Emergency Cardiac Ultrasound: Evaluation for Pericardial Effusion and Cardiac Activity

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DIAGNOSIS OF PERICARDIAL EFFUSION

Emergency physicians have proved to be accurate in the diagnosis of pericardial effusion. Previous research has shown that emergency physicians have a sensitivity of 96% to 100% as compared with formal overreading by trained echocardiographers.

HOW TO SCAN/SCANNING PROTOCOLS

PROBE SELECTION

Classic echocardiography requires the use of a phased-array probe, sometimes referred to as the thoracic probe. These probes have a small footprint and are ideal for achieving visualization with a small acoustic window between ribs.

ACOUSTIC WINDOWS

Bedside cardiac ultrasound is typically taught with the use of three separate acoustic windows and multiple orthogonal views within the windows. These acoustic windows include the parasternal, apical, and subcostal. Each window is then broken down into orthogonal views, including the parasternal long-axis, parasternal short-axis, apical four-chamber, apical two-chamber, apical long-axis, subcostal four-chamber, and subcostal long-axis views.

PROBE ORIENTATION

Echocardiography places the probe marker on the right side of the ultrasound screen so that when the ultrasound machine is in the cardiac mode, the right-hand side of the screen indicates the side of the probe with the marker on it (this is opposite any other scanning mode).

SPECIFIC VIEWS

Parasternal Long Axis

The parasternal long-axis view seen in Figure 5.1 is obtained by placing the probe in the third to fourth intercostal space with the probe marker pointed toward the patient’s right shoulder (Figs. 5.2 and 5.3). The long axis of the heart should be horizontal on the screen with the apex pointed to the left. If the apex is pointed up, the probe is too low and should be

KEY POINTS

- Emergency cardiac ultrasound is performed by the emergency physician to assess for the presence of cardiac activity, determine whether a pericardial effusion is present, and answer other specific questions.
- Echocardiography can be used during cardiac arrest to guide resuscitation decisions.
- Emergency use of echocardiography is indicated for assessment of cardiac ejection fraction, wall motion abnormalities, and other critical findings that will direct acute diagnostic decision making.

INTRODUCTION

Echocardiography has been the “gold standard” for cardiologists for decades. Over the past 20 years, emergency physicians have adopted point-of-care (POC) cardiac ultrasound to answer specific questions on the management of critically ill patients. Assessment for pericardial effusion and for cardiac activity have traditionally been the principal indications for emergency physicians, but indications for bedside echocardiography are growing rapidly.

WHAT WE ARE LOOKING FOR

The initial and best evidence-based indications include applications for tamponade, cardiac arrest, and acute heart failure. Rapidly developing areas of cardiac ultrasound include evaluation of hypotension, pulmonary embolism (PE), acute myocardial infarction, diastolic heart failure, and echocardiographically guided resuscitation (Box 5.1).

LITERATURE REVIEW

ESTIMATION OF GLOBAL CARDIAC FUNCTION AND EJECTION FRACTION

Multiple studies have shown the ability of emergency physicians to accurately evaluate cardiac function and ejection fraction. When compared with cardiologists, emergency physicians were found to have a correlation coefficient of 0.86 with cardiologists when assessing ejection fraction. Cardiologists had a similar coefficient of 0.84 among themselves.
moved up an interspace. This view allows visualization of the left ventricle, mitral valve, left atrium, right ventricular outflow tract, aortic valve, and aorta. The descending thoracic aorta is often visualized posterior to the left ventricle in transection.

**Parasternal Short Axis**

The parasternal short-axis view is obtained by rotating the probe 90 degrees from the parasternal long-axis position so that the probe marker is pointed to the patient’s left shoulder (Figs. 5.4 and 5.5). The ultrasound beam is now transecting the heart in its short axis. If the physician tilts the probe so that it is pointing to the base of the heart, the aortic valve is visualized along with the “inflow and outflow” of the right heart. This view includes the right atrium, right ventricular outflow tract, and pulmonic valve. As the probe is tilted more apically, the aortic valve is lost and a cross-sectional view of the mitral valve is obtained (Fig. 5.6). At this point the right ventricle becomes more apparent and takes a position as a
crescentic ventricle to the left and superficial to the mitral valve and left ventricle. Finally, as the probe is tilted more toward the apex, the mitral valve is lost and the muscular portion of the left ventricle is visualized. The posterior medial and anterior papillary muscles are visualized at this point, and the circular nature of the left ventricle can be appreciated (Fig. 5.7).

**Apical Four- and Two-Chamber Views**

The apical window allows visualization of either all four chambers (Figs. 5.8 and 5.9) or just two chambers (the left atrium and ventricle) (Fig. 5.10). The apical windows are difficult to obtain in the emergency setting and often require the patient to be in the left lateral decubitus position, which is often impossible. The window is obtained by placing the probe at the location of maximal impulse with the probe marker pointed to the left axilla. The probe must be tilted so that the probe is pointed to the patient’s right shoulder (Fig. 5.11).

The apical two-chamber view allows further evaluation of the left ventricle and mitral valve. The left atrial appendage can sometimes be seen on the right side of the screen on the anterior side of the basal left ventricle.

**Subcostal Four-Chamber View**

The subcostal four-chamber view (Figs. 5.12 to 5.14) is obtained by placing the probe just inferior to the xiphoid and applying pressure downward on the abdomen with the probe.
as an anechoic stripe of fluid surrounding the heart. This stripe is most commonly located between the right ventricle and the liver. Ideally, all three acoustic windows should be used when attempting to rule out pericardial effusion.

The critical complication of pericardial effusion is cardiac tamponade (Fig. 5.16). Physiologically, cardiac tamponade occurs when the pressure inside the pericardial sac becomes elevated above right ventricular diastolic filling pressure. This leads to decreased filling of the right ventricle in diastole and reduced preload and cardiac output. Echocardiographic signs of cardiac tamponade are the presence of right ventricular free wall collapse as seen in Figure 5.16. Alternatively, a more sensitive, but less specific finding is the presence of right atrial collapse during ventricular systole (atrial diastole).

**CARDIAC ARREST**

POC cardiac echocardiography can be invaluable during cardiac arrest. Typical uses include evaluation for tamponade, hypovolemia, and suggestions of PE (clot, right ventricular
ACUTE HEART FAILURE

Emergency physicians have been shown to be accurate in estimating left ventricular ejection fraction (LVEF). LVEF is most easily separated into three categories: reduced, normal, and hyperdynamic. Although echocardiographers often report actual percentages, we can think of normal LVEF as 55% to 75%, reduced as less than 55%, and hyperdynamic as greater than 75%. Some authors add a fourth category in which severely reduced LVEF is less than 30%. This distinction can be useful when discussing cardiac function with consultants.
The ejection fraction is typically estimated by visual inspection of the “squeeze” of the left ventricle, although it can also be measured with algorithms in the cardiac package of many emergency ultrasound machines.

**Pitfalls**
Emergency cardiac ultrasound involves the use of clear indications and directed ultrasound of the heart to answer specific questions, as described in the “Introduction.” Apart from these questions, a cardiologist should be consulted to aid in complex diagnosis and clinical decision making.

Normal systolic function does not rule out acute heart failure. Diastolic heart failure can occur in patients with a normal LVEF.

Diagnosis of cardiac tamponade by echocardiography can be complicated, and advanced echocardiographic techniques may be required, including Doppler evaluation. Stable patients may benefit from evaluation by a trained echocardiographer.

Technically, the bedside sonographer may encounter difficulty obtaining the full series of views as described earlier. Patient habitus or artifact from the lungs or ribs may present challenges. Placing the patient on the left side in a left lateral decubitus position may aid in better viewing the parasternal and apical windows. This position moves the heart closer to the anterior chest wall. In the subcostal window, asking the patient to breathe in deeply may move the heart closer to the transducer. Additionally, moving the transducer toward the patient’s right, while still pointing toward the left side of the chest, may overcome artifact caused by the stomach or bowel by using the left lobe of the liver as an acoustic window.

**PULMONARY EMBOLISM**
Although cardiac ultrasound cannot identify a pulmonary embolus, several findings are suggestive of this diagnosis. Right ventricular dysfunction and dilation are typically visualized in the apical four-chamber window. Right ventricular dilation has been described in reference to the relative areas of the right and left ventricles at end-diastole. A right-to-left ventricular area ratio of greater than 0.66 has been shown to be 85% specific for PE. Another finding is described as retained apical function in the setting of right ventricular free wall hypokinesis. This is called the McConnell sign and can be fairly specific for PE. McConnell et al. described this particular finding as being 94% specific for PE (Fig. 5.17). An additional finding in acute PE is flattening of the interventricular septum. This is seen in the parasternal short-axis view and is due to either volume or pressure overload of the right heart (Fig. 5.18).

**VOLUME STATUS**
Assessment of the patient’s condition and the presence of hypervolemia or hypovolemia can be complicated. Through direct visualization of chamber size and evaluation of the great vessels, this clinical conundrum can often be overcome.

Echocardiographic evaluation of volume status starts with global assessment of the ejection fraction and filling of the right and left sides of the heart. Reduced filling of both the right and left heart chambers implies reduced preload and hypovolemia. Conversely, the presence of dilated right and left heart chambers with a poor ejection fraction suggests hypervolemia. Finally, a dilated right ventricle with a contracted left ventricle and an elevated LVEF suggests a forward flow problem of the right heart, such as PE, right-sided myocardial infarction, or cor pulmonale.

Additionally, a body of research has led to evaluation of the inferior vena cava as a surrogate marker for central venous pressure and thus volume status. The current recommendations are summarized in Table 5.1. The inferior vena cava should be measured during both inspiration and expiration from the subcostal long-axis view as seen in Figure 5.19.
Fig. 5.19 Subcostal long axis of the inferior vena cava used to estimate central venous pressure.

Table 5.1 IVC Diameters and Respective Collapse Associated with CVP Estimates

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<thead>
<tr>
<th>IVC (CM)</th>
<th>COLLAPSE</th>
<th>CVP</th>
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<tbody>
<tr>
<td>Normal</td>
<td>&lt;2.1</td>
<td>&gt;50%</td>
</tr>
<tr>
<td>In between</td>
<td>&lt;2.1/2.1</td>
<td>&lt;50%/&gt;50%</td>
</tr>
<tr>
<td>High</td>
<td>&gt;2.1</td>
<td>&lt;50%</td>
</tr>
</tbody>
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CVP, Central venous pressure; IVC, inferior vena cava.

SUGGESTED READINGS

Blaivas M, Fox J. Outcome in cardiac arrest patients found to have cardiac standstill on the bedside emergency department echocardiogram. Acad Emerg Med 2001;8:616-21.


REFERENCES

References can be found on Expert Consult @ www.expertconsult.com.
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7. Blaivas M, Fox J. Outcome in cardiac arrest patients found to have cardiac standstill on the bedside emergency department echocardiogram. Acad Emerg Med 2001;8:616-21.