The Pericardium: Anatomy, Normal variants, and Pathology

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Learning objectives

To describe the anatomy of the pericardium.

1. The sinuses and recesses of the pericardial cavity.

To illustrate normal variants and the pathologic pericardium on CT, MRI and PET-CT.

1. Pericardial fluid mimicking lymph node.
2. Pericardial effusion and thickening
3. Constrictive pericarditis
4. Pericarditis other than constrictive pericarditis
5. Pericardial mass
   a. Pericardial cyst
   b. Pericardial tumor (Primary, Secondary)
Background

Knowledge of the pericardial anatomy and normal variants is necessary to avoid mistaking them for pathologic conditions. Recent advances in imaging technology have led to a detailed assessment of the pericardium. CT and MRI demonstrate delineation of the pericardial anatomy, and provide location, extension and characterization of pericardial lesions.

Multi-detector CT enables multi-planar reformation of images and evaluation of small lesions.

MRI provides depiction of the pericardium without radiation exposure and is superior to tissue characterization of pericardial disease. Cine MRI can evaluate the motion of the pericardium throughout the cardiac cycle, and get direct findings of the rigidity.

18F-PET-CT provides valuable information regarding the degree of activity in the infection and inflammatory pericardial disease in addition to malignant pericardial lesions.
Imaging findings OR Procedure details

Anatomy, Normal Variants

1. Pericardium

The pericardium surrounds the heart. The pericardial thickness is 1-3 mm. The pericardium consists of two layers: the outer fibrous pericardium and component and the inner serous pericardium.

The external surface of the fibrous pericardium is closed by its fusion with the external coats of the great vessels and is fused with the central tendon of the diaphragm.

The serous pericardium is divided into two layers, the outer parietal pericardium and the inner visceral pericardium (epicardium). The visceral pericardium, which is the layer intimately connected to the myocardium, reflects back upon itself at the level of the beginning of the great vessels to join the parietal pericardium, which lines the fibrous pericardium. The pericardial cavity is a potential space between the parietal and visceral pericardium. It contains 20-50 mL of serous fluid.

2. Pericardial sinuses and recesses

CT and MR imaging provide excellent visualization of the pericardium in most patients, especially in case of mediastinal fat deposit, pericardial effusion and thickening (Fig. 1 on page 9).

Pericardial sinuses and recesses can be visible if they contain enough fluid. Knowledge of the location of these sinuses and recesses will prevent mistaking them for abnormal lesions such as enlarged lymph nodes and other masses. Knowledge of the pericardial anatomy is also important because pericardial cysts and tumors may arise in these locations.

There are two pericardial sinuses (Fig. 2 on page 9): transverse and oblique. The transverse sinus is dorsal to the ascending aorta and main pulmonary artery, just above the left atrium. The oblique sinus is the posterior extension of the pericardium and is situated behind the left atrium. The transverse sinus lies superior and anterior to the oblique sinus. However, the transverse and oblique sinuses do not communicate at this level and are separated by pericardial reflections (Fig. 3 on page 10).

A. Recesses Arising from the Pericardial Cavity Proper
The pulmonic vein recesses are located between the superior and inferior pulmonary veins and lie along the lateral borders of the heart. At CT, the left pulmonic vein recess (Fig. 4 on page 12) is identified more frequently than the right pulmonic vein recess (Fig. 3 on page 10, Fig. 4 on page 12). However, the latter is usually deeper than the former, possibly because the left pulmonary veins often form a common trunk. The pulmonic vein recesses are in proximity to and can be mistaken for bronchopulmonary lymph nodes.

The postcaval recess lies posterior to and to the right of the SVC (Fig. 3 on page 10).

B. Recesses Arising from the Transverse Sinus

The superior extent of the transverse sinus is the superior aortic recess. The superior aortic recess is a curvilinear structure wrapped around the right wall of the ascending aorta and has anterior, posterior, and right lateral portions (Fig. 5 on page 12). The anterior portion of the superior aortic recess lies anterior to the aorta and pulmonary artery and has a characteristic triangular shape as it insinuates itself between the ascending aorta and the main pulmonary artery. The anterior portion of the superior aortic recess includes the area occasionally described as the aortopulmonary window recess (Fig. 5 on page 12). The lateral portion similarly insinuates itself between the ascending aorta and the SVC. The posterior portion lies posterior to the ascending aorta and manifests as a well-defined crescentic fluid collection adjacent to the posterior wall of the ascending aorta usually at the level of the left pulmonary artery.

The inferior aortic recess extends inferiorly from the transverse sinus posterior to the aorta and anterior to the left atrium (Fig. 3 on page 10). The caudal extent of this recess is at the level of the aortic valve annulus.

The right and left pulmonic recesses (Fig. 6 on page 13) form the lateral extent of the transverse sinus. The right and left pulmonic recesses lie inferior to the right and left pulmonary arteries, respectively.

Fluid collections within the posterior portion of the superior aortic recess can mimic the appearance of lymphadenopathy. Whereas the posterior portion demonstrates a crescent shape and water density on CT, precarinal lymph nodes tend to be round or oval and of soft-tissue attenuation (Fig. 7 on page 13). The posterior portion is located directly posterior to the ascending aorta so that intervening fat is not identified. The anterior portion of the superior aortic recess can extend more superiorly than expected to lie in a right paratracheal location (Fig. 8 on page 14), where it may be mistaken for a right paratracheal lymph node or bronchogenic cyst. The presence of the connection to the pericardium is distinguishing feature of the posterior portion. Fluid collections within the pulmonic recesses can mimic the appearance of lymphadenopathy. Fluid in the anterior portion of the superior aortic recess has also been described as mimicking the appearance of aortic dissection (Fig. 9 on page 15).
C. Recesses Arising from the Oblique Sinus

The oblique sinus extends superiorly behind the right pulmonary artery, where it is called the posterior pericardial recess. Fluid in the oblique sinus can simulate abnormalities in the esophagus, descending thoracic aorta, and subcarinal and bronchopulmonary lymph nodes (Fig. 10 on page 16).

Pericardial Disease

1. Pericardial effusion and thickening

There are various causes of pericardial effusion. Specific causes of pericardial effusion may include infection (bacterial, viral, or fungal), inflammation following a heart attack, connective tissue disease, renal failure, malignancy, irradiation, and heart surgery.

CT attenuation measurements enable the characterization of pericardial fluid. A fluid of water density is likely to be a simple effusion. A fluid of higher density suggests bloody effusions (Fig. 11 on page 17), which can result from acute myocardial infarction, rupture of the heart or aorta, neoplasm. A simple effusion has low signal intensity on T1-weighted images and high intensity on GRE cine images. Hemorrhagic effusion is characterized by high signal intensity on T1-weighted images and low intensity on GRE cine images.

Pericardial thickening is commonly nonspecific, but irregular or nodular pericardial thickening can be imaging findings suggesting the presence of malignant pericardial effusion.

2. Constrictive pericarditis

Constrictive pericarditis is characterized by fibrous thickening of pericardium (Fig. 12 on page 18), which leads to restriction of the heart motion and decreased filling of ventricular chambers. Constrictive pericarditis can be caused by tuberculosis or viral (Coxsackie B) infections, by chronic renal failure, rheumatoid arthritis, neoplasm, cardiac surgery (most common), radiotherapy to mediastinum, and idiopathic condition.

Pericardial thickening accompanied by clinical findings of heart failure is highly suggestive of constrictive pericarditis. Pericardial calcification is also associated with constrictive pericarditis. It is important to remember, however, that many patients do not present with these finding, and the diagnosis of constrictive pericarditis should not be discarded if thickening is not present.
With cine MRI technique (Fig. 13), the septal dynamics can be evaluated. Cine MRI can also be applied to evaluate the motion of the pericardium, and to get a direct idea about the rigidity of the pericardium.

3. Pericarditis

Pericarditis is an inflammation of the pericardium. The causes of pericarditis are varied, including viral infections, bacterial infections, uremia, rheumatoid arthritis, sarcoidosis (Fig. 14 on page 20), and radiation therapy.

4. Pericardial mass

A. pericardial cyst

Pericardial cysts (Fig. 15 on page 21) are usually found in the inferior part of the pericardium, especially in the right cardiophrenic angle. Pericardial cysts usually present a thin-walled unilocular cyst containing fluid of water density and do not enhance after contrast material administration. A pericardial cyst may occur anywhere in the mediastinum. A pericardial cyst in an unusual location may be indistinguishable from a bronchogenic cyst or thymic cyst.

B. Pericardial tumor

Pericardial tumors may be primary or secondary. Benign primary tumors include teratomas, lipomas, fibromas, and hemangiomas. Malignant primary tumors include mesotheliomas (Fig. 16 on page 22), lymphomas, and sarcomas.

Whereas pericardial mesothelioma is less than 1% of all mesotheliomas, it is 50% of all primary pericardial tumors. It affects all ages, males more than females. It causes tamponade and can metastasize to the spine, adjacent soft tissues, and brain. Primary malignant mesothelioma of the pericardium may manifest as pericardial effusion, occasionally accompanied by pericardial thickening or nodules.

Pericardial metastases are much more common than primary pericardial tumors. Lung and breast carcinoma are the most common sources of metastases to the pericardium. Malignant lymphoma and malignant melanoma often metastasize to the pericardium. Tumors may seed the pericardium via the lymph system or the blood stream or may invade directly from the lung or mediastinum.

Hematogenous metastases to the epicardium commonly occur via the coronary arteries and are usually accompanied by evidence of hematogenous metastases in other organs such as lung and liver. In particular, pulmonary metastases are usually present.
Direct invasion of tumors into the pericardium occurs in patients with bronchogenic carcinomas, esophageal carcinoma, breast carcinoma, thymic carcinoma (Fig. 17 on page 23), or mediastinal lymphoma.
Fig. 1: Normal pericardium. Axial CT image show a pericardium with normal thickness (arrows). The pericardium is visible over the right atrium and right ventricle. The pericardium is visible over the right atrium and right ventricle.

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Fig. 2: Pericardial recesses and sinuses. Structure diagram of pericardial sac from an anterior view. The heart is removed. Pericardium extends superiorly to cover the SVC and aorta. Transverse sinus and oblique sinus are separated by pericardial reflections. Pulmonic vein recesses lie between the superior and inferior pulmonary veins. The transverse sinus and oblique sinus are separated by pericardial reflections. SVC = superior vena cava, IVC = inferior vena cava, PA = pulmonary artery

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Fig. 3: Pericardial sinuses and recesses. The transverse sinus (asterisks in b, c) is dorsal to the ascending aorta and main pulmonary artery. The inferior aortic recess (black arrows in d, e) extends inferiorly from the transverse sinus posterior to the aorta and anterior to the left atrium. Coronal reformatted image shows the caudal extent of inferior aortic recess (black arrows in f). The Oblique sinus (white arrows in a-c) is situated behind the left atrium and is separated do not communicate at this level and are separated from the transverse sinus by pericardial reflections. A small amount of fluid is seen posterior to left pulmonary vein in the left pulmonic vein recess recess (arrowheads in a-c). The postcaval recess (curved arrows in b, c) is located behind and right lateral to SVC. SVC = superior vena cava, PA = pulmonary artery, RA = right atrium, LA = left atrium, LV = left ventricular

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**Fig. 4:** Pulmonic vein recess. Axial CT shows fluid in right pulmonic vein recess (white arrow) medial to right pulmonary vein and in left pulmonic vein recess (black arrow) posterior to left pulmonary vein. The pulmonic vein recesses are in proximity to and can be mistaken for bronchopulmonary lymph nodes.

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**Fig. 5:** The superior aortic recess. (a) The anterior portion (arrows) of the superior aortic recess lies anterior to the aorta and pulmonary artery and has a characteristic triangular shape as it insinuates itself between the ascending aorta and the main pulmonary artery. The posterior portion manifests as a well-defined crescentic fluid collection adjacent to the
posterior wall of the ascending aorta usually at the level of the left pulmonary artery. (b) The anterior portion of the superior aortic recess includes the area occasionally described as the aortopulmonary window recess.

Fig. 6: Pulmonic recess. The right (arrow) and left (asterisk) pulmonic recesses form the lateral extent of the transverse sinus. The right and left pulmonic recesses lie inferior to the right and left pulmonary arteries, respectively.

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**Fig. 7:** Fluid in the posterior portion of the superior aortic recess and lymph node. Whereas the posterior portion (arrow) demonstrates a crescent shape and water density on CT, precarinal lymph nodes (arrowhead) shows oval shape and of soft-tissue attenuation.

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**Fig. 8:** The anterior portion of the superior aortic recess. (a) Fluid collection within the anterior portion, which is round on axial image, extends superiorly to lie in a right paratracheal location. (b) Coronal reformatted image shows the cranial extent of anterior portion. Ao = aorta, PA = pulmonary artery, SVC = superior vena cava, IVC = inferior vena cava, LA = left atrium

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**Fig. 9:** The anterior portion of the superior aortic recess. Fluid in the anterior portion of the superior aortic recess mimics the appearance of aortic dissection.

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Fig. 10: Pericardial recesses mimicking lymph nodes. Axial CT image shows fluid in the posterior pericardial recess of the oblique sinus (black arrow), a finding that can be mistaken for subcarinal lymph node. The right pulmonic vein recess (white arrow) mimicking lymphadenopathy is also shown. Transverse sinus (asterisk) is located in front of them.

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**Fig. 11:** Bloody pericardial effusion. Axial unenhanced CT reveals a high density pericardial effusion (white arrow) indicating hemopericardium and intimal flap (black arrow) in the ascending aorta. There is left hemothorax (asterisk).

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Fig. 12: Constrictive pericarditis. Axial enhanced CT scan shows pericardial thickening (white arrows in a). Dilatation of the inferior vena cava, the right hepatic vein (black arrow), and bilateral pleural effusion (asterisks) is noted. Axial and short axis images reveal pericardial thickening (white arrows in c, d).

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**Fig. 13:** Constrictive pericarditis. Cine MRI of the same patient shown in Fig. 12 demonstrates adherence in front of the left ventricular wall and paradoxical septal bounce.

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Fig. 14: Sarcoidosis. Axial CT (a) and MRI (b) show pericardial thickening (arrows). PET-CT demonstrates increased FDG-uptake (SUVmax 2.8) in the pericardium (arrows in c).

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Fig. 15: Pericardial cyst. Axial CT image shows a low attenuation mass in the right cardiophrenic angle. This mass, which is surgically removed at the same time with thymoma (not shown), was diagnosed as pericardial cyst.

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Fig. 16: Pericardial mesothelioma invading the right atrium. Axial enhanced CT (a, b) shows a heterogeneous mass (M) located inferior to the right atrium, pericardial effusion and thickening. On coronal reformatted image (c), this mass displaces the right atrium superiorly. Ao = aorta, PA = pulmonary artery, RA = right atrium, RV = right ventricle, LV = left ventricle

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Fig. 17: Pericardial metastases Woman in her sixties with thymic cancer and pulmonary metastases. Axial enhanced CT shows pericardial masses (arrowheads), pericardial effusion (asterisks) and right pleural effusion. PET-CT demonstrates increased FDG-uptake (SUVmax 3.5) in the masses (arrows).

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Conclusion

Familiarity with the anatomy and normal variants is necessary to prevent misinterpretation of images. CT, MRI and PET-CT are very useful in the evaluation of pericardial lesions, and it is mandatory to know the imaging features of these diseases.
References


