. The diploma can be completed over one or two years. It differs from most other certification options by providing all the educational material required. The syllabus was originally based on the United States National Board of Echocardiography (NBE) syllabus.

United States National Board Echocardiography

The US NBE offers two exams; the PTEeXAM (Examination of Special Competence in Perioperative Transoesophageal Echocardiography), and the ASCeXAM (Examination of Special Competence in Adult Echocardiography). The PTEeXAM is listed as an acceptable standard for TOE in ANZCA document PS46. It clearly limits itself to TOE currently, and therefore is not formally a qualification that assesses competence in TTE.

The ASCeXAM is an exit examination for echocardiography, which is rapidly becoming a requirement for practice in TTE. The Intersocietal Commission For The Accreditation Of Echocardiography Laboratories (ICAEL) requires practitioners to hold the ASCeXAM for laboratory accrediaition. Increasing numbers of insurers are requiring the PTEeXAM or ASCeXAM for reinbursement in the USA and Canada. The NBE examines in TTE and TOE in the areas of adult, paediatric and stress echocardiography, although it confines itself to adult echocardiographic competence. A separate examination for congenital echocardiography is being considered by the NBE.

From 2009 the NBE may hold examinations at multiple sites within and outside the USA. At present their examinations are held annually at a single site in the USA.

Australasian Society of Ultrasound Medicine

The Australian Society of Ultrasound Medicine administers the Diploma of Diagnostic Ultrasound (DDU), which has two examinations (Part I and Part II), and requires submission of case studies with analysis as part of the process of admission. The Part II exam is specialised in a number of areas, including general ultrasound and cardiology. The Part II applicant must have completed one year of echocardiography training plus two years of independent practice, and possess a speciality qualification. Entrance to the DDU is limited to certain specialities, and has very recently opened admission to anaesthetists possessing a FANZCA. The requirement to have two years of independent practice (minimum) plus a speciality fellowship marks the DDU as a higher level certification, not required (by its own rules) in order to commence independent practice in echocardiography. It is a qualification that can be obtained after years of independent practice, to effectively certify a higher level of experience in the area than simply having physician or radiology speciality qualifications.

The Australian Society of Ultrasound Medicine also offers a Certificate in Clinician Performed Ultrasound (CCPU), but anaesthetists are still excluded by speciality from entering any of the streams for this certificate (see above).

FELLOWSHIP TRAINING IN ECHOCARDIOGRAPHY.

A number of hospitals offer training in echocardiography. However, this is generally in association with training in cardiac anaesthesia, and is limited to TOE. A very small number of fellowships focus on the echocardiography training independently. The most notable institution in this regard in Westmead Hospital, which has offered comprehensive TOE and TTE training since 1996 at the fellowship level.

Several other institutions offer semi-formal programs in TTE, usually undertaken in conjunction with other training or examinations such as the diploma course, a board examination, and various workshops and courses. This would include institutions such as St Vincent's in Melbourne and the Sir Charles Gairdner Hospital in Perth.

Although training is mostly being undertaken by specialists post fellowship at present, in the future training will most likely commence during speciality training. The University of Melbourne diploma has been accepted as a formal project for the purposes of anaesthesia training, and a small number of trainees are now enrolling in this course.

WORKSHOPS

Workshops provide an introduction to echocardiography and may supplement information or skills gained in the workplace. However, they are no substitute for a fellowship or formal program of instruction.

Australian Institute of Ultrasound Medicine

The Australian Institute of Ultrasound (AIU) provides a regular stream of educational workshops on ultrasound in a variety of areas, including high quality training in formal echocardiography. These are run as a five day workshop with morning tutorials and afternoon hands on sessions.

University of Melbourne

The University of Melbourne runs 2 day workshops on point of care ultrasound in a hands-on approach with pre-reading material supplied. Specific courses for the HEART will also be available in a similar format.

ANZCA and ASA

Almost every major meeting from both ANZCA and the ASA have offered workshops in echocardiography for several years. The focus of most of these workshops has moved from TOE to TTE, with increasing opportunities to offer hands on experience. The workshops are generally short and serve as an introduction to the area. Typically the workshops are around 90 minutes in duration, and run concurrently with other sessions during the meetings.

VENDOR SPECIFIC

Most equipment vendors provide some form of hands on training programs, both free standing workshops and those run by other bodies such as the AIU and the University of Melbourne. Details of what workshops are available can be obtained from the vendor, but typically vary from one to three days in duration typically.

THE FUTURE

The future of TTE in anaesthesia holds great promise. Portable equipment will most likely follow the trend of all electronics – they will become cheaper, smaller and more capable than the current machines. Training opportunities will increase for anaesthetists, and its use in all areas of critical care will increase. Directed examinations will become more routine, and just as TOE has become a standard of care in cardiac anaesthesia, it is possible that some form of directed examination will ultimately become a standard technique in all areas of critical care, including anaesthesia and intensive care medicine. The challenge for anaesthetists is to ensure adequate training and accreditation, and to recognise their limitations. Unless an even better technology supersedes TTE, it is likely to become the cardiac imaging modality of choice in point of care assessment, for all of critical care, including anaesthesia.

SUMMARY

TTE as a cardiac imaging modality offers portability, safety and repeatability in addition to high quality imaging. The use of TOE in cardiac anaesthesia has progressed from scepticism to standard of care in less than a decade. A similar progression is now starting in TTE, mostly due to advances in portable ultrasound equipment. It is likely that at least two levels of examination will evolve: A directed assessment protocol that can be done rapidly (such as the HEART scan), and a full diagnostic examination comparable to that available in any echocardiography laboratory, which will require more extensive training and accreditation. Given the availability of adequate training and high quality equipment, the adoption of TTE in anaesthesia has the strong potential to improve patient care and contribute to the advancement of our specialty.

APPENDIX ONE - WEBSITES

The following societies provide information on standards and training that have been used in this article:

Australian Institute of Ultrasound Medicine	AIU	http://www.aiu.edu.au/
Australasian Society of Ultrasound Medicine	ASUM	http://www.asum.com.au/
American Society of Echocardiography	ASE	http://asecho.org/
British Society of Echocardiography	BSE	http://bsecho.org/
Cardiac Society of Australia and New Zealand	CSANZ	http://www.csanz.edu.au/
European Association of Echocardiography	EAE	http://www.escardio.org/bodies/associations/EAE/
The Intersocietal Commission for the Accreditation of Echocardiography Laboratories	ICAEL	http://www.icael.org/icael/index.htm
National Board of Echocardiography	NBE	http://www.echoboards.org/
University of Melbourne (*)	UMelb	http://www.heartweb.com.au/

(*) The formal location of the University of Melbourne Diploma Course is:
http://www.pharmacology.unimelb.edu.au/echocourse/

REFERENCES

1 Currie JM. Measurement of the depth to the extradural space using ultrasound. Br J Anaesth 1984; 56: 345–7

2 Armstrong PJ, Cullen M, Scott DHT. The siterite ultrasound machine—an aid to internal jugular vein cannulation. Anaesthesia 1993; 48: 319–23

3 Alderson PJ, Burrows FA, Stemp LI, Holtby HM. Use of ultrasound to evaluate internal jugular vein anatomy and to facilitate central venous cannulation in paediatric patients. Br J Anaesth 1993; 70: 145–8

4 A. Hatfield and A. Bodenham. Ultrasound: an emerging role in anaesthesia and intensive care. Br J Anaesth 1999; 83: 789–800

5 Royse C, Donnan G, Royse A. Pocket Guide to Perioperative and Critical Care Echocardiography. Chapter 13: Ultrasound Guided Regional Anaesthesia. McGraw Hill, ISBN 0 074 71611 5

[6] The Echo Working Group. CSANZ Training Guidelines In Adult Echocardiography
Available Online at: http://www.csanz.edu.au/guidelines/training/index.htm
[7] Ferguson EA; Paech MJ; Veltman MG Hypertrophic cardiomyopathy and caesarean section: intraoperative use of transthoracic echocardiography. Int J Obstet Anesth. 2006; 15:311-6
[8] Stanko LK ; Jacobsohn E ; Tam JW ; De Wet CJ ; Avidan M. Transthoracic echocardiography: impact on diagnosis and management in tertiary care intensive care units. Anaesth Intensive Care. 2005; 33:492-6
[9] Editorial II Br J Anaesth 2006;96: 414–17
[10] Spencer KT; Anderson AS; Bhargava A; Bales AC; Sorrentino M; Furlong K; Lang RM
Physician-performed point-of-care echocardiography using a laptop platform compared with physical examination in the cardiovascular patient. J Am Coll Cardiol. 2001; 37:2013-8
[11] Hope MD; de la Pena E; Yang PC; Liang DH; McConnell MV; Rosenthal DN. A visual approach for the accurate determination of echocardiographic left ventricular ejection fraction by medical students. J Am Soc Echocardiogr. 2003; 16:824-31
[12] Kallmeyer IJ; Collard CD; Fox JA; Body SC; Shernan SK. The safety of intraoperative transesophageal echocardiography: a case series of 7200 cardiac surgical patients. Anesth Analg. 2001; 92:1126-30
[13] Hüttemann E ; Schelenz C ; Kara F ; Chatzinikolaou K ; Reinhart K The use and safety of transoesophageal echocardiography in the general ICU -- a minireview. Acta Anaesthesiol Scand. 2004; 48:827-36
[14] Min JK; Spencer KT; Furlong KT; DeCara JM; Sugeng L; Parker Ward R; Lang RM
Clinical Features of Complications From Transesophageal Echocardiography: A Single Center Case Series of 10,000 Consecutive Examinations. J Am Soc Echocardiogr 2005;18:925-929
[15] De Vries AJ, van der Maaten JM, Laurens RR. Mallory-Weiss tear following cardiac surgery: transoesophageal echoprobe or nasogastric tube? Br J Anaesth 2000; 84:646-9.
[16] Reynolds HR, Jagen, MA, Tunick PA, Kronzon I. Sensitivity of transthoracic versus transesophageal echocardiography for the detection of native valve vegetations in the modern era. J Am Soc Echocardiogr. 2003; 16: 67-70
[17] TTE/TEE Appropriateness Criteria Writing Group ACCF/ASE/ACEP/ASNC/SCAI/SCCT/SCMR 2007 Appropriateness Criteria for Transthoracic and Transesophageal Echocardiography. J Am Soc Echocardiogr, 2007; 20: 787-805
[18] Miguel A. Quinones et al.
ACC/AHA Clinical Competence Statement on Echocardiography
A Report of the American College of Cardiology/American Heart Association/American College of Physicians–American Society of Internal Medicine Task Force on Clinical Competence
J Am Coll Cardiol 2003;41:687-708
[19] Jensen MB, Sloth E, Larsen KM and Schmidt MB
Transthoracic echocardiography for cardiopulmonary monitoring in intensive care.
European Journal of Anaesthesiology 2004;21:700-707
[20] Pershad J ; Myers S ; Plouman C ; Rosson C ; Elam K ; Wan J ; Chin T
Bedside limited echocardiography by the emergency physician is accurate during evaluation of the critically ill patient.
Pediatrics. 2004; 114:e667-71