CHEST Recent Advances in Chest Medicine

Advanced Echocardiography for the Critical Care Physician

Part 2

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This article is the second part of a series that describes practical techniques in advanced critical care echocardiography and their use in the management of hemodynamic instability. Measurement of left ventricular function and segmental wall motion abnormalities, evaluation of left ventricular filling pressures, assessment of right-sided heart function, and determination of preload sensitivity, including passive leg raising, are discussed. Video examples help to demonstrate techniques described in the text.
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Abbreviations: 2DE = two-dimensional echocardiography; AP4 = apical four chamber; ASE = American Society of Echocardiography; CCE = critical care echocardiography; CWD = continuous wave Doppler; IVC = inferior vena cava; LAP = left atrial pressure; LV = left ventricular; LVOT = left ventricular outflow tract; PAH = pulmonary arterial hypertension; PAOP = pulmonary artery occlusion pressure; PASP = pulmonary artery systolic pressure; PSL = parasternal long axis; PSS = parasternal short axis; RAP = right atrial pressure; RV = right ventricular; SC = subcostal; SV = stroke volume; TAPSE = tricuspid annular plane systolic excursion; TDI = tissue Doppler imaging; TR = tricuspid regurgitation; TV = tricuspid valve; VTI = velocity time integral

The evaluation of left ventricular (LV) function is an essential skill for both basic and advanced critical care echocardiography (CCE) examination. It allows the intensivist to categorize shock state and to determine the appropriateness of rapid volume resuscitation.

Measurement of LV Function and Segmental Wall Motion Abnormality

Measurement Technique

There is a qualitative and a quantitative approach to assessing overall LV function using two-dimensional echocardiography (2DE). With the qualitative approach, the clinician makes a visual estimate of overall LV function. He or she examines the contractile function of the left ventricle in the parasternal long-axis (PSL) and parasternal short-axis (PSS) views, the apical four-chamber (AP4) view, and the subcostal (SC) view. In the PSS view, the estimate of LV function should be made at the level of the papillary muscles. The descriptors commonly used are normal, mildly reduced, moderately reduced, severely reduced, and hyperdynamic LV function. Hyperdynamic LV function is defined as end-systolic effacement of the ventricular cavity. Visual estimates of overall LV function are reliable if the observer is experienced.[1] Quantitative assessment of LV function uses the Simpson method, where the end-systolic and end-diastolic areas of the left ventricle are measured in the AP4 and apical two-chamber views to calculate an ejection fraction. The Simpson method is time consuming, requiring clear endomyocardial definition and perfect long-axis orientation from the apical window. Because of time constraints and technical

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difficulties in obtaining the requisite high-quality images, it has limited utility in the ICU.

In addition to assessing overall LV function, the advanced CCE examination includes assessment of segmental wall function. Standard segmental wall anatomy includes 17 segments.[2] Wall motion and thickening for each myocardial segment is graded as normal, hypokinetic, akinetic, or dyskinetic (Video 1). Wall motion abnormalities at the segmental level may be identified qualitatively by visual examination of the 2DE image set in multiple standardized views. For quantitative purposes, wall thickening of $<50\%$ or wall excursion <5 mm defines abnormal segmental contractility. The coronary distribution of these segments is reviewed in Figure 1.

Limitations of LV Function Measurement

Assessment of overall LV and segmental wall function requires high-quality 2DE imaging. The standard views must be on the axis with clear endomyocardial definition, which may be difficult to achieve in the critically ill patient because of constraints of body habitus, wound dressings, and inability to achieve optimal body position. The intensivist must be proficient at assessing LV function with limited views. Limitations of the identification of segmental wall abnormalities are under the same constraints as assessment of overall LV function. This is compounded by the consideration that the abnormalities may be subtle and, therefore, require a high level of training on the part of the clinician.

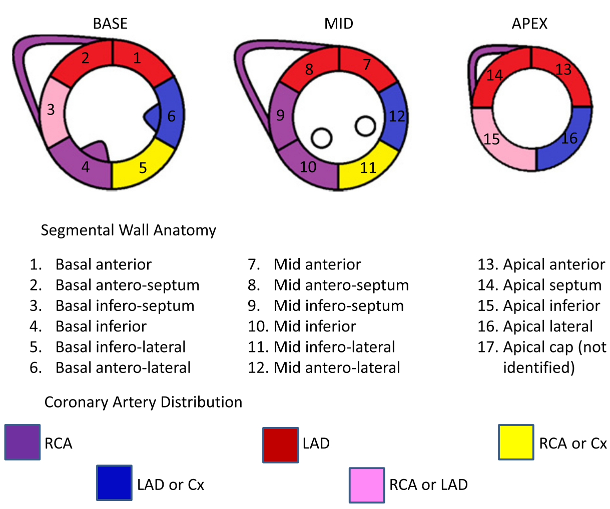

FIGURE 1. Segmental wall anatomy and typical distributions of the RCA, LAD, and Cx in the parasternal short-axis view at the basal, mid, and apical levels. The apical cap is not included in this analysis. Some segments have variable coronary artery perfusion so that arterial distribution varies between patients. Cx = circumflex coronary artery; LAD = left anterior descending coronary artery; RCA = right coronary artery. (Reprinted with permission from Lang et al.[3])

Clinical Applications

Information on LV function is useful to the intensivist for categorizing shock state. Severely reduced LV function with shock suggests a cardiogenic component. A hyperdynamic left ventricle with end-systolic effacement with shock may support a diagnosis of hypovolemia; alternatively, it may be associated with an afterload reduced left ventricle as a result of distributive/vasoplegic shock. The LV function may be hyperdynamic in obstructive shock due to a pulmonary embolism in association with right ventricular (RV) enlargement. The finding of normal LV function in a patient with shock suggests the possibility of distributive/vasoplegic shock. It may also suggest some reduction in intrinsic myocardial contractility because the LV function with distributive shock is commonly hyperdynamic. Assessment of LV function is helpful in guiding the rate of volume resuscitation. The patient with severely reduced LV function may not tolerate rapid volume infusion. Volume resuscitation, if appropriate, may be guided by repeated lung ultrasonography. The continued presence of A lines suggests that volume infusion may be continued from the point of view of lung function.[4] Chronic or acute myocardial segmental wall motion abnormalities may occur with a variety of cardiac diseases, such as stress cardiomyopathy or myocardial ischemia.

Measurement of LV Filling Pressures

Skill with advanced CCE allows the intensivist to estimate LV filling pressures without the use of a pulmonary artery catheter. Although measurement of the pulmonary artery occlusion pressure (PAOP) is not helpful in assessing preload sensitivity, knowledge of the PAOP is important in determining whether the patient has respiratory failure related to hydrostatic pulmonary edema.[5,6] The distinction between heart failure and primary lung injury as the cause for respiratory dysfunction is a key differential point that has major implications for management strategy.

Measurement Technique

The American Society of Echocardiography (ASE) published recommendations for the evaluation of LV diastolic function by echocardiography that include a definitive summary of the various methods of measurement of left atrial pressure (LAP) with echocardiography.[7] Included in the recommendations are two algorithms useful to the intensivist that allow a qualitative estimate of LAP. The reader is encouraged to review and use these algorithms, which are summarized next.