Perioperative Use of Focus Assessed Transthoracic Echocardiography (FATE)

Jimmy Højberg Holm, MD,* Christian Alcaraz Frederiksen, MD,†‡ Peter Juhl-Olsen, MD,†‡ and Erik Sloth, MD, DMSc†‡

A 47-year-old man with severe cardiac failure (New York Heart Association class III) underwent an uneventful heart transplant. Initial recovery in the thoracic intensive care unit (ICU) was satisfactory, and he returned to the surgical ward 2 days later. During the following days, leakage appeared from the sternal wound, and a resuturing was planned. The standard preoperative anesthetic assessment, performed by a consultant with >20 years of experience in cardiothoracic anesthesia, did not disclose any specific hemodynamic challenges. On arrival to the operating room, a focus assessed transthoracic echocardiography (FATE) examination was performed with the patient placed in the supine position. Approximately 2 cm of pericardial effusion was disclosed facilitating changes in anesthetic and surgical procedures. A tracheal tube was inserted instead of a larynx mask, monitoring with transesophageal echocardiography was performed, and the surgeon was present in the theater during the induction of anesthesia to help in case of hemodynamic collapse. Coagulated blood 400 mL was evacuated, and a subcostal drain was inserted. The next day the patient showed substantial improvement.

Monitoring and treatment of the hemodynamically unstable patient is a difficult challenge in the perioperative setting. Hemodynamic evaluation comprises estimates of preload and afterload as well as the complex influence that these determining factors have on existing systolic and diastolic cardiac function. Information on these entities can be obtained with 2-dimensional ultrasound, because both wall thickness and cavity dimensions are easily visualized from different views.

The relative change in cavity dimensions during the cardiac cycle states that the ventricle's systolic function and the ejection fraction can be estimated by fractional shortening or eyeballing. In addition, the presence of diastolic dysfunction is likely if a combination of left ventricular (LV) hypertrophy, estimated from increased wall thickness, and an enlarged left atrium is encountered.[1]

From the *Department of Anesthesiology and Intensive Care, Odense University Hospital, Odense; †Department of Anesthesiology and Intensive Care, Aarhus University Hospital, Skejby; and ‡Institute of Clinical Medicine, Faculty of Health Sciences, Aarhus University, Aarhus, Denmark.
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Address correspondence to Jimmy Højberg Holm, MD, Department of Anesthesiology and Intensive Care, Odense University Hospital, Sdr. Blvd. 29, Odense, 5000 Denmark. Address e-mail to jimmyholm@dadlnet.dk.

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It therefore follows that simple 2-dimensional ultrasound offers interpretation of the basic hemodynamic determinants. The FATE protocol[2] has been developed specifically to address these key issues. In addition, obvious pathology that directly causes or contributes to the hemodynamic state is visualized. The FATE protocol is rapid and repeatable. It aids the physician in evaluating the genesis of circulatory instability, serially monitors hemodynamic status, and assesses the effect of intervention without delay.

The FATE protocol helps to solve circulatory problems in 5 steps:

1. Looks for obvious pathology.
2. Assesses wall thickness and chamber dimensions.
3. Assesses biventricular function.
4. Visualizes pleura on both sides.
5. Relates the information to the clinical context.

Four scanning positions are of particular interest in the FATE protocol (Fig. 1). We recommend beginning the examination without altering patient positioning with the option of changing position in the case of suboptimal image quality. All essential information is available as an application for iPhone or Android mobile phones. Further information is available at http://www.fate-protocol.com.

1. Subcostal 4-chamber view (Fig. 1, position 1 and Fig. 2). The transducer is placed inferior to the right costal curvature pointing toward the patient's left shoulder. The orientation marker (OM) on the transducer is orientated toward the patient's left side and caudally until all 4 cardiac chambers appear on the screen. By counterclockwise rotation, a short-axis view may be obtained displaying the LV and, in part, the right ventricle. This subcostal 4-chamber view will display any pericardial effusion (Video 1, see Supplemental Digital Content 1, http://links.lww.com/AA/A467), severe LV failure (Video 2, see Supplemental Digital Content 2, http://links.lww.com/AA/A468), and severe right ventricular dilation.
2. Apical 4-chamber view (Fig. 1, position 2 and Fig. 3). The transducer is placed over the cardiac apex beat. The OM is aimed to the patient's left, and the ultrasound beam is directed parallel to the long axis of the heart. Small adjustments are made until the 4 chambers are presented on the screen. The apical 4-chamber view allows for the evaluation of LV systolic function, left atrial size, and right ventricular size. The latter should be two-thirds of the LV, provided that the LV is normal.
3. Parasternal views (Fig. 1, position 3 and Fig. 4). The transducer is placed on a line connecting the apex beat with the middle of the right clavicle, adjacent to the left lateral margin of the sternum. By pointing the OM

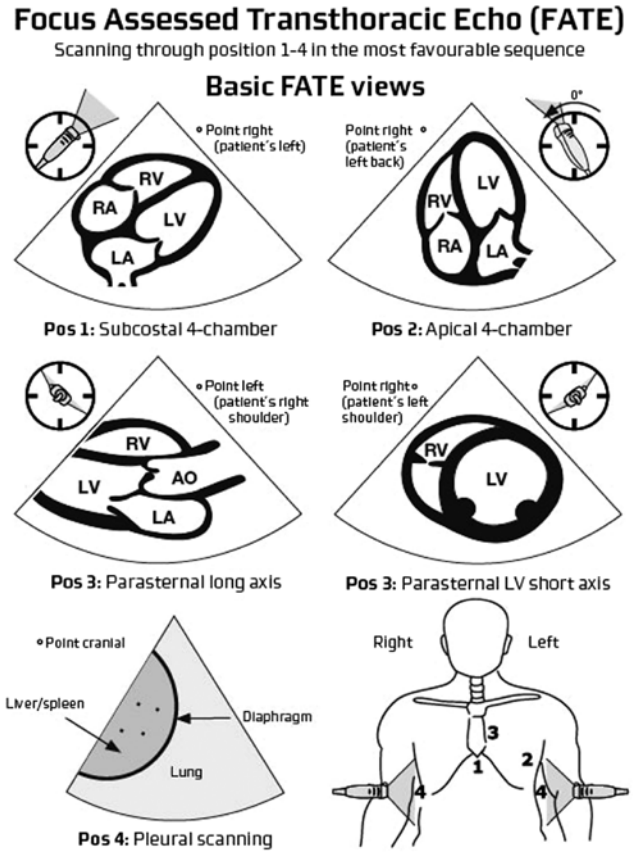


Figure 1. Focus assessed transthoracic echocardiography (FATE) card with its 4 scanning positions. RA = right atrium; RV = right ventricle; LA = left atrium; LV = left ventricle; AO = aorta; Pos = position.

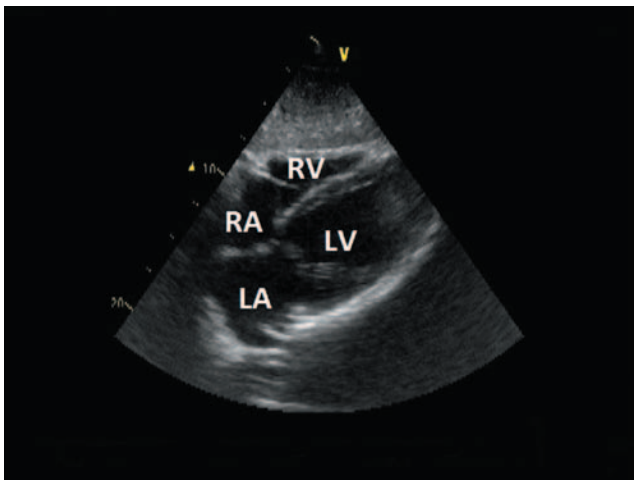
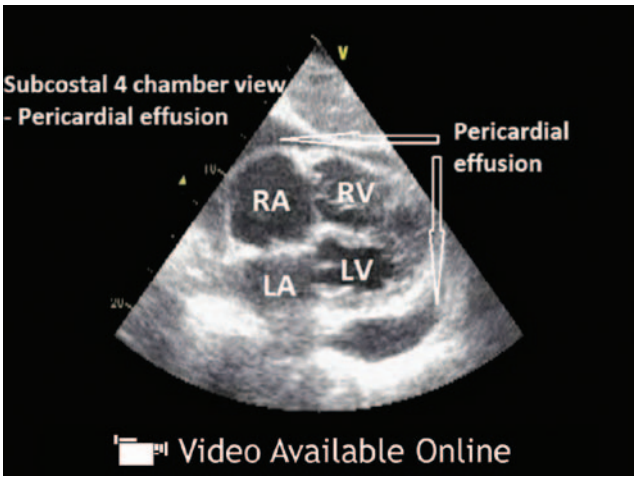
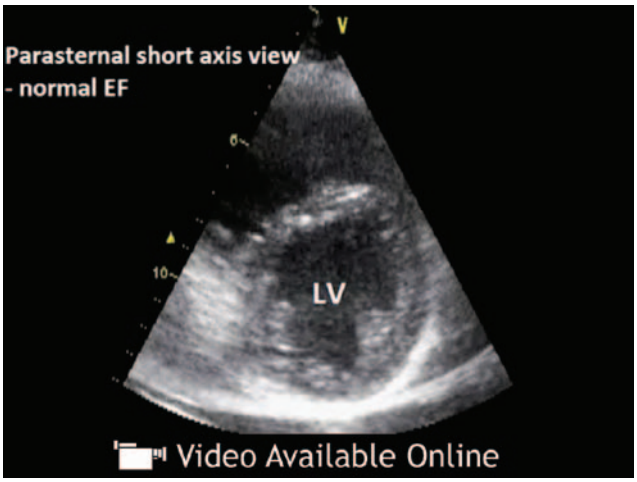


Figure 2. Normal subcostal 4-chamber view obtained at position 1. RA = right atrium; RV = right ventricle; LA = left atrium; LV = left ventricle.

toward the patient's right shoulder, the parasternal long-axis view is displayed. Rotation of the transducer 90° clockwise will display a short-axis view. From the parasternal long-axis view, the classical M-mode scan may be achieved, which is the basis for quantitative measurements of chamber dimensions and wall thickness. Image quality often improves by turning the patient to the left side. The parasternal views



Video 1. Massive pericardial effusion displayed in position 1, the subcostal 4-chamber view. RA = right atrium; RV = right ventricle; LA = left atrium; LV = left ventricle.



Video 2. Loops 1 and 2 show a normal left ventricle followed by left ventricular failure from position 3, the parasternal short-axis view. Loops 3 and 4 show the same patients, but viewed from position 1, the subcostal 4-chamber view. LV = left ventricle.

may reveal pathologic states such as hypovolemia (Video 3, see Supplemental Digital Content 3, http://links.lww.com/AA/A469), LV failure (Video 2, see Supplemental Digital Content 2, http://links.lww.com/AA/A468), LV hypertrophy, or dilation of the right ventricle suggestive of right ventricular failure or pulmonary embolism.

4. Pleural views (Fig. 1). The transducer is placed on the lateral thoracic wall at the approximate level of the 10th rib. By orienting the OM cranially, caudal structures will be presented to the left side of the screen and vice versa. From here, small movements of the transducer and subtle adjustments of the imaging plane are made until the image shows the diaphragm as a white curved line. To prevent false-negative scans, the patient should be placed in a semirecumbent position, because pleural fluid obeys gravity (see Video 4 for visualization of pleural fluid, Supplemental Digital Content 4, http://links.lww.com/AA/A470).

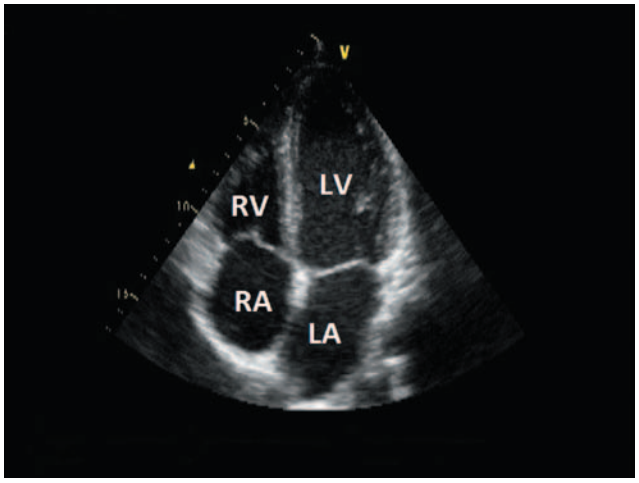


Figure 3. Normal apical 4-chamber picture obtained at position 2. RA = right atrium; RV = right ventricle; LA = left atrium; LV = left ventricle.

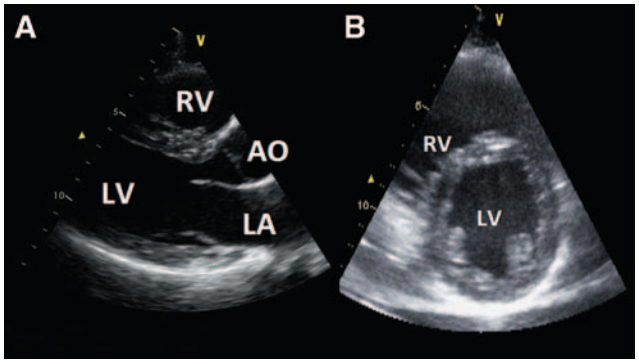
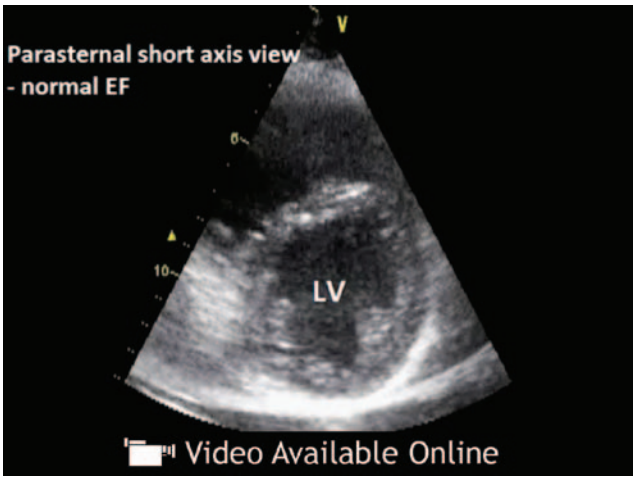
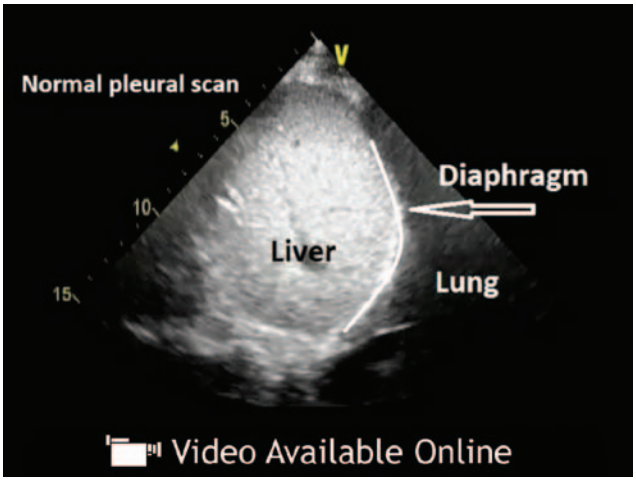


Figure 4. A, Parasternal long-axis view obtained at position 3. B, Parasternal short-axis view obtained at position 3. RA = right atrium; RV = right ventricle; LA = left atrium; LV = left ventricle; AO = aorta.



Video 3. Initially a normally functioning heart followed by a different patient with severe hypovolemia caused by intraabdominal bleeding. The scan is from position 3, the parasternal short-axis view. LV = left ventricle.



Video 4. A normal scan of the right pleura followed by a loop showing pleural effusion. The diaphragm is clearly discernible over the liver. Both scans are obtained from position 4.

The FATE protocol has been shown to be fast and reliable, providing images suitable for interpretation in 97% of a mixed ICU population.[2] When used as a preoperative evaluation tool, full examinations can be done in approximately 70 seconds, and 4-chamber views can be achieved in only 10 seconds.[3] Whether such limited time consumption is applicable to perioperative settings and to the ICU remains to be proven.

Ultrasound in the postoperative period in patients recovering from thoracic surgery can be challenging because of issues with air in the mediastinum, bandages, and dressings that cover imaging windows. However, it has been shown that images suitable for interpretation can be obtained in 88% of this particular patient population on the first postoperative day.[4]

Successful use of focused ultrasound in the sitting patient has been published,[1,3,5] making FATE even more feasible, even as part of the preoperative assessment. As for feasibility and clinical impact, a recent study on the use of focused echocardiography in the preoperative clinic, including patients older than 65 years or patients with suspected heart disease, showed convincing results. The use of transthoracic echocardiography (TTE) facilitated a change in management in 54 of 100 patients, including both step-up and step-down in treatment.[6] In patients admitted for emergency surgery with known or suspected cardiac disease, preoperative focused TTE, performed by an anesthesiologist, has been shown to change the cardiac diagnosis in 67% and the management plan in 44% of patients.[7] In the prehospital settings, the use of focused echocardiography has been demonstrated to contribute substantially to the diagnosis of a significant number of potentially treatable underlying conditions and subsequent alterations in patient management.[8]

Together, these features make abbreviated transthoracic ultrasound protocols an effective supplementary tool for the evaluation of patients in both in-hospital and prehospital settings.

It must be emphasized that the FATE examination or similar protocols are predominantly based on qualitative measures and pattern recognition of major pathology. Thus, it mainly serves as a supplement to clinical evaluation, whereas a full echocardiographic examination performed

by a cardiologist requires extensive echocardiographic training.

Training is of utmost importance before performing independent FATE examinations; however, studies show that even limited training will suffice. A 3-hour training course and 5 hours of hands-on training have been shown to be sufficient for noncardiologist ICU residents to address simple clinical questions using point-of-care ultrasound.[9] For critically ill patients in a surgical ICU, intensivists, after only ten 1-hour tutorials, performed diagnostic limited TTE in 94% of patients and interpreted these correctly in 84% of cases.[10]

Ultrasound in general is a very user-dependent technology, and focus on training, documentation, and quality assurance is warranted. These issues have inspired several teaching institutions and medical societies to implement point-of-care ultrasound as part of their standard teaching curriculum.

We advocate the incorporation of ultrasound in our approach to the critically ill patient for rapid and dynamic patient assessment, freeing the anesthesiologist from relying on surrogate, invasive variables of circulatory status. Future studies should evaluate the diagnostic and monitoring strength of focused cardiac ultrasound protocols intraoperatively as well as during the postoperative period.

Teaching Points

- The focus assessed transthoracic echocardiography (FATE) examination provides basic information on cardiac chamber size and function in 4 steps.
- The FATE examination consumes little time and is feasible in the intensive care unit and preoperative setting.
- Obvious pathology such as left ventricular failure, severe pulmonary embolism, and pleural or pericardial fluid may be visualized.
- Focused transthoracic cardiac ultrasound protocols require limited training as opposed to a full echocardiography.

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Name: Christian Alcaraz Frederiksen, MD.
Contribution: This author helped prepare the manuscript.
Conflicts of Interest: The author has no conflicts of interest to declare.
Name: Peter Juhl-Olsen, MD.
Contribution: This author helped prepare the manuscript.
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Name: Erik Sloth, MD, DMSc.
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