

# Advanced Ultrasound Procedures

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## KEYWORDS

- Ultrasound guidance • Pericardiocentesis • Thoracentesis • Paracentesis
- Lumbar puncture • Nerve block • Peritonsillar abscess • Advanced procedures

## KEY POINTS

- Ultrasound capabilities can assist in increasing the success and precision of many bedside procedures traditionally performed using landmark guidance alone.
- Ultrasound guidance is already becoming the standard of care in many bedside procedures, and providers should be familiar with its use in such applications.
- Procedures using ultrasound guidance described in this article include pericardiocentesis, thoracentesis, paracentesis, lumbar puncture, peripheral nerve blocks, and peritonsillar abscess drainage.
- Preparation is key. Knowledge of normal anatomy and associated abnormality, along with understanding of the procedure, necessary equipment, and associated complications can help lead to successful procedures while minimizing adverse outcomes.

## ULTRASOUND-GUIDED PERICARDIOCENTESIS

### *Background*

The heart is protected by 2 layers of pericardium called the visceral pericardium and the parietal pericardium. The visceral pericardium, which is immediately adherent to the epicardium, is surrounded by the parietal pericardium, a protective, fibrinous layer normally 2 mm thick. These 2 layers are normally well approximated and separated by less than 50 mL of pericardial fluid.

Any abnormal accumulation of fluid in this space creates a pericardial effusion. The clinical effects vary and are determined by the cause of the accumulation, the fluid type, and, most importantly, how quickly it develops.<sup>1</sup> Causes of pericardial effusion include hemorrhage, infection, malignant effusions, chronic pericarditis, autoimmune diseases, inflammatory processes, and other idiopathic causes.

Cardiac tamponade is a result of pressures within the pericardial space exceeding the right ventricular filling pressures, and represents a true cardiovascular emergency.

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There are no disclosures to report.

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Tamponade can develop with as little as 150 mL of fluid if it has accumulated rapidly. When the intrapericardial pressure exceeds the right ventricular pressure, ventricular filling is impaired, preload is reduced, and cardiac output decreases.

Traditionally, practitioners performing a pericardiocentesis relied on anatomic landmarks alone. This approach put the diaphragm, liver, gastrointestinal tract, lung, and myocardial tissue at risk for accidental perforation or laceration. Echocardiographic-guided pericardiocentesis using the subxiphoid approach is relatively safe and effective, with 97% success and only 1% having serious complications.<sup>2</sup> With ultrasound guidance, practitioners have improved complication rates and have discovered other approaches to performing a bedside pericardiocentesis.<sup>1</sup>

### **Diagnosis**

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Early stages of pericardial tamponade may produce signs and symptoms of dyspnea, positional relief with sitting forward, tachycardia, displaced point of maximal impulse, and narrowed pulse pressure. As tamponade becomes more severe, additional findings may include Beck's triad (muffled heart sounds, elevated jugular venous pressure, hypotension) and evidence of shock. Pulsus paradoxus may be a useful clue when it is present and detectable. Pain is usually not present until late tamponade occurs or if there is a concurrent pericarditis.

An electrocardiogram (ECG) is typically the first diagnostic test obtained, and may show findings such as low-voltage QRS complexes, PR-segment depression, and ST-segment elevation. Electrical alternans is commonly described, but is very insensitive and seen only in less than 20% of cases.

A chest radiograph may show an enlarged cardiac silhouette; however, this is usually not evident until effusions are moderately sized or larger. The pericardial fat pad sign may be seen on lateral views, and is described as a lucent interval between the anterior heart and the chest wall.

Bedside 2-dimensional cardiac ultrasonography is the best way of making the diagnosis of a pericardial effusion and cardiac tamponade in the critically ill patient, and can be used to guide an emergent bedside pericardiocentesis. Tamponade results as a pericardial effusion progressively increases in pressure. As the effusion develops, collapse of the right atrium during diastole will be the first sonographic change, and is highly sensitive for tamponade. Eventually pericardial pressures will overwhelm the right ventricle as well, and cause both the right atrium and right ventricle to collapse during diastole. This finding indicates more severe tamponade, and is more specific than right atrial collapse alone.<sup>3</sup> Once end-diastolic right ventricular collapse is noted on bedside ultrasonography, a pericardiocentesis must be performed immediately to release the pressure surrounding the heart.

### **Precautions**

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- Patients with a pericardial effusion with any indication of clinical deterioration and instability will need an emergent bedside pericardiocentesis performed before more definitive management.
- Pericardial effusions secondary to trauma or ventricular wall rupture will likely not stop bleeding spontaneously, and may have more complications with bedside drainage. In general, one should avoid performing a closed pericardiocentesis in these cases, and instead insert a catheter into the pericardial sac that allows for continuous or intermittent drainage of any blood or fluid that accumulates.
- In those presenting with hemodynamic instability, intravenous hydration may temporarily stabilize vital signs while preparing for the procedure. Half of patients

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