Transoesophageal echocardiography in anaesthesia and intensive care

Transoesophageal echocardiography (TOE) is becoming an increasingly important diagnostic tool in anaesthesia and intensive care. The oesophagus lies immediately posterior to the heart and great vessels and, unlike transthoracic ultrasound, provides an imaging window without interference from intervening structures. Because of this proximity, TOE can use high frequency 5-MHz probes which provide much higher resolution images than those that can be obtained with conventional 2.5–3-MHz transthoracic probes. The uses of TOE have been classified into five main categories [1]:

1. Imaging of structures which may be inadequately displayed by transthoracic echocardiography, such as the left atrial appendage and the descending thoracic aorta, or when the presence of a prosthetic valve produces an ultrasound shadow.

2. Diagnosis of conditions in which the superior image quality is vital, for example assessment of endocarditis, intracardiac thrombus, valvular malfunction or aortic dissection. In aortic dissection, TOE has been reported in experienced hands to have a diagnostic sensitivity and specificity of more than 95% [2]. An emerging indication is the routine use of TOE to exclude the presence of left atrial thrombus before elective cardioversion for atrial fibrillation [3].

3. Ultrasound examination of patients with conditions such as obesity or emphysema which prevent image clarity with transthoracic techniques.

4. Intraoperative use in both cardiac and non-cardiac surgery to monitor such variables as left ventricular wall motion, effectiveness of valve repair and presence of air embolism without disturbing the surgical field.

5. Use in the intensive care unit to aid diagnostic conundrums unresolved by other techniques.

The technique was first used in 1976 using a rigid device but standard technology now comprises a biplane probe mounted on a flexible, steerable endoscope imaging in both horizontal and transverse planes, with spectral and colour flow Doppler. Newer multiplane probes allow scanning at any angle through 180°. The technique is invasive, usually carried out under sedation and appears remarkably safe. The overall complication rate is of the order of a fraction of 1% in most series [1]. In one large study group of more than 10,000 diagnostic cases, there was one fatality (bleeding tumour infiltrating the oesophagus) and 18 cardiac, pulmonary or bleeding complications [4]. This safety record contrasts markedly with that of gastrointestinal endoscopy [5], perhaps because patients are monitored more intensively and the danger of cardiorespiratory complications are readily apparent. The principal contraindications to TOE are oesophageal tumours, stenoses, diverticulae or varices. Transient bacteraemia has been reported after TOE but antibiotic prophylaxis against endocarditis is currently considered unnecessary.

The TOE probe can be maintained in a stable position allowing beat-by-beat monitoring of cardiac function over prolonged periods. Cardiac output can be measured by Doppler interrogation of aortic blood flow, assessment of preload can be obtained by measurement of left ventricular diastolic dimension and of afterload by calculation of end-systolic wall stress, as described by Greim, Roewer and Esch [6]. Contractility can be assessed by measurement of shortening fraction and ejection fraction, although the dependence of such measures on loading conditions and the geometrical assumptions made with calculation of ejection fraction imply that such measures are of limited value. Determination of the end-systolic left ventricular diameter–pressure relationship in a manner analogous to the pressure–volume relationship may be a better echo-derived index of ventricular function [7].

The ability of TOE to image clearly the endocardial surface allows the technique to be used to monitor global and regional ventricular function in both cardiac and non-cardiac surgical patients in an attempt to detect the occurrence of myocardial ischaemia. Regional wall motion abnormalities occur within seconds of the onset of myocardial ischaemia [8], well before the occurrence of ECG changes or chest pain. Studies in high risk patients have confirmed that TOE is a more sensitive indicator of perioperative myocardial ischaemia than the ECG or haemodynamic monitoring [9, 10]. Whether or not this increased ability to detect perioperative ischaemia results in improved patient outcome is unknown. Compared with preoperative clinical evaluation and standard ECG monitoring, intraoperative TOE failed to add significantly to the ability to identify patients with adverse outcomes caused by myocardial ischaemia [11]. A limitation to monitoring myocardial ischaemia by TOE is that continuous monitoring is usually performed in only one plane and may fail to detect ischaemia in other segments. More importantly, detection of wall motion abnormalities is made by eye so that considerable experience is necessary in image interpretation. This is a particular problem when there are pre-existing wall motion abnormalities, a common feature of
patients with ischaemic heart disease. Automated edge detection techniques and the use of cine loops and split screens to allow image comparison may help to overcome such problems. On-line analysis packages are being developed which give continuous information on both measured and derived haemodynamic indices.

The increasing use of mitral and tricuspid valve repair rather than replacement in cases of valvular incompetence has made detailed knowledge of valvular anatomy important in the preoperative assessment of such patients. A TOE study performed before operation or on the operating table before cardiopulmonary bypass allows the surgeon to plan appropriate operative strategies to deal with annular dilatation, cusp retraction, prolapse or perforation. Intraoperative TOE performed after mitral valve repair has been found to identify accurately both satisfactory repairs and those cases with significant residual regurgitation requiring surgical revision [12, 13]. However, assessment of the severity of mitral regurgitation by echo Doppler study is unsatisfactory because colour flow Doppler mapping displays velocity, not total regurgitant flow, and certainly does not provide an “ultrasonic angiogram”. The tendency of eccentric regurgitant jets to wrap around the circumference of the left atrium makes underestimation of their severity a common problem. Again, because of the lack of hard numerical data and derived indices, considerable experience in signal interpretation is necessary. Numerous other cardiac surgical procedures have been reported in which intraoperative TOE has been helpful, including myectomy for hypertrophic cardiomyopathy, resection of membranous subaortic stenosis and pulmonary artery and vein anastomosis during lung transplantation.

Although not all editorial writers have been enthusiastic about intraoperative TOE [14–16] and have emphasized the dangers of increased complications and the potential for misdiagnoses, there seems to be a growing acceptance of its value, particularly in valve reconstruction. If TOE is to be brought into routine use as an intra- and post-operative monitoring procedure or in the assessment on the operating table of the results of valvular surgery, two important difficulties arise. The first is the ready availability of equipment, as and when it is needed, and the second is the presence of a well trained operator to interpret the results. The costs of providing an intraoperative TOE service are hard to estimate. A TOE probe alone currently costs in the region of £30 000 (and has a limited life span of approximately 500 procedures) and an echo Doppler system approximately £100 000. The set-up costs of a dedicated intraoperative unit are consequently substantial, yet sharing time on machines which are in heavy demand for routine diagnostic use inevitably implies that they may be unavailable when required.

Because of their clarity, TOE signals are much easier to interpret than those from transthoracic probes, but nevertheless correct training is essential. To date in the UK, TOE has been largely the preserve of cardiologists but it is impractical to expect them to provide an on-demand intraoperative service. For anaesthetists or surgeons to undertake the responsibility of image interpretation requires an addendum to their normal training programmes. Furthermore, when trained, skills need to be practised to be retained. At present there are no UK guidelines even for the training of cardiologists in TOE but the American Society of Echocardiography published its recommendations in 1992 [17]. Recent preliminary data from Yale indicate that it is not possible during a 3-month cardiac anaesthesia rotation to acquire the standard of skill necessary for independent practice [18]. Although it is recognized that specialized training in TOE for anaesthetists is essential, it is currently difficult to know how it would be best achieved or what numbers and type of case mixed will be required. As with so many things in the UK, success with the technique is likely to come from a small group of enthusiasts who have the energy to raise the money for equipment and the commitment to train correctly, probably in their own time.

The impressive image quality obtainable with TOE and the relative ease with which it can be performed make it likely that it will become an increasingly important diagnostic and monitoring tool during surgery and in the intensive care unit. However, as with any imaging technique, the results obtained will only be as good as the quality of interpretation and this implies appropriate training and continued collaboration with cardiological colleagues, not “having a go” when it becomes a necessity. The potential for misdiagnosis with any imaging technique must never be forgotten.

J. N. Townend, P. Hutton
University Departments of Cardiovascular Medicine and Anaesthetics and Intensive Care Queen Elizabeth Hospital Edgbaston Birmingham B15 2TH

References


