January 2015

Perioperative and acute care transesophageal echocardiography (TOE)

Madiha Hashmi

Aga Khan University, madiha.hashmi@aku.edu

SPECIAL ARTICLE

Perioperative and acute care transesophageal echocardiography (TOE)

Madiha Hashmi

Director Surgical ICU & Assistant Professor, Department of Anesthesiology, Aga Khan University, Karachi, 74800 (Pakistan)

Correspondence: Madiha Hashmi, Director Surgical ICU & Assistant Professor, Department of Anaesthesiology, Aga Khan University, Stadium Road, P.O. Box 3500, Karachi, 74800 (Pakistan); hashmi_madiha@yahoo.ie

ABSTRACT

In Pakistan perioperative transoesophageal echocardiography (TOE) during cardiac surgery is available in a few centers with reliance on cardiologists and cardiac technicians and its use in non-cardiac surgery and intensive care units is very limited. In view of the increasing popularity of TOE based on obvious benefits this review is presented with an aim to evaluate the current indications and potential benefits of using TOE during anesthesia for cardiac and non-cardiac surgery and the intensive care units and compare TOE with pulmonary artery catheter (PAC) and transthoracic echocardiography (TTE) as an hemodynamic monitor in the acute care setting.

Key words: Transesophageal echocardiography; Anesthesia; Intensive care unit; Cardiac surgical procedures; Hemodynamics; Pulmonary artery catheter

Citation: Hashmi H. Perioperative and acute care transesophageal echocardiography (TOE). Anaesth Pain & Intensive Care 2015;19(3):297-302

INTRODUCTION

Transoesophageal echocardiography (TOE) was introduced for perioperative use during cardiac surgery in the late 1980s.[1] It is a semi-invasive imaging technique that provides a rapid, real-time, point-of-care assessment of structure and function of the heart and great vessels.[2] The timely provision of information about the filling status, ventricular systolic and diastolic function, the function of the valves and presence or effect of fluid in the pericardial and pleural cavities may significantly influence surgical and medical decision making in anesthesia and in intensive care.[3-5] It is not only an important monitoring technique and diagnostic tool for the management of cardiac surgical patients but is being utilized more frequently during non-cardiac surgery and acute care settings like intensive care units and emergency departments.

In a retrospective evaluation of 7200 cardiac surgery patients, there was no mortality associated with the use of TOE, and morbidity was only about 0.2%.[6] The TOE probe is introduced blindly into the esophagus and can damage the hypopharynx and the esophagus.[7] Pre-existing esophageal diseases are therefore, absolute contraindications to the use of TOE. In order to minimize complications careful passage of the probe by a properly trained practitioner is recommended. Improper use can also cause hemodynamic changes such as hypertension, hypotension, and arrhythmias, therefore, in awake patients, especially when marked hemodynamic instability is present or expected, good sedation or adequate local anesthesia is required to avoid circulatory disturbances.

Adopting TOE without formal training can misguide and lead to mismanagement. The American Society of Echocardiography (ASE) established the Council for Intraoperative Echocardiography in 1993, to address issues related to the use of echocardiography in the operating room. In 1997, the Council board created a set of guidelines for performing a comprehensive TOE examination that has been endorsed by the Society of Cardiovascular Anesthesiologists (SCA) Task Force for Certification in Perioperative Transesophageal Echocardiography.[8]

In Pakistan perioperative TOE during cardiac surgery is available in a few centers with reliance on cardiologists and cardiac technicians and its use in non-cardiac surgery and other acute care settings

is very limited. In view of the increasing popularity of TOE based on obvious benefits this review is presented with an aim to evaluate;

- Current indications and potential benefits of using TOE during anesthesia for cardiac and non-cardiac surgery and acute care settings like intensive care unit and emergency department.
- Compare TOE with pulmonary artery catheter (PAC) and transthoracic echocardiography (TTE) as a hemodynamic monitor, perioperatively and in the acute care settings.

PERIOPERATIVE TOE FOR CARDIAC SURGERY

The TOE probe is positioned inside the oesophagus and the transducer is close to the heart so that a good acoustic window is available for TOE even when the chest is open, without competing for space with the surgeon[1]. Comprehensive Intraoperative TOE examination consists of a series of 20 cross-sectional views of the heart and great vessels.[8] Miller and colleagues have published a revised basic examination with recommendation to acquire and record six views in the Pre-CPB views, three at the time of separation from the CPB and four views Post-chest closure.[9]

1. **Coronary Revascularization:** Real time visualization of cardiac chambers during coronary revascularization makes hemodynamic manipulation simple and evidence-based. Its ability to assess both global and regional ventricular systolic function makes it an invaluable monitor to diagnose ischemia secondary to graft failure at the time of separation from the cardiopulmonary bypass which may prove lifesaving.[10] Use of TOE for coronary artery bypass grafting in patients at an increased risk of myocardial ischemia or infarction is described as a category II indication.[11] However routine use of TOE during coronary revascularization can be adopted as it has shown to have a significant impact on management, decision making and outcome.[12-14] Intraoperative transoesophageal echocardiography can result in major change of surgical strategy in a significant number of patients when used routinely for off-pump coronary artery bypass (OPCAB).[15]
2. **Mitral Valve Repair:** Mitral valve repair surgery is a category I indication for the use of perioperative TOE.[11] During repair of a regurgitant mitral valve, a pre-bypass TOE examination is used to evaluate the mechanism of regurgitation that guides the surgeon to plan proper surgical technique before the heart is stopped.[16] Adequacy of repair can be assessed before the chest is closed and remedial work undertaken, thus avoiding a second operation.[1]
3. **Prosthetic Valve Replacemnt:** According to the ASA/SCA guidelines the use of TOE for valve replacement is a category II indication [11]. However during valve replacement use of TOE allows sizing the valve annulus, confirms proper functioning of the new valve by ruling out any peri-valvular leaks and confirms that there is no air in the cardiac chambers.
4. **Complex Congenital Heart Procedures:** Use of TOE during correction of adult and paediatric congenital heart disease is also a category 1 indication.[11] TOE examination will not only confirm the preoperative diagnosis of complex lesions, but may identify new lesions not diagnosed before and documents satisfactory correction.
5. **Aortic Dissection:** Aorta can be visualized along its entire length from the aortic valve to the diaphragm by advancing and withdrawing the TOE probe in the esophagus and rapidly detect, localize and assess the extent of the dissection.[17] Rapid and accurate identification of the site of aortic dissection is vital because prompt surgical treatment is required if the dissection affects the ascending aorta (Stanford Type A) and if ascending aorta is not involved (Stanford Type B), patients do better with conservative management.[1]

Routine use perioperative TOE for all cardiac surgical cases may not be feasible in centers with high workload, but in centers with low workload use of TOE is recommended for acquisition and maintenance of skill and teaching purposes.[18]

PERIOPERATIVE TOE FOR NON-CARDIAC SURGERY

Following are some of the indications for using TOE during anesthesia for non-cardiac surgery.

1. **Myocardial Ischemia:** TOE can detect left ventricular regional wall motion abnormalities (RWMAs) associated with ischemia before ECG can demonstrate evidence of ischemia[1]. Use of perioperative TOE is therefore highly recommended in patients at risk for myocardial ischemia undergoing major non-cardiac

surgery[19].

2. **Hypovolemia:** It is simple to diagnose hypovolemia by TOE because in patients with normal systolic function, hypovolaemia results in a small, vigorously contracting left ventricle resulting in end-systolic cavity obliteration and 'kissing' papillary muscles[18].
3. **Hemodynamic Instability:** Hemodynamic instability is common during major surgeries as a result of acute blood loss, hypovolaemia, reduced peripheral vascular resistance or pump failure. TOE has the unique ability of direct real time visualization of cardiac structures and giving information about left ventricular contractility, cardiac filling, cardiac output, or decreased peripheral vascular resistance. Identification of the most likely cause of hemodynamic instability directs appropriate use of fluids, inotropes or vasopressors.
4. **Liver Transplant Surgery:** Surgical manipulation and massive fluid shifts during liver transplant surgery leads to hemodynamic instability. TOE provides a useful adjunct to PAC in intraoperative hemodynamic monitoring during liver transplantation, especially in those patients at risk for cardiac complications due to pre-existing cardiovascular disease.[20]
5. **Neurosurgery:** During craniotomies in the sitting position there is a risk of venous air embolism (VAE). Massive VAE and paradoxical embolism across a patent foramen ovale can be life threatening therefore early detection and treatment is necessary. TOE is a more sensitive method for the detection of entrained intracardiac air than precordial Doppler. Identification of patients at risk for right-to-left shunts with a basic perioperative TOE examination may influence the operative team to avoid the sitting position in this patient population and avoid the risk of paradoxical embolisms.[21]

TOE IN ACUTE CARE

1. **Hemodynamic Assessment:** Evaluation of hemodynamic instability in by TOE is safe, rapid, accurate, and can be done repeatedly by the physicians trained in its use.[22] A simple systematic approach for assessment of circulatory failure consists of seeking answers to the following four queries;[23]

- Is the of intravascular volume status adequate, and/or is the patient 'fluid responsive'?
- Is there evidence of impaired cardiac function? If yes what is the reason? Is it LV systolic dysfunction, acute cor pulmonale or is there myocardial ischemia?
- Is there any valvular dysfunction?
- Is there evidence of vasoplegia?

How to assess fluid responsiveness: The collapsibility index of the SVC can be used to assess volume responsiveness in ventilated ICU patients based on the respiratory variations in the dimensions of the SVC[24]. To calculate the collapsibility index, the maximum (expiratory) and minimum (inspiratory) diameters of the SVC during tidal ventilation are required.

Collapsibility index = $(SVC_{max} - SVC_{min} / SVC_{max})$ x 100

A collapsibility index of more than 36% identifies fluid responders versus nonresponders, with a sensitivity of 90% and a specificity of 100%. Partial or total collapse of SVC during inspiration accurately predicts fluid responsiveness.

How to assess LV systolic dysfunction: FAC is calculated by measuring LVEDA and LVESA[18]. Systolic function is categorized as normal (FAC > 50%), moderately decreased (FAC = 40% to 50%), or severely decreased (FAC < 40%). "Eye-ball" assessment of FAC by experienced observers is also reliable to categorize systolic function. Impaired systolic function may suggest the need for an inotrope.

How to diagnose Cor pulmonale: RV dilatation is indicated by a ratio of RVEDA/ LVEDA > 0.6. A ratio > 1.0 indicates severe RV dilatation and RV systolic failure or acute cor pulmonale and contraindicates further fluid therapy[18]. Acute cor pulmonale is most likely secondary to massive pulmonary embolism and ARDS and indicates the need for vasopressors and inotropic therapy to support RV function, strategies to reduce PVR (correction of acidosis and hypoxia, inhaled nitric oxide, etc.) and a reduction in airway pressure to reduce RV afterload.

How to diagnose valvular dysfunction: Colour flow Doppler is used to assess the presence of severe mitral, aortic or tricuspid regurgitation or stenosis. The goal is not to quantify the grade of regurgitation exactly

but to establish whether the regurgitation is responsible for or contributes to the circulatory or respiratory failure.[18]

How to assess vasoplegia: A normal LVEDA along with reduced LVESA (high FAC), is suggestive of vasoplegia and indicates the need for vasopressor therapy.

2. **Septic Shock:** In septic shock TOE can be used to identify fluid responders by demonstrating SVC collapsibility.[23,24] LV dysfunction is also common in septic shock or may occur after norepinephrine therapy and can be diagnosed by a decreased FAC and indicates need for inotropes. Demonstration of vasoplegia is also suggestive of sepsis and the need for vasopressor therapy.
3. **Suspected Pulmonary Embolism:** TOE finding of RV dilatation and paradoxical motion of the ventricular septum are strongly suggestive of massive PE.[18] A thrombus may also be identified in the right atrium or ventricle.

   However failure to identify a pulmonary artery thrombus does not rule out PE.
4. **ARDS:** In patients with ARDS, fluid overload should be avoided as it worsens gas exchange and lung compliance and hypovolaemia should be avoided as it reduces mixed venous oxygen saturation. TOE assessment of the volume status may help maintain the delicate fluid balance in ARDS by suggesting the need for fluid loading or determining the tolerance for diuretic therapy. 30% patients with ARDS have cor pulmonale.[25] Presence of RV failure is a strong predictor of mortality,[26] which can be diagnosed by TOE.
5. **Thoracic Trauma:** TOE is a useful tool for the rapid evaluation of injuries in chest trauma, especially because TTE cannot be used in this setting due to technical difficulties and the gold standard imaging modalities of computerized tomography (CT) and MRI may not be feasible if the patient is hemodynamically unstable. Potentially life threatening injuries that can be detected rapidly and reliably using TOE include myocardial contusion, pericardial effusion or tamponade, aortic rupture, and traumatic mitral and tricuspid regurgitation[1,2].
6. **Systemic Embolism:** In patients who present with stroke and ischemia of the limbs and viscera, TOE examination may identify a thrombus in LA, LA appendage or LV, vegetations, atherosclerotic material in aorta or gas in LA following CPB.[18]
7. **Failure to Wean:** TOE in an intubated patient may offer a better acoustic window for cardiac evaluation during weaning maneuvers to diagnose a cardiac cause of failure to wean.
8. **Unexplained Hypoxemia:** Right-to-left intracardiac shunting may be secondary to flow across a patent foramen ovale (PFO) due to acutely raised RA pressure and causes unexplained hypoxaemia. Colour flow Doppler or a saline contrast study can detect right-to-left shunting and treatment directed at reducing RA pressure.[18]

TOE vs PAC

Pulmonary artery catheter (PAC) is the gold standard for measuring cardiac output. A recent review[27] of practice in hospitals in North America, Europe, Asia, Australia, New Zealand, and South America showed that PAC is still preferred during most cardiac surgeries even though the effect of routine use of PAC on outcome of cardiac surgeries remains unproven. Trials in high risk non-cardiac surgical patients and in intensive care medicine have not shown any benefit for the use of PACs.[28] TOE on the other hand is safe, minimally invasive and can be performed rapidly and repeatedly by the bedside to evaluate hemodynamic instability by assessing both global and regional ventricular systolic function, providing a better estimate of intravascular volume status and giving information on the cause of the cardiac abnormality. However, availability and cost of specialized equipment and expertise and on-going training might limit its use in the resource poor settings.

TOE vs TTE

Transthoracic echocardiography (TTE) is a simple, noninvasive first-line imaging modality which is better tolerated by conscious patients. It is more reliable in visualizing the LV apex, M-mode imaging across the ventricular septum, and estimation of stroke volume and AV pressure gradients as compared to TOE. However in mechanically ventilated patients the image quality is frequently suboptimal[29] and in patients with thoracic or upper abdominal surgical wounds, drains and dressings, TTE cannot be performed. The image quality of TOE is superior in patients ventilated with high levels of PEEP. The potential for pharyngeal and oesophageal trauma should be kept in mind and

it is not uncommon to dislodge enteral feeding tubes specially the nasojejunal tubes while inserting the TOE probe. TOE is better than TTE to visualize LA appendage, MV, AV, small vegetations, paraprosthetic valve regurgitation and central pulmonary emboli. Assessment of pericardial and pleural fluid collections is also better with TOE. In addition TOE is more reliable than TTE for accurate diagnosis of thoracic trauma.[30]

CONCLUSIONS

TOE is a semi-invasive imaging technique that provides a rapid, real-time, point-of-care assessment of structure and function of the heart and great vessels associated with minimum complications.

Valve repair surgery and correction of adult and paediatric congenital heart disease are a category I indications for the use of perioperative TOE but evaluation of hemodynamic instability not responding to standard measures is a strong indication for doing a perioperative TOE examination during any cardiac or non-cardiac surgical procedure. However the cost and maintenance of equipment and expertise have to be considered especially in centers with low volume of work or limited resources. Ability to rapidly evaluate hemodynamic instability of uncertain or suspected cardiac etiology has made TOE an essential monitor and diagnostic tool in the acute care settings including intensive care units and emergency rooms. However physicians practicing acute care medicine should be familiar with both TTE and TOE techniques, as each modality has its advantages and disadvantages.

Acknowledgement: The author wishes to acknowledge Professor Rehana Kamal, Department of Anesthesiology Aga Khan University for reviewing and suggesting improvements in this manuscript.

Conflict of interest: None declared by the author

REFERENCES

1. Kneeshaw JD. Transoesophageal echocardiography (TOE) in the operating room. Br J Anaesth 2006;97:77-84. [PubMed] [Free full text]
2. F.Guarracino, R. Baldassarri. Transesophageal echocardiography in OR and ICU. Minerva Anestesiologica. 2009;75(9):518-529. [PubMed] [Free full text]
3. Kneeshaw J, Canty D, Roscoe A, Klein A. Peri-operative TOE—does it have an effect on surgical practice. J Br Soc Echocardiogr 2006;55:7–8.
4. Hofer CK, Zollinger A, Rak M, Matter-Ensner S, Klaghofer R, Pasch T, et al. Therapeutic impact of intraoperative transoesophageal echocardiography during noncardiac surgery. Anaesthesia 2004;59:3–9. [PubMed] [Free full text] DOI: 10.1111/j.1365-2044.2004.03459.x
5. Kolev N, Brase R, Swanevelder J, Oppizzi M, Riesgo MJ, vander Maaten JM, et al. The influence of transoesophageal echocardiography on intra-operative decision making. A European multicentre study. European Perioperative TOE Research Group. Anaesthesia 1998;53:767-73. [PubMed] [Free full text] DOI: 10.1046/j.1365-2044.1998.00341.x
6. Kallmeyer IJ, Collard CD, Fox JA, et al. The safety of intraoperative transesophageal echocardiography: a case series of 7200 cardiac surgical patients. Anesth Analg 2002;95(1):255-6. [PubMed]
7. Spahn DR, Schmid S, Carrel T, Pasch T, Schmid ER. Hypopharynx perforation by a transesophageal echocardiography probe. Anesthesiology 1995;82:581–3. [PubMed] [Free full text]
8. Shanewise JS, Cheung AT, Aronson S, Stewart WJ, Weiss RL, Mark JB, et al. ASE/SCA Guidelines for Performing a Comprehensive Intraoperative Multiplane Transesophageal Echocardiography Examination: recommendations of the American Society of Echocardiography/ Council for Intraoperative Echocardiography and the Society of Cardiovascular Anesthesiologists Task force for Certification in Perioperative Transesophageal Echocardiography. Anesth Analg 1999;89:870-83. [Free full text]
9. Miller JP, Lambert AS, Shapiro WA, Russell IA, Schiller NB, Cahalan MK. The adequacy of basic intraoperative transesophageal echocardiography performed by experienced anesthesiologists. Anesth Analg. 2011;92:1103-10. [PubMed]
10. Sisto DA, Hoffman DM, Fernandes S, Frater RWM, Orihashi K, Oka Y. Early detection of coronary artery graft dysfunction with intraoperative 2-dimensional transesophageal echocardiography. Tex Heart Inst J 1992;19:130–3. [PubMed] [Free full text]
11. Practice Guidelines for Perioperative Transesophageal Echocardiography. A report by the American Society of Anesthesiologists and the Society of Cardiovascular Anesthesiologists Task Force on Transesophageal Echocardiography. Anesthesiology 1996;84:986-1006. [PubMed] [Free full text]
12. Couture P, Denault AY, Boudreault D, Plante F, Perron R, et al. Impact of routine use of intraoperative transesophageal echocardiography during cardiac surgery. Can J Anesth 2000;47:20-6. [PubMed]
13. Eltzschig HK, Rosenberger P, Löffler M, Fox JA, Aranki SF, Shernan SK. Impact of intraoperative transesophageal echocardiography on surgical decisions in 12 666 patients undergoing cardiac surgery. Ann Thorac Surg 2008;85(3):852-3. [PubMed] doi: 10.1016/j.athoracsur.2007.11.015.
14. Bergquist BD, Bellows WH, Leung JM. Transesophageal echocardiography in myocardial revascularization: II. Influence on intraoperative decision making. Anesth Analg 1996;82(6):1139-

45. [PubMed]
15. Gurbuz AT, Hecht ML, Arslan AH. Intraoperative transesophageal echocardiography modifies strategy in off-pump coronary artery bypass grafting. Ann Thorac Surg. 2007 Mar;83(3):1035-40. [PubMed]
16. Bridgewater B, Hooper T, Munsch C, Hunter S, von Oppell U, Livesey S, et al. Mitral repair best practice: proposed standards. Heart 2006 Jul;92(7):939-44. [PubMed] [Free full text] doi: 10.1136/hrt.2005.076109
17. Bossone E. Prognostic role of transesophageal echocardiography in acute type A aortic dissection. Am Heart J. 2007;153:1013-20. [PubMed]
18. Sidebotham D, Merry A, Legget M. Practical perioperative transesophageal echocardiography. London: Butterworth-Heinemann: 2003
19. Subramaniam B. Park KW. Impact of TEE in noncardiac surgery. Int Anesthesiol Clin 2008;46:121-36. [PubMed] doi: 10.1097/AIA.0b013e3180f30fc5.
20. Transesophageal echocardiography utilization in high volume liver transplantation centers in the United States. J Cardiothorac Vasc Anesth 2008;22:811-3. [PubMed] doi: 10.1053/j.jvca.2008.07.007.
21. Reeves ST, Finley AC, Skubas NJ, Swaminathan M, Whitley WS, Glas KE, et al. Basic Perioperative Transesophageal Echocardiography Examination: A Consensus Statement of the American Society of Echocardiography and the Society of Cardiovascular Anesthesiologists. J Am Soc Echocardiogr 2013;26:443-56. [PubMed] doi: 10.1016/j.echo.2013.02.015.
22. Charron C, Prat G, Caille V, Belliard G, Lefèvre M, Aegerter P, et al. Validation of a skills assessment scoring system for transesophageal echocardiographic monitoring of hemodynamics. Intensive Care Med. 2007;33:1712-8. [PubMed]
23. Vieillard-Baron A, Prin S, Chergui K, Dubourg O, Jardin F. Hemodynamic instability in sepsis: bedside assessment by Doppler echocardiography. Am J Respir Crit Care Med. 2003;168:1270-6. [PubMed] [Free full text] doi: 10.1164/rccm.200306-816CC
24. Vieillard-Baron A, Chergui K, Rabiller A, Peyrouset O, Page B, Beauchet A, et al. Superior vena caval collapsibility as a gauge of volume status in ventilated septic patients. Intensive Care Med. 2004;30:1734-9. [PubMed]
25. Jardine F, Fellahi JL, Beauchet A, Viellard-Baron A, Loubieres Y, Page B. Improved prognosis of acute respiratory distress syndrome 15 years on. Intensive care Med. 1999;25:936-41. [PubMed]
26. Monchi M, Bellenfant F, Cariou A, et al. Early predictive factors of survival in the acute respiratory distress syndrome. A multivariate analysis. Am J Respir Crit Care Med. 1998;158:1076-1081. [PubMed] [Free full text] doi: 10.1164/ajrccm.158.4.9802009
27. Onkar Judge, Fuhai Ji, Neal Fleming, Hong Liu. Current Use of the Pulmonary Artery Catheter in Cardiac Surgery: A Survey Study. J Cardiothorac Vasc Anesth. 2015;29(1):69–75. [PubMed] doi: 10.1053/j.jvca.2014.07.016.
28. Sandham JD, Hull RD, Brant RF, Knox L, Pineo GF, Doig CJ, et al. Canadian Critical Care Clinical Trials Group. A randomized, controlled trial of the use of pulmonary-artery catheters in high-risk surgical patients. N Engl J Med 2003;348(1):5-14. [PubMed] [Free full text] DOI: 10.1056/NEJMoa021108
29. Heidenreich PA, Stainback RF, Redberg RF, Schiller NB, Cohen NH, Foster E. Transesophageal echocardiography predicts mortality in critically ill patients with unexplained hypotension. J Am Coll Cardiol. 1995;26:152-58. [PubMed]
30. Chirillo F, Totis O, Cavarzerani A, Bruni A, Farnia A, Sarpellon M, et al. Usefulness of transthoracic and transoesophageal echocardiography in recognition and management of cardiovascular injuries after blunt chest trauma. Heart. 1996;75:301-6. [PubMed] [Free full text]

★★★★★