DOI: https://doi.org/10.5114/ait.2021.107945

A systematic approach to transoesophageal echocardiography in the intensive care unit – a practical guide for intensivists

Wojciech Mielnicki[1,2], Agnieszka Dyla[1,2], Justyna Małyszek-Tumidajewicz[2]

[1]*Anaesthesiology and Intensive Care Unit, District Hospital in Olawa, Poland*
[2]*Department of Cardiac Surgery, Cardiac and Lung Transplantation, Mechanical Circulatory Support, Silesian Centre for Heart Diseases, Zabrze, Poland*

Anaesthesiol Intensive Ther 2021; 53, 4: 329–335

Received: 20.09.2020, **accepted:** 27.04.2021

Abstract

Transoesophageal echocardiography (TOE) has become a useful diagnostic and monitoring tool in critical care settings, especially when transthoracic echocardiography is difficult to perform. It gives valuable information in mechanical ventilation, especially in the prone position, in obese patients, and in patients with surgical dressings and chest tubes. Transthoracic echocardiography allows visualization of deep cardiac structures and their pathologies. It has extensive diagnostic implications.

This article describes the systematic approach to critical care TOE examination with a detailed description of the views necessary for rapid haemodynamic assessment in critical care patients. It is concordant with European Diploma in Advanced Echocardiography (EDEC) requirements, and its structural approach is based on the author's experience acquired in the EDEC examination process.

Performing TOE in an organized fashion can help to pinpoint most of the pathologies and monitor the treatment process in the intensive care unit.

Key words: transoesophageal echocardiography, TOE, critical care TOE, EDEC, TOE views.

CORRESPONDING AUTHOR:
Dr. Agnieszka Dyla, Anaesthesiology and Intensive Care Unit, District Hospital in Olawa, Poland,
e-mail: a.dyla@zozolawa.wroc.pl

Transoesophageal echocardiography (TOE) has become a useful diagnostic and monitoring tool in critical care settings, especially when transthoracic echocardiography is difficult to perform. It provides valuable information regarding mechanical ventilation, in obese patients, and in patients with surgical dressings and chest tubes. It is also feasible to perform TOE in a prone positioning [1, 2]. It allows visualization of deep cardiac structures and certain pathologies, including valve morphology, endocarditis, and patent foramen ovale, with better sensitivity than transthoracic echocardiography (TTE). It also makes it possible to visualize the superior vena cava, which can be useful in predicting fluid responsiveness in mechanically ventilated patients [1, 3, 4]. In addition, it is superior to TTE for the diagnosis of aortic dissection [1, 5], left atrial thrombus, and extracorporeal membrane oxygenation (ECMO) canula position [1, 6].

Critical care TOE is said to have extensive diagnostic implications. In a review of 20 studies in 2508 patients, TOE had a diagnostic impact in 67.2% of cases [1, 7]. It also has a substantial therapeutic impact leading to treatment changes in between 38% [8] and 79% of cases [9]. TOE is also safe to perform in critically ill patients, with a complication rate of 2.6% [7] reported in 2508 patients. No major complications were reported in a series of 152 TOE exasiminations performed by fellows [7, 10].

This article describes a systematic approach to critical care TOE examination with a detailed description of views necessary for rapid haemodynamic assessment in intensive care patients. It is concordant with the European Diploma in Advanced Echocardiography (EDEC) requirements, and its structural approach is based on the author's experience acquired in the EDEC examination process.

EDEC is part of an educational program endorsed by the European Society of Intensive Care Medicine (ESICM). It is a curriculum in Echocardiography offered by ESICM to practitioners who have acquired a basic level of competence in critical care echocardiography (CCE) and would like to extend their competences to an advanced level.

According to the American Society of Echocardiography, there are 28 standard views often accompanied by Doppler measurements [10, 11]. TOE examination in critically ill patients has not yet been formally standardized. An extended TOE protocol (including non-standard views) in comprehensive TOE examinations carried out by cardiologists is not essential to achieve the goals defined by intensivists. The purpose of critical care TOE is to evaluate haemodynamically unstable patients [10]. The key is to develop a systematic approach to TOE examination and perform it in a repeatable sequence. The TOE examination presented in this article is based on "international consensus statement on training standards for advanced critical care echocardiography" (Expert Round Table on Echocardiography in ICU) [12]. When performed for the first time, it consists of all views essential to diagnose the patient and, when performed at subsequent examinations, it encompasses views necessary to monitor changes in the patient's status. The figures presented in the following paragraph were selected due to their value for haemodynamic monitoring in patients in shock states.

CRITICAL CARE TRANSOESOPHAGEAL ECHOCARDIOGRAPHY VIEWS

We present critical care TOE examination in Tables 1 and 2. Table 1 is divided into 3 sections: how to obtain the view, exemplary findings and pathologies, and how we can use these views for haemodynamic assessment. Table 2 describes aorta visualization.

Critical care TOE has evolved to become one of the most versatile modalities for diagnosing and guiding the treatment of critically ill patients [7]. It is less frequently performed in the ICU settings [13] compared to TTE. Nevertheless, TOE possesses many unique properties of an "ideal" haemodynamic tool [6, 14]. Vignon *et al*. [6] described 10 reasons to perform TOE in the ICU setting. It allows good visualization of heart structures and vessels not hampered by some TTE limitations (e.g. emphysema, high PEEP level in mechanically ventilated patients, obesity, fluid overload, dressings, and drains). TOE is a reliable source of information on the mechanism of circulatory failure (e.g. cardiac tamponade, thrombus in the proximal pulmonary arteries consistent with massive pulmonary embolism, etc.). In septic shock, it provides information on the main mechanism of circulatory failure, such as hypovolaemia, vasoplegia, and left or right ventricular systolic failure [6, 14]. TOE allows reproducible and sequential haemodynamic assessments and helps to predict fluid responsiveness [6]. Haemodynamic assessment, predicting fluid responsiveness, and finding the cause of shock are the main domains of critical care echocardiography. A clinician has to assess the patient quickly and decide on the treatment process; thus, goal-directed critical care TOE is often applied. Benjamin *et al*. [16] described goal-directed TOE with the use of 4 views. Vieillard-Baron *et al*. [17] described septic shock patients who had daily therapy guided by TOE. The typical views were as follows: mid-oesophageal 4-chamber view, transgastric mid-papillary muscle view, and mid-oesophageal bicaval view for SVC assessment. This limited approach is especially useful for haemodynamic assessment and response to treatment [10]. The views described in this article are based on the "international consensus statement on training standards for advanced critical care echocardiography" [12]. The clinician can use any combination of views to answer the clinical question. We present critical care TOE in a table, with a short description of how to acquire the view, how to use it, and what views are most helpful for haemodynamic assessment. It is not our goal to describe all the pathologies found when performing TOE examination. Clinicians interested in the subject of pathologies assessed in TOE are referred to detailed articles [7, 10, 18]. We present only 1 method of view acquisition that we found to be easy and reproducible. At times, it is necessary to use different views or omniplanes to identify a cardiac structure or to make reliable measurements. Because critical care patients have multiple cardiac problems, cooperation with the cardiology department is very important in the field of valvular assessment, regional wall motion abnormalities, and qualification for invasive procedures. Establishing close relations with cardiology, cardiac surgery, and cardiac anaesthesia departments improves the diagnostic and treatment process of critically ill patients [6]. This article is dedicated to critical care physicians who possess some knowledge in echocardiography and who want to get ready for the EDEC examination. It is constructed as a brief curriculum and cannot be used as the sole source of information required for the exam. Acquiring competence in this technique has become part of the critical care training curriculum and is recommended by critical care societies [12].

Critical care TOE has a lot in common with critical care TTE. Many image planes are similar, but the only difference is the presentation on the screen. The manner of conducting the cardiac evaluation is the same, and haemodynamic assessment is based on Doppler measurements. The complete discussion on both methods is presented in a 2-part series in CHEST [10, 19, 20].

The main difference between these techniques is the method of image acquisition. In critical care TOE, the intensivist learns how to handle the probe introduced into the oesophagus or stomach [10]. In general, in TOE, the transducer is closer to the heart structures and thus produces a better image resolu-

TABLE 1. Transoesophageal echocardiography (TEE) views based on Expert Round Table on Echocardiography in ICU. International consensus statement on training standards for advanced critical care echocardiography [12]

How to obtain the view	Use this view to diagnose	Haemodynamic assessment
Mid-oesophageal ascending aorta short-axis view (SAX) (20–25 cm)		
Insert the probe to ME to find four chamber view (4CH) and withdraw the probe with anteflexion till you see AV in the centre of image ("Mercedes" sign) and continue to withdraw: the image will be lost and then it will reappear (Figure 1)	Massive pulmonary embolus Ascending aorta pathology (e.g. dilatation, aneurysm, dissection) Vascular catheters iv SVC	1) Fluid responsiveness in mechanically ventilated patients a) Move SVC to the centre of image and rotate the omniplane to 90°, measure respiratory variations of SVC diameter during mechanical ventilation using M-Mode: $\Delta SVC = (SV_{Cmax} - SV_{Cmin})/SV_{Cmax}$ (Figure 2) b) Using pulsed wave Doppler signal, place sampling volume just above pulmonic valve and assess respiratory variations of maximal velocity (V_{max}) and VTI 2) Assessing cardiac output: RVOT VTI assessment as a surrogate of cardiac output measurement, especially when VTI of LVOT difficult to obtain (not validated)
Mid-oesophageal aortic valve SAX		
Insert the probe to ME to find 4CH and withdraw the probe till you see AV in 5CH and rotate the omniplane to 30–45° Position the AV in the centre with 3 cusps visible	AV pathologies (e.g. endocarditis, AVR, bicuspid valve) LA assessment (e.g. enlargement, thrombus) AS defect	
Mid-oesophageal right ventricle inflow-outflow		
From ME AV SAX rotate the omniplane to 60–75° and optimize TV and PV in the image	TV and PV pathologies (e.g. insufficiency, endocarditis) RVOT pathologies	
Mid-oesophageal Bicaval		
Insert the probe to the ME to find 4CH and turn the probe right to put the RA in the centre of the screen Rotate the omniplane to 90° to image simultaneously IVC on the left and SVC on the right	RA pathologies (thrombus, enlargement, spontaneous contrast) AS (PFO, aneurysm, ASD) Venous catheter position ECLS/ECMO cannula position Lines, wires position	Fluid responsiveness: place M-mode perpendicular to the SVC and measure respirophasic changes of SVC diameter
Mid-oesophageal 4-chamber view (4CH) (30–35 cm)		
Insert the probe to the ME till you image 4CH (0–10°). Optimize the apex by slight retroflexion of the probe (Figure 3)	RWMA LV hypertrophy RV dilatation, overload Paradoxical septal motion	Two-dimensional (2D): LV contractility (antero-lateral wall, infero-septal wall, apex), RV contractility (free wall), RV/LV assessment (diameter, area, volume) to look for signs of acute RV pressure overload, assessment of pericardial effusion Colour Doppler: MV and TV pathologies Pulsed Doppler: mitral inflow pattern, measure E and A wave and calculate E/A, combine with tissue Doppler to assess lateral e' and s'
Mid-oesophageal 2-chamber (2CH)		
Insert the probe to the ME till you image 4CH view, rotate the omniplane to 90° and retroflex the probe to visualize LV with apex and LA	RWMA LV hypertrophy	Two-dimensional (2D): LV contractility (anterior wall, inferior wall) Color Doppler: MV pathology Pulsed Doppler: mitral inflow pattern, measure E and A and calculate E/A
Mid-oesophageal aortic valve long-axis (LAX)		
Insert the probe to visualize AV in SAX (30–45°) and rotate the omniplane to 120° to visualize AV in long axis (Figure 4)	Aortic root assessment LVOT assessment (e.g. diameter measurement, VS hypertrophy MV pathologies (MR, MS, endocarditis)	Two-dimensional (2D): LV contractility (anterior septum wall, inferior posterior wall), LVOT diameter measurement for cardiac output calculation Colour Doppler: AV disease, MV disease

TABLE 1. Cont.

How to obtain the view	Use this view to diagnose	Haemodynamic assessment
Transgastric mid short-axis view (40–45 cm)		
Insert the probe to the stomach till you see liver on the screen, anteflex the probe and centre LV with papillary muscles in the centre of the image, omniplane 0° (Figure 5)	RWMA LV hypertrophy RV dilatation, overload Paradoxical septal motion	Two-dimensional 2D: LV contractility (anterior, septal, inferior, lateral walls), signs of acute RV pressure overload (flattened septum, LV not spherical) Fractional area change (FAC) measurement FAC = (LVEDA – LVESA)/LVEDA LVEDA – left ventricle end-diastolic area LVESA – left ventricle end-systolic area
Transgastric long-axis view		
Insert the probe to the stomach and optimize the image to acquire transgastric mid SAX, and rotate the omniplane to 110–120° to visualize LVOT and AV on the right side of the screen (Figure 6)	Aortic valve pathologies (e.g. endocarditis, sclerosis)	Two-dimensional 2D: LV contractility (anteroseptal wall, inferolateral wall) Colour Doppler: MR and AV pathologies Pulsed Doppler: a) measurement of VTI velocity change in LVOT (ΔVA) $\Delta VA = (V_{maxA} - V_{minA})/V_{maxA}$ V_{maxA} – maximal velocity measured in LVOT V_{minA} – minimal velocity measured in LVOT b) measurement of VTI change measured in LVOT (ΔVTI) during passive leg raising test (PLR)
Deep transgastric long-axis view		
Insert the probe to the stomach – omniplane 0°, from mid or apical TG SAX views anteflex and slowly advance the probe until the LV apex is seen at the top of the display	Aortic valve pathologies (e.g. endocarditis, sclerosis)	Two-dimensional 2D: LV contractility Colour Doppler: MR and AV pathologies Pulsed Doppler: a) measurement of VTI velocity change in LVOT (ΔVA) $\Delta VA = (V_{maxA} - V_{minA})/V_{maxA}$ V_{maxA} – maximal velocity measured in LVOT V_{minA} – minimal velocity measured in LVOT b) measurement of VTI change measured in LVOT (ΔVTI) during passive leg raising test (PLR)

MO – mid oesophagus, TG – trasgastric, 4CH – 4-chamber view, 5Ch – 5-chamber view, LV – left ventricle, RV – right ventricle, SVC – superior vena cava, IVC – inferior vena cava, AV – aortic valve, MV – mitral valve, TV – tricuspid valve, PV – pulmonic valve, AS – atrial septum, VS – ventricle septum, PFO – patent foramen ovale, VTI – volume time integral, RVOT – right ventricle outflow track, LVOT – left ventricle outflow track, RWMA – regional wall motion abnormality

TABLE 2. Aorta visualisation in critical care transoesophageal echocardiography

View	How to obtain the view	USE FOR
Mid-oesophageal ascending aorta SAX	Already described in first paragraph	
Mid-oesophageal ascending aorta LAX	Insert the probe to ME and optimize the image to acquire ME ascending aorta SAX, then rotate the angle to 90° with aorta in the center of the screen in LA	Aortic pathology Pulmonary embolus in right PA
Mid-oesophageal descending aorta SAX	Insert the probe to ME and turn the probe left till you find aorta, introduce and withdraw the probe to assess the descending aorta	Aortic pathology IABP position Left pleural effusion
Mid-oesophageal descending aorta LAX	From ME descending aorta SAX turn the angle to 90–100° and visualize the descending aorta in LAX	Aortic pathology IABP position
Upper-oesophageal aortic arch SAX	From ME descending aorta SAX withdraw the probe to visualize AA (0°), and then rotate the angle to 60–90° to acquire AA, PV and PA in view	AA pathology PV pathology
Upper-oesophageal aortic arch LAX	From ME descending aorta SAX withdraw the probe to visualize AA (0°) and turn the probe slightly right, aorta changes its shape to oval	AA pathology

AA – aortic arch, IABP – intra-aortic balloon pump, PA – pulmonary artery, PV – pulmonic valve

tion. One consistent failure of TOE is the measurement of tricuspid regurgitation with Doppler due to the difficulty in achieving a Doppler angle. In the measurement of TR, TTE is recommended [10]. TOE is chosen over TTE when the physician cannot acquire good image quality with TTE, especially in mechanically ventilated patients – when there is an urgent need to determine the cause of haemody-

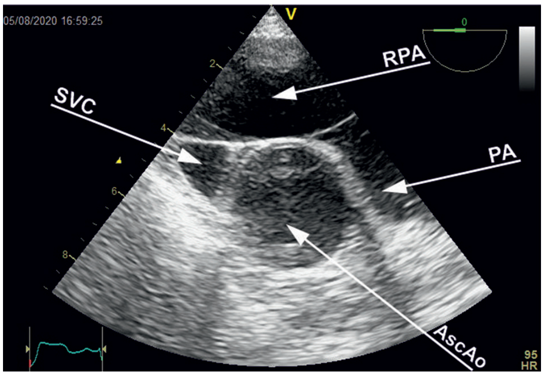

FIGURE 1. Mid-oesophageal ascending aorta short-axis view (SAX). Anatomic structures indicated by arrows: SVC – superior vena cava, PA – pulmonary artery, RPA – right pulmonary artery, AscAo – ascending aorta

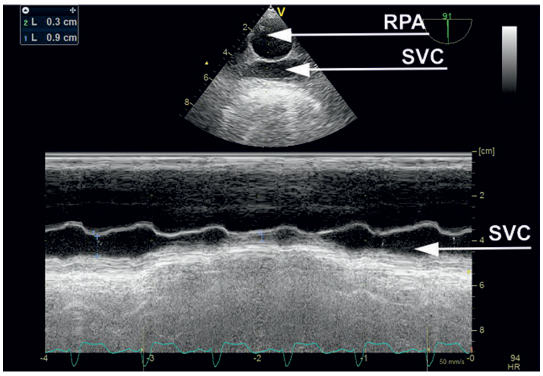

FIGURE 2. M-mode assessment of SVC collapsibility. Anatomic structures indicated by arrows: SVC – superior vena cava, RPA – right pulmonary artery

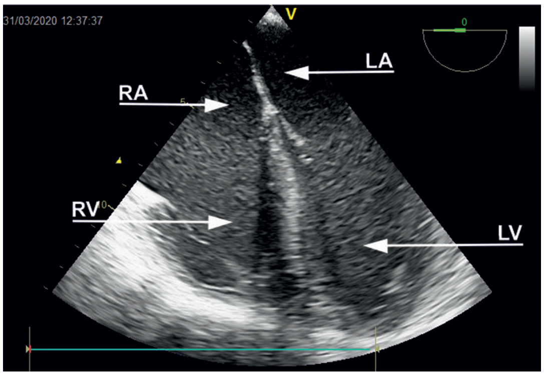

FIGURE 3. Mid-oesophageal 4-chamber view. Anatomic structures indicated by arrows: LA – left atrium, RA – right atrium, RV – right ventricle, LV – left ventricle

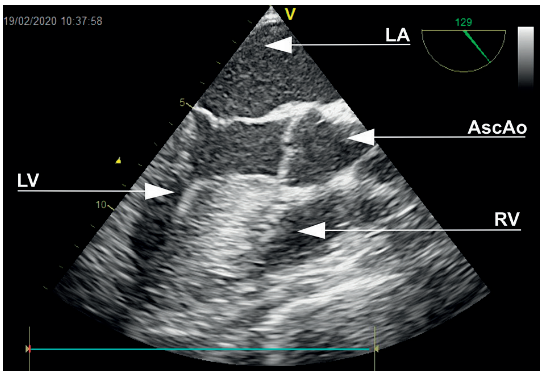

FIGURE 4. Mid-oesophageal aortic valve long-axis (LAX). Anatomic structures indicated by arrows: LA – left atrium, LV – left ventricle, RV – right ventricle, AscAo – ascending aorta

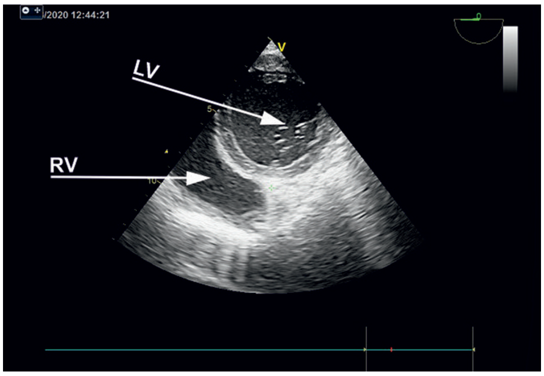

FIGURE 5. Transgastric mid SAX. Anatomic structures indicated by arrows: LV – left ventricle, RV – right ventricle

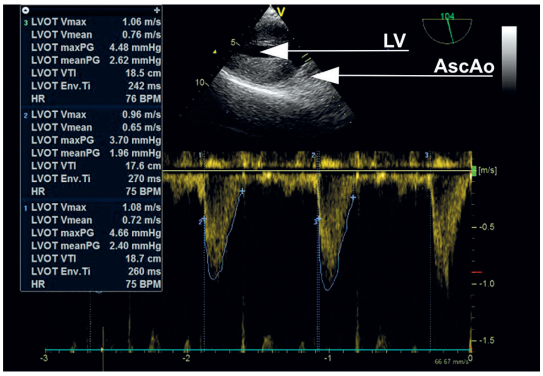

FIGURE 6. Transgastric LAX. PW – doppler through LVOT for VTI assessment. Anatomic structures indicated by arrows: LV – left ventricle, Ao – ascending aorta

namic instability. TOE can be performed in less than 15 minutes, it is less operator dependent than TTE [6, 21], and probe manipulation is actually easier with TOE than with TTE because the probe is well-positioned simply by being in the oesophagus [10]. Although it might be easier to perform TOE after a certain level of training, competence in TTE should precede the competence in TOE.

There are different data regarding the number of studies required to achieve competence in critical care TOE. Charron *et al*. [22] state that 31 studies under supervision are sufficient for competent acquisition [10]. The advanced critical care statement [12] requires a minimum of 35 studies of good quality. It also states that more studies might be required if the quality is not optimal [10]. Thirty-five TOE examinations are also required to fulfil the criteria for the European Diploma in Advanced Echocardiography (EDEC) examination process. EDEC requires the trainee to be supervised by a cardiologist and intensivist who have mastered the knowledge of advanced critical care echocardiography. As far as TTE is concerned, a minimum of 100 studies is required to achieve a sufficient level of competence to perform TTE without supervision [12]. It is optimal for an intensivist to work with a cardiologist during training. This provides expert assistance in image acquisition and interpretation.

Critical care TOE is a minimally invasive procedure and can be safely performed in the ICU setting. Critical care patients are very often sedated and mechanically ventilated so that the introduction of a probe can be safely performed with a laryngoscope. The patient is well-monitored, and any change in their condition can be quickly identified. Critical care TOE is safe with a low complication rate (2.6%). The most commonly reported complications were circulatory disturbances, such as hypo- or hypertension, superficial mucous lesions, hypoxaemia, arrhythmias, and dislodgement of nasogastric or nasojejunal tubes [7, 18]. However, complications of TOE performed in the emergency department were more frequent than in the ICU. In one series of 142 emergency department TOEs, there were 18 complications (12.6%): respiratory insufficiency/failure (7), emesis (4), hypotension (3), agitation (2), death (1), and cardiac dysrhythmia (1) [23].

Critical care TOE is contraindicated in active gastrointestinal (GI) bleeding, perforated viscus, and oesophageal pathologies: laceration, perforation, stricture, tumour, and diverticulum. Relative contraindications encompass the following: history of neck and mediastinum radiation, previous GI surgery and bleeding, Barrett's oesophagus, history of dysphagia, restriction of neck motility, symptomatic hiatal hernia, oesophageal varices, coagulopathy, thrombocytopaenia, active oesophagitis, and active peptic ulcer disease [10, 17]. We strongly encourage intensivists to perform critical care TOE on a regular basis, keeping in mind its limitations and contraindications. Advances in technology, such as miniaturized probes, 3D-ultrasound, and automatic flow measurement, will expand the role of TOE in critical care. It does not replace other techniques of advanced haemodynamic monitoring. It provides different information compared to pulmonary artery catheter or thermodilution indicator technique, and thus the methods are not competitive but complementary [18].

The systematic approach to critical care TOE examination presented in this article can be helpful in acquiring basic skills to learn this technique.

CONCLUSIONS

We present a structural approach to TOE examination in critically ill patients. Performing TOE in an organized fashion will help to pinpoint most of the pathologies and monitor the treatment process. TOE is a quick, easy, and operator-independent diagnostic method, which can be successfully taught in any intensive care unit.

ACKNOWLEDGEMENTS

1. Financial support and sponsorship: none.
2. Conflict of interest: none.

REFERENCES

1. Boissier F, Bagate F, Mekontso Dessap A. Hemodynamic monitoring using trans esophageal echocardiography in patients with shock. Ann Transl Med 2020; 8: 791. doi: 10.21037/atm-2020-hdm-23.
2. Mekontso Dessap A, Proost O, Boissier F, Louis B, Roche Campo F, Brochard L. Transesophageal echocardiography in prone position during severe acute respiratory distress syndrome. Intensive Care Med 2011; 37: 430-434. doi: 10.1007/s00134-010-2114-z.
3. Pedersen WR, Walker M, Olson JD, et al. Value of transesophageal echocardiography as an adjunct to transthoracic echocardiography in evaluation of native and prosthetic valve endocarditis. Chest 1991; 100: 351-356. doi: 10.1378/chest.100.2.351.
4. Shively BK, Gurule FT, Roldan CA, Leggett JH, Schiller NB. Diagnostic value of transesophageal compared with transthoracic echocardiography in infective endocarditis. J Am Coll Cardiol 1991; 18: 391-397. doi: 10.1016/0735-1097(91)90591-v.
5. Willens HJ, Kessler KM. Transesophageal echocardiography in the diagnosis of diseases of the thoracic aorta: part 1. Aortic dissection, aortic intramural hematoma, and penetrating atherosclerotic ulcer of the aorta. Chest 1999; 116: 1772-1779. doi: 10.1378/chest.116.6.1772.
6. Vignon P, Merz TM, Vieillard-Baron A. Ten reasons for performing hemodynamic monitoring using transesophageal echocardiography. Intensive Care Med 2017; 43: 1048-1051. doi: 10.1007/s00134-017-4716-1.
7. 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: 827-836. doi: 10.1111/j.0001-5172.2004.00423.x.
8. Garcia YA, Quintero L, Singh K, et al. Feasibility, safety, and utility of advanced critical care transesophageal echocardiography performed by pulmonary/critical care fellows in a medical ICU. Chest 2017; 152: 736-741. doi: 10.1016/j.chest.2017.06.029.
9. Arntfield R, Lau V, Landry Y, Priestap F, Ball I. Impact of critical care transesophageal echocardiography in medical-surgical ICU patients: characteristics and results from 274 consecutive examinations. J Intensive Care Med 2020; 35: 896-902. doi: 10.1177/0885066618797271.
10. Mayo PH, Narasimhan M, Koenig S. Critical care transesophageal echocardiography. Chest 2015; 148: 1323-1332. doi: 10.1378/chest.15-0260.
11. Hahn RT, Abraham T, Adams MS, et al. Guidelines for performing a comprehensive transesophageal echocardiographic examination: recommendations from the American Society of Echocardiography and the Society of Cardiovascular Anesthesiologists. J Am Soc Echocardiogr 2013; 26: 921-964. doi: 10.1016/j.echo.2013.07.009.
12. Expert Round Table on Echocardiography in ICU. International consensus statement on training standards for advanced critical care echocardiography. Intensive Care Med 2014; 40: 654-666. doi: 10.1007/s00134-014-3228-5.
13. Zieleskiewicz L, Muller L, Lakhal K, et al. Point-of-care ultrasound in intensive care units: assessment of 1073 procedures in a multicentric, prospective, observational study. Intensive Care Med 2015; 41: 1638-1647. doi: 10.1007/s00134-015-3952-5.
14. Vincent JL, Rhodes A, Perel A, et al. Clinical review: update on hemodynamic monitoring – a consensus of 16. Crit Care Lond Engl 2011; 15: 229. doi: 10.1186/cc10291.
15. Aneman A, Vieillard-Baron A. Cardiac dysfunction in sepsis. Intensive Care Med 2016; 42: 2073-2076. doi: 10.1007/s00134-016-4503-4.
16. Benjamin E, Griffin K, Leibowitz AB, et al. Goal-directed transesophageal echocardiography performed by intensivists to assess left

ventricular function: comparison with pulmonary artery catheterization. J Cardiothorac Vasc Anesth 1998; 12: 10-15. doi: 10.1016/s1053-0770(98)90048-9.
17. Vieillard-Baron A, Caille V, Charron C, Belliard G, Page B, Jardin F. Actual incidence of global left ventricular hypokinesia in adult septic shock. Crit Care Med 2008; 36: 1701-1706. doi: 10.1097/CCM.0b013e318174db05.
18. Hüttemann E. Transoesophageal echocardiography in critical care. Minerva Anestesiol 2006; 72: 891-913.
19. Narasimhan M, Koenig SJ, Mayo PH. Advanced echocardiography for the critical care physician: part 1. Chest 2014; 145: 129-134. doi: 10.1378/chest.12-2441.
20. Narasimhan M, Koenig S, Mayo PH. Advanced echocardiography for the critical care physician: part 2. Chest 2014; 145: 135-142. doi: 10.1378/chest.12-2442.
21. Cecconi M, De Backer D, Antonelli M, et al. Consensus on circulatory shock and hemodynamic monitoring. Task force of the European Society of Intensive Care Medicine. Intensive Care Med 2014; 40: 1795-1815. doi: 10.1007/s00134-014-3525-z.
22. Charron C, Prat G, Caille V, et al. Validation of a skills assessment scoring system for transesophageal echocardiographic monitoring of hemodynamics. Intensive Care Med 2007; 33: 1712-1718. doi: 10.1007/s00134-007-0801-1.
23. Gendreau MA, Triner WR, Bartfield J. Complications of transesophageal echocardiography in the ED. Am J Emerg Med 1999; 17: 248-251. doi: 10.1016/s0735-6757(99)90117-1.