Perioperative echocardiography enables direct visualization of the chambers of the heart, its valves, and the major connecting vessels (aorta, pulmonary artery, pulmonary veins, and vena cavae). Many aspects of cardiac function may be measured and monitored by transoesophageal (TOE) and transthoracic (TTE) echocardiography. In cardiac anaesthesia, echocardiography has become an established imaging modality.\textsuperscript{1} With recent proposed changes in training, the goalposts for perioperative echocardiography appear to have extended to include non-cardiac surgery.\textsuperscript{2} This Editorial examines the feasibility of using perioperative echocardiography in routine non-cardiac practice. It adopts a framework similar to that for diagnostic tests in the laboratory,\textsuperscript{3} that is to say, clinical validity (the ability to detect presence or absence of disease), clinical usefulness (does the test lead to better patient outcomes?), safety, education, and economics.

The validity of TOE as a monitor may be illustrated using a model of infective endocarditis in which multiple structural abnormalities, for example, vegetations, abscesses, and pseudoaneurysms may be seen. In a study of 29 patients who underwent cardiac surgery for infective endocarditis, the sensitivity and specificity of TOE for visualization of vegetations compared with intraoperative findings were 96% and 100%, respectively. Equally high values (89% and 100%, respectively) were obtained for detection of abscess and pseudoaneurysm. These values were similar to those obtained by computed tomography in the same patients.\textsuperscript{4} For assessment of valvular function, imaging by TOE and by magnetic resonance imaging (MRI) is equivalent. Compared with intraoperative findings of mal-apposition of mitral valve leaflets, TOE had a sensitivity of 75% and specificity of 88%. The values for MRI were 71% and 88%, respectively.\textsuperscript{5}

These favourable findings for TOE in the heart contrast with those for TOE in the major vessels. In a study of patients requiring pulmonary embolectomy, TOE was found to have a specificity of 95% but a sensitivity of only 26%.\textsuperscript{6} Furthermore, in a meta-analysis of six studies evaluating TOE for detection of atherosclerosis in the ascending aorta, the specificity was 99%, whereas the sensitivity was only 21%.\textsuperscript{7}

The use of TTE also has validity. In critical care practice, TTE has been used to investigate causes of haemodynamic instability. In a study of 100 patients, imaging was deemed to be adequate in 99%, with sensitivity and specificity for a cardiac cause of 100% and 95%, respectively. Typical causes of haemodynamic instability were ventricular dysfunction, tamponade, rupture of myocardium, and obstruction of the left ventricular outflow tract.\textsuperscript{8}

For risk stratification of patients who are at risk of myocardial infarction and death, stress echocardiography (TTE) before elective non-cardiac surgery has been found to provide diagnostic information. In a meta-analysis comprising 25 echocardiographic and 50 nuclear diagnostic tests in patients who had non-cardiac surgery, the positive likelihood ratio, that is to say, the ratio of the true-positive rate (sensitivity) to the false-positive rate (1-specificity) was obtained. The likelihood ratio of 4.09 (95% CI 3.21–6.56) for a cardiac event with stress echocardiography was superior to that of 1.83 (95% CI 1.59–2.10) for thallium imaging.\textsuperscript{9} In addition, stress echocardiography was found to be a better predictor of an uneventful perioperative period than thallium scanning. The likelihood ratio for absence of a cardiac event was, conversely, lower for stress echocardiography (0.23, 95% CI 0.17–0.32) than for thallium scanning (0.44, 95% CI 0.36–0.54).

Perioperative echocardiography has been reported during a variety of types of non-cardiac surgery, that is to say, vascular, endovascular, transplant, obstetrics, trauma, and orthopaedics.\textsuperscript{10} It is believed to be clinically useful as it has influenced intraoperative anaesthetic decisions, particularly in patients with increased risk factors for myocardial ischaemia or haemodynamic instability. In a prospective observational case series of 98 patients undergoing abdominal surgery, the opinion of the anaesthetists was that TOE led to useful changes in intraoperative management such as administration of fluids, vasopressors, vasodilators, and beta-blockers. In some patients, use of the pulmonary artery catheter was obviated.\textsuperscript{11} Similarly, in another case series comprising 90 patients undergoing vascular, visceral, and chest surgery, TOE was associated with changes in drug (47%) and fluid therapy (24%).\textsuperscript{12}
Cardiac arrests occur occasionally during non-cardiac surgery. In this situation, TOE has been reported to be helpful for diagnosis and for establishing rescue therapy. In a prospectively collected case series of 125,965 patients, 10 cardiac arrests occurred. In these patients, TOE was able to detect abnormalities in ventricular wall motion and myocardial infarction (confirmed by increase in troponin). It was also possible to identify pulmonary embolism and severe hypovolaemia. In another case series of patients who suffered a cardiac arrest during non-cardiac surgery, TOE was also found to be useful. Of 22 patients scanned, a primary diagnosis was identified by TOE in 19 patients; these included myocardial ischaemia, thromboembolism, pericardial tamponade, and hypovolaemia. Patients went on to have definitive rescue treatment such as emergency coronary artery surgery, intra-aortic balloon support, pulmonary embolectomy, pericardiotomy, and fluid resuscitation.

In addition to the operating theatre, echocardiography has been shown to be useful in critical care. For example, in a case series comprising 224 TOE and TTE scans in 217 patients, change in management, that is to say, administration of fluids, inotropes and other drugs, occurred in 51% as a direct consequence of the information provided by echocardiography. In general, echocardiography is believed to be helpful for the investigation and treatment of haemodynamic instability in critical care.

It can be seen that the evidence for clinical usefulness of perioperative echocardiography is derived from audit data and expert opinion in case series. In audits, authors compare published guidelines with their practice. They then interpret data and make conclusions on the utility of echocardiography. Unfortunately, evidence from case series is largely descriptive and subject to bias from the investigators. The purist would look for more objective evidence from cohort studies and randomized controlled trials. A cohort study evaluating the association between echocardiography and outcome may be possible. As would be the case with any outcome study evaluating a monitoring technique, it would require large numbers of patients over a long period of time. Cohort studies would be subject to selection bias and information bias; there would also be the problem of confounding owing to other factors such as severity of illness.

What can we say about randomized controlled trials, perhaps evaluating TOE in high-risk patients having abdominal aneurysm surgery? In theory, this study design would obviate the problem of confounding, provided results are analysed on an intention-to-treat basis. Both arms of the study, that is to say, with and without echocardiography, would have the same confounding factors and thus any difference in outcome between them would be attributable to perioperative echocardiography and enhanced clinical management. While this type of study design would provide the best level of evidence, it would still be subject to much observer and performance bias, as blinding would not be possible. Thus, study designs for assessing the relationship between perioperative echocardiography and outcome have limitations.

The benefits of perioperative echocardiography should be weighed against its risks. Of the imaging methods, TOE is the most invasive and complications have arisen, albeit infrequently. Data for complications attributable to TOE are derived from cardiac anaesthetic practice. Typical injuries include odynophagia, dental injury, upper gastrointestinal haemorrhage, and oesophageal perforation. In a case series of 4,784 patients, six complications were detected, giving an incidence of 0.13%. This rate is similar to that of 0.2% in another case series examining 7,200 patients.

A monitor is useful only if the information that it provides is of high quality and interpreted correctly. Perioperative echocardiography is still a specialized form of monitoring in anaesthetic practice. Unlike any other monitors in anaesthesia, for example, pulse oximetry or gas analysis, more training is required before sufficient expertise and consistency can be attained. In cardiac anaesthetic practice, courses, examinations, and accreditation processes have been introduced over the past 15 years to educate and encourage its use. More recently, these educational initiatives have extended to include non-cardiac practice. There is considerable enthusiasm and four levels of competencies have been proposed for training in critical care. At the most basic level, an emergency echocardiogram may be obtained to diagnose major causes of arrest or shock, and the operator is capable of recognizing when referral for a second opinion is indicated. The focused scan fits in here and acronyms include FATE (Focused Assessment with Transthoracic Echocardiography) and FEEL (Focused Echocardiographic Evaluation in Life support). The next stage is Level 1 where all standard views should be obtained and there is some ability to diagnose common abnormalities. At Level 2, the sonographer should be able to diagnose all cardiovascular abnormalities but not carry out specialized and research-based echocardiographic examinations that would befit competence at Level 3.

Although perioperative echocardiography is well-established in cardiac anaesthesia, it is not so in routine general anaesthetic practice. The main reason for this disparity probably relates to the profound influence it has made on cardiac surgery. For example, retrospective analysis of prospectively collected data from two case series showed that at least 5.6% of cardiac operations were altered on the basis of intraoperative echocardiographic findings and that there were cost-benefit savings. These findings concur with more recent data from 12,566 patients in whom TOE influenced surgical decisions (and thus cost effectiveness), particularly during combined valve and graft operations. For non-cardiac surgery, however, there is no definitive recommendation for perioperative echocardiography. Indeed, the 2007 guidelines of
the American College of Cardiology and the American Heart Association maintain that there is insufficient evidence to determine the cost-effectiveness of TOE for its use as a diagnostic monitor or to guide therapy during non-cardiac surgery.26

Perioperative outcomes are affected adversely by haemodynamic complications such as myocardial ischaemia, cardiac tamponade, thromboembolism, and hypovolaemia. Official guidelines recommend echocardiography for investigation of such major haemodynamic disturbances.27 In the peri-arrest situation, proposals have been made recently to include ‘point-of-care’ TTE in Advanced Life Support algorithms.38 However, as expectations for improved medical care continue to increase in an ageing population, prophylaxis or early detection of haemodynamic complications would be preferable to rescue utilization. To achieve this goal from a monitoring perspective, perioperative echocardiography would have to become more widely utilized in non-cardiac anaesthesia. We suggest that routine perioperative echocardiography in non-cardiac surgery would be indicated in patients who have cardiovascular disease and are expected to require cardiovascular support, such as inotropes or mechanical support. Other indications include: surgery, such as major vascular surgery and lower limb surgery, in which significant haemodynamic changes are anticipated; cardioversion in patients with risk factors for thromboembolism,39 and during percutaneous cardiological procedures, for example, device closure of a patent foramen ovale. In addition, perioperative echocardiography is indicated when conventional anaesthetic monitoring does not provide the answer to an underlying cardiovascular problem, for example, endocarditis, pericardial effusion, valvular dysfunction, and obstruction of the left ventricular outflow tract. The modality of perioperative echocardiography (TOE or TTE) would depend on factors such as: general anaesthetic state, access to the patient, anticipated image quality, and expertise of the echosonographer. While TOE would be the preferred method in the operating theatre, a combination of TOE and TTE is more likely to be utilized in critical care.

In conclusion, over time with improvements in education, miniaturization of transducers, and affordable basic equipment, more anaesthetists will utilize echocardiography. We envisage that there will be increased integration with conventional anaesthetic monitors and that perioperative echocardiography will be the new standard in monitoring as it becomes part of routine non-cardiac anaesthetic practice.

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References
1 Kneeshaw JD. Transoesophageal echocardiography (TOE) in the operating room. Br J Anaesth 2006; 97: 77–84
8 Joseph MX, Disney PJS, Da Costa R, Hutchison SJ. Thoracochoracic echocardiography to identify or exclude cardiac cause of shock. Chest 2004; 126: 1592–7
Securing the airway in a safe and timely manner is of prime importance in anaesthetic practice. This applies to both routine and difficult intubations, be they expected or unexpected. Airway management was the cause of just over half of anaesthesia-related cardiac arrests in a recent review of adult and paediatric perioperative cardiac arrests. A number of new airway aids and devices are available that aim to facilitate airway management. They may be broadly classified as: (i) tracheal tube guides, (ii) supraglottic devices such as the laryngeal mask airway (LMA), and (iii) indirect video-laryngoscopes (Table 1). Over the past few years, fiberoptic technology has been incorporated into airway equipment with huge potential to obtain good glottic visualization during laryngoscopy.

A number of guides and introducers are available to facilitate passage of the tracheal tube into the trachea. Lighted stylets or ‘lightwands’ have been described as far back as the 1950s to facilitate tracheal intubation. Newer, specifically designed devices now provide an intubation stylet equipped with a bright light at the tip. Intubation is blind and does not require direct laryngoscopy. Correct positioning relies on transillumination of the anterior neck tissues. In experienced hands, it is a useful alternative to direct laryngoscopy even in cases of difficult intubation and it can be especially valuable when the airway is obscured by blood or secretions. The lightwand technique is part of the ASA difficult airway algorithm, and in a postal survey of Canadian anaesthetists published in 2005, the lighted stylet was the preferred equipment in a difficult intubation scenario, ranked ahead of even the fiberoptic bronchoscope.

Optical stylets are lighted stylets that also incorporate fiberoptics into their tip. What lies ahead of the stylet/tracheal tube unit can be visualized through an eye piece or...