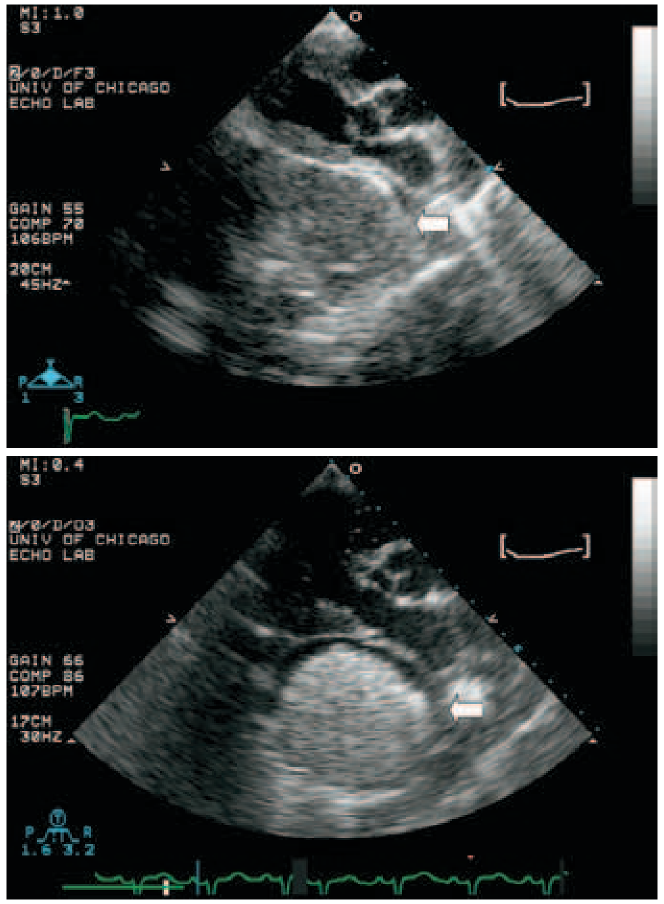


Figure 12.20 A mass posterior to the left atrium (*arrow*) is noted from the parasternal long axis view (*top*). Following the ingestion of a carbonated beverage mixed with 1.5 mL of activated Definity contrast media this mass became well delineated (*bottom*); thus confirming the suspicion that this extracardiac mass was a hiatus hernia. Reprinted from Smelley M, Lang RM. Large Mass Impinging on the Left Atrium: Diagnostic Value of a New Cocktail, *J Am Soc Echocardiogr*, Vol. 20(12), page 1414.e6, © 2007 with permission from Elsevier.

Pericardiocentesis

Pericardiocentesis is a procedure whereby fluid is aspirated from the pericardial cavity via a needle. It may be performed: (1) when there is a large pericardial effusion, (2) to relieve cardiac tamponade, or (3) to obtain fluid for analysis.

The role of echocardiography in this procedure is to:

1. confirm the presence, size and distribution of the effusion,
2. identify the ideal puncture site and trajectory angle for needle entry,
3. confirm the needle location within the pericardial cavity,
4. reassess the amount of residual fluid following the procedure.

In particular, the ideal site and trajectory angle for needle entry is based on: (1) the shortest distance from the body surface to the pericardial effusion where fluid accumulation is maximal, and (2) a straight trajectory path that avoids vital structures such as the liver, myocardium and lungs.

Most commonly, pericardiocentesis is performed from the subcostal and para-apical locations (Fig. 12.21). The injection of a small volume of saline can be performed to confirm the location of the needle within the pericardial space (Fig. 12.22). This is especially important if a bloody fluid return is noted following needle insertion.

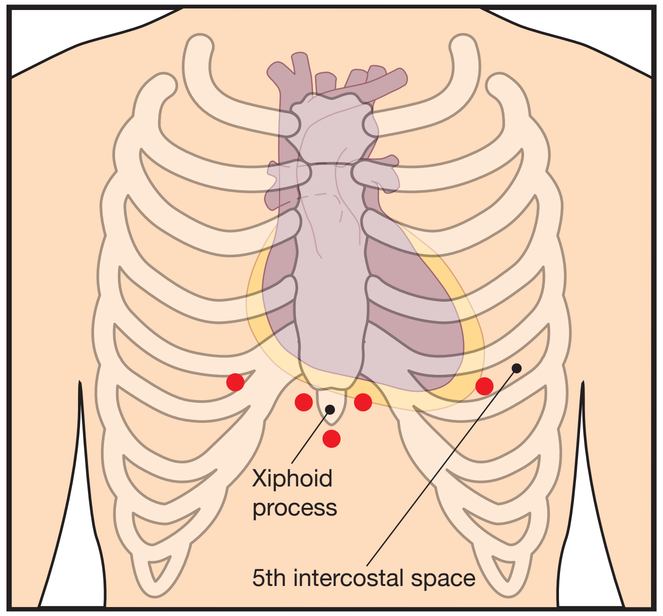


Figure 12.21 The red dots on this schematic indicate the commonly selected locations for pericardiocentesis.

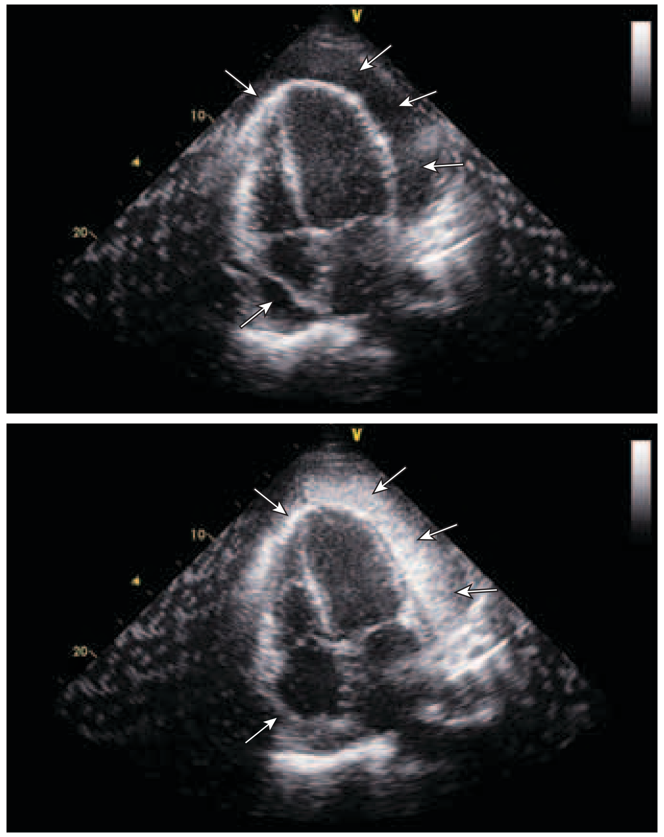


Figure 12.22 The apical 4-chamber view shows a large circumferential pericardial effusion (*top*, *arrows*). Following the injection of agitated saline through the pericardiocentesis needle opacification of the pericardial space is demonstrated confirming the intrapericardial position of the needle (*bottom, arrows*).

Important Note: Aortic dissection is a major contra-indication for pericardiocentesis due to the risk of intensified bleeding and extension of the dissection [12.1].

[12.1] Maisch B, Seferović PM, Ristić AD, Erbel R, Rienmüller R, Adler Y, Tomkowski WZ, Thiene G, Yacoub MH; Task Force on the Diagnosis and Management of Pericardial Diseases of the European Society of Cardiology. Guidelines on the diagnosis and management of pericardial diseases executive summary; The Task force on the diagnosis and management of pericardial diseases of the European Society of Cardiology. *Eur Heart J.* 2004 Apr;25(7):591 & 603.

Cardiac Tamponade

Cardiac tamponade occurs when there is an increase in the intrapericardial pressure (IPP) due to accumulation of an effusion, blood, clots, pus, gas or combinations of these within the pericardium. This ultimately leads to compression of the heart, impeded diastolic filling of both ventricles, systemic and pulmonary congestion, and a decreased stroke volume and cardiac output.

Pathophysiology of Cardiac Tamponade

In order to understand the pathophysiological changes that occur with cardiac tamponade, consideration of the transmural pressures, changes in right and left heart filling with respiration, and ventricular interdependence is required.

Transmural Filling Pressures

The transmural filling pressure describes the difference in pressure between the inside and the outside of a walled structure. Therefore, for the heart the transmural filling pressure (TMFP) can be used to describe the pressure difference between the intracavity pressure (ICP) and the IPP.

In the normal situation, the intrathoracic pressure (ITP) is transmitted to the pericardial sac so the IPP is approximately the same as the negative (subatmospheric) ITP. Therefore, as the ICP is usually positive, there is a positive TMFP which is higher than the ICP. This positive TMFP maintains the shape of the cardiac chambers and prevents them from collapsing at end-diastole when the ICP falls to zero (Fig. 12.23).

With cardiac tamponade, the IPP is increased. As the IPP rises, the ICP also rises in an attempt to maintain a positive TMFP and an adequate cardiac output. However, further increases in the IPP result in a fall in the TMFP which will result in impeded diastolic filling of the heart and a subsequent reduction in cardiac output. When the TMFP becomes negative there is collapse (compression) of the cardiac chambers (Fig. 12.24).

Right and Left Heart Filling with Respiration

In the normal situation, there is augmentation of right heart filling with inspiration, a decrease in right heart filling with expiration, and minimal variation in left heart filling with respiration.

During inspiration, as the diaphragm descends there is an increase in the intraabdominal pressure (IAP) and a reduction in the ITP which leads to an augmentation of systemic venous return and increased filling of the right heart. With expiration, the opposite occurs so as the diaphragm ascends, there is an increase in the ITP and a decrease in the IAP which leads to a reduction in the systemic venous return and a decrease in right heart filling.

There is minimal variation in left heart filling with respiration. This is because changes in ITP are transmitted to both the pericardial sac (and the cardiac chambers) and the pulmonary veins to the same degree (Fig. 12.25, top). For instance, as the ITP decreases with inspiration the IPP and ICP also decrease to the same degree; and as the pulmonary veins are also contained within the thoracic cavity, the decrease in ITP is also reflected in the pulmonary veins to the same degree. Likewise with expiration, as the ITP increases so does the IPP, ICP and pulmonary venous pressure to the same degree. Therefore, the effective filling gradient (EFG) of the left heart changes only slightly during respiration. This slight respiratory variation in the left heart EFG is based on changes in right heart filling with inspiration as described above. In particular, increased RV filling during inspiration causes the IVS to bow slightly to the left; as a result there is a slight inspiratory reduction in LV filling and LV stroke volume as well as a slight inspiratory fall in the systemic arterial pressure (< 10 mm Hg).

In the case of tamponade, the normal respiratory changes described above are accentuated. That is, with inspiration left heart filling is decreased more than normal and right heart filling is increased more than normal. These changes occur because the IPP is increased. Therefore, the normal decline in the ITP during inspiration is not fully transmitted to the pericardial sac and to the cardiac chambers; however, the ITP decline is transmitted to the pulmonary veins as normal. As a result, the increased IPP means that the ICP does not fall as it should but because the pulmonary venous pressure falls

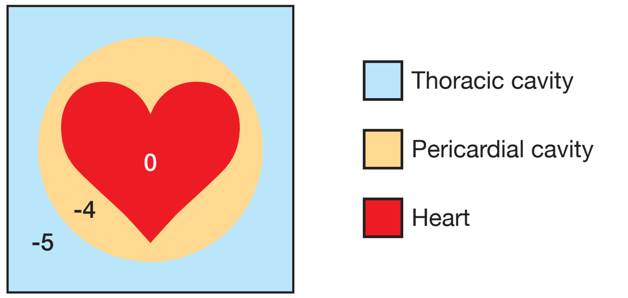
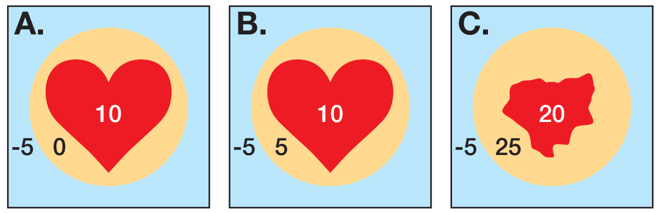


Figure 12.23 The transmural filling pressure (TMFP) is the difference between the intracavity pressure (ICP) and the intrapericardial pressure (IPP). In this schematic the ICP is 0 and the IPP is -4 so the TMFP is 4 mm Hg. Therefore, even when the ICP is 0 there is a positive TMFP which prevents the cardiac chambers from collapsing.

The effective filling gradient (EFG) is calculated as the difference between the pulmonary capillary wedge pressure (PCWP) and the intrapericardial pressure (IPP). This value is almost the same as the diastolic gradient between the pulmonary veins and the ventricular cavity. Therefore, the EFG essentially reflects the driving pressure from the lungs across the pulmonary veins and into the left heart.



A.	B.	C.
TMFP = ICP – IPP	TMFP = ICP – IPP	TMFP = ICP – IPP
= 10 – 0	= 10 – 5	= 20 – 25
= 10 mm Hg	= 5mm Hg	= -5mm Hg

Figure 12.24 This schematic illustrates the changes to transmural filling pressures (TMFP) with increasing intrapericardial pressure (IPP). **Panel A:** IPP is zero and the intracardiac pressure (ICP) is 10 mm Hg; the resultant TMFP, which is the difference between the ICP and the IPP, is 10 mm Hg. Cardiac output and diastolic filling are maintained. **Panel B:** IPP is slightly positive at 5 mm Hg and ICP is 10 mmHg; the resultant TMFP is 5 mm Hg. This results in a decrease in both the cardiac output and diastolic filling. **Panel C:** IPP is more positive at 25 mm Hg and despite the increase in ICP to 20 mm Hg, the resultant TMFP is -5 mm Hg. This results in a negative TMFP and subsequent collapse of the cardiac chambers.