DIAGNOSTIC IMAGING OF THE PERICARDIAL DISEASES

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Anatomy

- The pericardium is a conical fibro-serous sac, in which the heart and the roots of the great vessels are contained.
- It is placed behind the sternum and the cartilages of the third, fourth, fifth, sixth, and seventh ribs of the left side, in the mediastinal cavity.
Topographic anatomy

In front, it is separated from the anterior wall of the thorax, in the greater part of its extent, by the lungs and pleurae; but a small area, somewhat variable in size, and usually corresponding with the left half of the lower portion of the body of the sternum and the medial ends of the cartilages of the fourth and fifth ribs of the left side, comes into direct relationship with the chest wall. The lower extremity of the thymus, in the child, is in contact with the front of the upper part of the pericardium.

Behind, it rests upon the bronchi, the esophagus, the descending thoracic aorta, and the posterior part of the mediastinal surface of each lung.

Laterally, it is covered by the pleurae, and is in relation with the mediastinal surfaces of the lungs; the phrenic nerve, with its accompanying vessels, descends between the pericardium and pleura on either side.

Below - attachment to the centrum tendineum diaphragmae.
Posterior wall of the pericardial sac, showing the lines of reflection of the serous pericardium on the great vessels.
• **Structure of the Pericardium** - Although the pericardium is usually described as a single sac, an examination of its structure shows that it consists essentially of two sacs intimately connected with one another, but totally different in structure.

• **The outer sac**, known as the *fibrous pericardium*, consists of fibrous tissue - X binded collagen fibres - combines strength and elasticity. Ligg. Sternopericardiaca, membrana bronchopericardiaca are attached to it.

• **The inner sac**, or *serous pericardium*, is a delicate membrane which lies within the fibrous sac and lines its walls; it is composed of a single layer of flattened cells (with secretory and resorbive function) resting on loose connective tissue (which is very good supplied with blood and nerves).
Structure of the pericardium

- The fibrous pericardium encases the heart and blends with the adventitia of the roots of the great vessels. In the inferior aspect it also blends with the central tendon of the diaphragm.

- The serous pericardium is invaginated by the heart and comprises visceral and parietal layers that enclose a narrow pericardial cavity. The visceral pericardium covers the surface of the heart and is continuous with the thin parietal layer that lines the inner surface of the fibrous pericardium. Normally, the pericardium contains just enough lubricating fluid-15-35 ml between its two layers for them to slide easily over one another.

- On the posterior surface of the heart, reflections of serous pericardium around the pulmonary veins form a recess, the oblique sinus. The transverse sinus is formed by reflection of serous pericardium between the aorta and pulmonary trunk anteriorly and the pulmonary veins posteriorly.
The arteries of the pericardium are derived from the *internal mammary* and its musculo-phrenic branch, and from the descending thoracic aorta.

The nerves of the pericardium are derived from the *vagus* and *phrenic* nerves (fibrous and parietal serous layers), and the sympathetic (for pain and muscles and vessels of the heart) trunks.
Embryology

- Four cavities are formed within the embryo, viz., one on either side within the **mesoderm** of the pericardial area, and one in either lateral mass of the general mesoderm. All these are at first independent of each other and of the extraembryonic coelom, but later they become continuous.

- The two cavities in the general mesoderm unite on the ventral aspect of the gut and form the pleuro-peritoneal cavity, which becomes continuous with the remains of the extraembryonic coelom around the umbilicus;

- the two cavities in the pericardial area rapidly join to form a single pericardial cavity, and this from two lateral diverticula extend caudalward to open into the pleuroperitoneal cavity.
During the 5th week lateral structures called **pleuropericardial folds** begin to grow towards the midline.
Embryology

- As the pleuropericardial folds move medially, they bring along the phrenic nerves. While the pleuropericardial folds grow medially, the root of each fold migrates ventrally.
At the end of the 5th week, the pleuropericardial folds fuse, partitioning the thoracic cavity into a pericardial cavity and two partially formed pleural cavities.
Functions of the pericardium

- **Anatomical**
  1. Fixing of cardiac position in the thorax.
  2. Isolation to reduce spread of pathologic process to or from the heart.
  3. Reduction of the friction resistance between the pericardial layers by the presence of pericardial fluid.
  4. Inclusion of blood and lymphatic vessels and of cardiac nerves.

- **Mechanical**
  1. Prevents the (acute) dilatation of the cardiac chambers and is probably thicker along the right than along the left ventricular myocardium.
  2. Supports atrial filling by creating negative pericardial pressure during systole.
  3. Prevents ventriculoatrial reflux if the end diastolic pressures are elevated.
  4. In case of increased systemic circulatory resistance, the right ventricular stroke volume is adapted to the reduced left ventricular stroke volume.
Diagnostic imaging of the pericardium

**Chest X-ray**
1. initial step
2. monitoring the pulmonary vessels,
3. and other chest and pulmonary abnormalities, pneumothorax, pneumomediastinum, pneumopericardium, effusions, calcifications.

**Echocardiography**
1. remains the primary method of investigation- (available, does not use ionizing radiation) for effusion, tamponade
2. disadvantages - small, limited field of view, poor acoustic windows.
3. not suitable for evaluation of pericardial masses, characterization of the pericardial effusions, constrictive pericarditis or congenital total or partial absence of the pericardium, detection of associated abnormalities in the lungs or mediastinum.
Imaging methods

- **CT**
  1. Larger field of view, allows assessment of the entire chest and detection of associated abnormalities in the adjacent structures.
  2. Less operator dependent
  3. Improved temporal resolution of multidetector CT allows the acquisition of high quality motion-free images of the pericardium.
  4. Multidetector CT scanners may offer retrospective cardiac gating, thus allowing acquisition of cine CT images, which provide valuable information about the function and dynamics of the heart and pericardium.
  5. Demonstrate pericardial calcification.

- **MR**
  1. Provide information about the pericardial effusion in addition to the effects on cardiac functioning and diastolic filling.
  2. Simple transudative effusions usually exhibit low signal intensity on T1- or PD-weighted SE or double inversion images and high signal intensity on T2-weighted SE, fast SE, GRE, or triple inversion as well as steady-state free precession and fast cine images. The presence of septations and debris suggests a complex effusion.
  3. Hemorrhagic and exudative effusions generally exhibit high signal intensity on T1- and T2-weighted images owing to the high protein content. Hemorrhage in the pericardial space usually exhibits low signal intensity on gradient-echo images;
Imaging anatomy

- CT and MR imaging provide excellent visualization of the pericardium in most patients.
- The thickness of the normal pericardium, measured on CT scans and on MR images, is less than 2 mm.
- Discrimination of the pericardium from the myocardium on radiologic images requires the presence of epicardial fat or pericardial fluid. Although the pericardium is visible over the right atrium and right ventricle in most individuals, it often is not visible over the lateral and posterior walls of the left ventricle.
- The left atrium is only partially covered by the pericardium; it has been suggested that this anatomic feature may contribute to the left atrial enlargement seen in patients with constrictive pericarditis.
**Normal pericardium.** Axial contrast-enhanced CT scan and axial ECG gated spin-echo MR image show a pericardium with normal thickness. Note the epicardial and anterior mediastinal fat, outlining the pericardium.
Imaging anatomy

Normal pericardium. Electrocardiography-gated CT appearance of normal pericardium in oblique aortic root long axis reconstruction shows the pericardi-um (arrows) extending 3cm upwards on the pulmonary artery (PA) and aorta (AO), where the pericardial reflection site is located. LA, left atrium; LV, left ventricle, RPA, right pulmonary artery; RV, right ventricle.
MR – dynamic study

**SSFP** (trueFISP/Siemens, FIESTA /GE/) Tissue contrast is generated based on the ratio of the spin-spin relaxation time (T2) and spin lattice relaxation time (T1). The sequence accentuates the contrast of spins with high T2/T1 ratios (such as CSF and fat) while suppressing signal from tissues with low T2/T1 ratios (such as muscle and myocardium - a term used to describe the middle layer of the heart wall).

- High signal-to-noise images
- Excellent contrast between soft tissues and fluids
- Reduced repetition times, which minimizes motion artifacts. Inherent flow compensation, which minimizes artifacts due to blood flow.
Summary MRI: Anatomy and Sequences

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Conclusions

• **Cardiovascular MR** combines three key features:
  • good visualisation of anatomy/morphology,
  • high quality functional assessment (static, during dynamic manoeuvres or with stress) and
  • the ability to distinguish normal and abnormal tissue, according to different magnetic properties, either before or after contrast.

• In particular, CMR can help with the diagnosis of constrictive pericarditis (CP) and its differentiation from restrictive cardiomyopathy (RCMP), which can at times be particularly difficult.

• Surgical planning and estimate the presence of a fat plane between the pericardium and myocardium indicating an easier dissection in that area,
Pericardial recesses

- Several pericardial recesses may be visible on CT scans and MR images. Small amounts of fluid may be present in these structures in healthy individuals.

- **The superior pericardial recess**, a curvilinear structure wrapped around the right wall of the Ao asc, may be mistaken for an aortic dissection, mediastinal mass, lymph node.

- **The transverse pericardial sinus**, which is dorsal to the Ao asc, sometimes may be mistaken for aortic dissection or lymphadenopathy.

- **The oblique pericardial sinus**, which is situated behind the left atrium, may be misinterpreted as esophageal lesions or bronchogenic cysts
Pericardial recesses

Transverse sinus (T) and oblique sinus(*) are separated by pericardial reflections.
Pericardial recesses

• *Recesses Arising from the Pericardial Cavity Proper*
  • The pulmonic vein recesses, which are usually small, lie along the lateral borders of the heart between the superior and inferior pulmonary veins. These recesses are located where the pericardium is attached to the venous adventitia. The pulmonic vein recesses can be mistaken for broncho-pulmonary LN.
The pulmonic vein recesses (arrows) lie between the superior and inferior pulmonary veins
Recesses Arising from the Transverse Sinus.

- The superior aortic recess extends anterio-posterior to the ascending aorta and has anterior, posterior, and right lateral portions.
- (Lack of fat plane distinguish them from LN)
Recesses Arising from the Transverse Sinus.

Axial CE CT scan shows a small amount of fluid in the transverse sinus, posterior to the Ao asc. Communication laterally with the left pulmonic recess.
Recesses Arising from the Oblique Sinus

The oblique sinus extends superiorly behind the right pulmonary artery and medial to the bronchus intermedius, where it is called the posterior pericardial recess. Fluid in the posterior pericardial recess may be mistaken for peribronchial or subcarinal LN.
Pericardial recesses

- **Pericardial cavity proper**
  - PCR-postcaval recess
  - RPVR-right pulm. vein recess
  - LPVR-left pulm. vein recess
- **Transverse sinus - TS**
- **Superior aortic recess - SAR**
  - Anterior portion - aSAR
  - Posterior portion - pSAR
  - Right lateral portion - rSAR
- **Inferior aortic recess - IAR**
- **Right pulmonic recess - RPR**
- **Left pulmonic recess - LPR**
- **Oblique sinus - OS**
  - Posterior pericardial recess
Conclusions

- Faster scanning techniques and cardiac gating allow improved visualization of finer anatomic details of the heart and pericardium compared with older scanning techniques.
- Knowledge of the cardiac anatomy will prevent mistaking normal anatomic structures for pathologic processes.
Natural associations

It is the content in the sac that counts!
Classification of pericardial diseases
ESC guidelines

- Congenital defects
- Pericarditis (dry, effusive, effusive-constrictive, and constrictive)
- Neoplasm
- Cysts
Congenital defects of the pericardium

- 1/10000 autopsies
- Partial left (70%), right (17%) or total bilateral (rare) pericardial absence.
- Most patients with total pericardial absence are asymptomatic. Homolateral cardiac displacement and augmented heart mobility impose an increased risk for traumatic aortic dissection. Partial left side defects can be complicated by herniation and strangulation of the heart through the defect (chest pain, syncope or sudden death). Surgical pericardioplasty is indicated (Dacron, Gore-tex, bovine pericardium).
Congenital absence of the pericardium

Axial contrast-enhanced CT scan (a) and ECG-gated T1-weighted SE image (b) show interposition of lung tissue between the aorta and the main segment of the pulmonary artery (arrow), indicating the absence of the pericardium in this area. Note the rotation of the heart toward the left.
Partial absence of the pericardium. The lucency beneath the heart is interposition of lung between the heart and the diaphragm. The left border is unusually convex and the mediastinum is shifted to the left. The aortopulmonary window has an acute angle with lung in the left side of the mediastinum usually occupied by the pericardium. Shunt vascularlature is also present from an atrial septal defect.
ACUTE PERICARDITIS

- Idiopathic
- Infections (viral, tuberculosis, fungal)
- Uraemia
- Acute myocardial infarction (acute, delayed)
- Neoplasm
- Postcardiac injury syndrome (trauma, surgery)
- Systemic autoimmune disease (systemic LE, RA, ankylosing spondylitis, periarteriitis nodosa, Reiters syndrome)
- After mediastinal radiation
ACUTE PERICARDITIS

- Inflammatory thickened pericardial blades ± pericardial fluid
- Fibrin deposition with fibrinous adhesion of pericardial layers


- DD thickening <=> effusion
Chronic pericarditis

- Chronic (>3 months) pericarditis includes effusive (inflammatory or hydropericardium in heart failure), adhesive, and constrictive forms.

- Symptoms are *usually mild* (chest pain, palpitations, fatigue), related to the degree of cardiac compression and pericardial inflammation. The diagnostic algorithm is similar as in acute pericarditis.
• **Pericardial** effusion originates in the obstruction of venous or lymphatic drainage from the heart.
• **Common causes of pericardial** effusion include heart failure, renal insufficiency, infection (bacterial, viral, or tuberculous), neoplasm (carcinoma of lung or breast, or lymphoma), and injury (from trauma or myocardial infarction).
• **X-ray**- enlarged heart, epicardial fat pad sign suggesting a pericardial effusion.
PERICARDIAL EFFUSION

- **Echocardiography**
  1. primary imaging modality, because of its high sensitivity and specificity
  2. lack of ionizing radiation
  3. low cost.

- **CT and MR**
  1. indicated when loculated or hemorrhagic effusion or pericardial thickening is suspected.
  2. CT attenuation measurements also enable the initial characterization of pericardial fluid. A fluid collection with attenuation close to that of water is likely to be a simple effusion. Attenuation greater than that of water suggests malignancy, hemopericardium, purulent exudate, or effusion associated with hypothyroidism. Pericardial effusions with low attenuation also have been reported in cases of chylopericardium.
  3. The appearance of pericardial fluid is different on SE and GRE cine MR images. Nonhemorrhagic fluid has low signal intensity on T1-weighted SE images and high intensity on GRE cine images. Conversely, hemorrhagic effusion is characterized by high signal intensity on T1-weighted SE images and low intensity on GRE cine images.
  4. When an effusion is secondary to malignancy, an irregularly thickened pericardium or pericardial nodularity may be depicted on MR images.
  5. Associated abnormalities in the mediastinum and lungs also may be detected during the examination.
PERICARDIAL EFFUSION

X-ray and CT of the chest showing the fat pad sign.
- red arrow-fat outside pericardium
- green arrow-pericardial space
- yellow arrow-fat outside the heart
- blue arrow- myocardium
Pericardial effusion in a 40-year-old woman with shortness of breath. Axial contrast-enhanced CT scan shows an effusion (*) with the same attenuation as water (0 HU). Cine GRE image shows a high-signal-intensity pericardial effusion (*) consistent with non-hemorrhagic fluid.
Pericardial effusion in a 68-year-old woman with a recent history of myocardial infarction. Axial ECG-gated T1-weighted SE image shows an effusion with high signal intensity (*) suggestive of hemorrhage.

Four chamber SSFP (Steady State Free Precession) cine view
Pericardial effusion and cardiac tamponade

- Cardiac tamponade is the decompensated phase of cardiac compression caused by effusion accumulation and the increased intrapericardial pressure. **Clinical**-elevated systemic venous pressure, pulsus paradoxus, hypotension, dyspnea.

- Cardiac tamponade is a condition characterized hemodynamically by decreased intracardiac volumes and increased diastolic filling pressures. Increase of the intrapericardial pressure producing external cardiac compression is the critical event in the development of tamponade.

- Under normal physiologic conditions, the intrapericardial pressure is equal to intrapleural pressure and therefore negative. The elevation of the intrapericardial pressure is the result of rapid or slow accumulation of fluid, gas, or tissue within the pericardial cavity.
Cardiac tamponade

- The rate of accumulation is more significant in establishing cardiac tamponade than the ultimate size or composition of the pericardial contents. In the acute setting, the pericardium is relatively stiff and noncompliant. Accordingly, acute or rapidly developing pericardial effusions can abruptly increase the intrapericardial pressure and produce cardiac tamponade with as little as 100–200 mL of pericardial fluid. On the other hand, over time the pericardium can stretch and become more compliant. Therefore, slow or gradual accumulation of pericardial fluid of up to 1000-1500 ml can be tolerated without hemodynamic impairment.

- Precipitating factors
  1. Drugs—cyclosporine, anticoagulants
  2. Recent cardiac surgery
  3. Blunt chest trauma
  4. Malignancies
  5. Connective tissue disease
  6. Renal failure
  7. Septicaemia
Cardiac tamponade-US

Some of the echocardiographic findings described in cardiac tamponade include:

1. Cardiac chamber compression,
2. Inferior vena cava (IVC) plethora,
3. Doppler flow velocity paradoxus,
4. Compression of the pulmonary trunk, compression of the thoracic IVC,
5. Paradoxical motion of the interventricular septum, and swinging motion of the heart in the pericardial sac.
6. Collapse in diastole of the right atrium.
Cardiac tamponade X-ray

- **Conventional radiographs** of the chest in patients with cardiac tamponade may demonstrate:
  1. an enlarged cardiac silhouette
  2. with or without an epicardial fat pad sign suggesting a pericardial effusion;
  3. the lungs are typically clear.

- In patients with tamponade due to pneumopericardium, termed *tension pneumopericardium*, a substantial decrease in the size of the cardiac silhouette may be observed on radiographs, the so-called small heart sign.
Cardiac tamponade CT

- Some of the reported CT findings in tamponade include:
  1. Enlargement of the superior vena cava with a diameter similar to or greater than that of the adjacent thoracic aorta,
  2. Enlargement of the IVC with a diameter greater than twice that of the adjacent abdominal aorta,
  3. Periportal lymphedema,
  4. Reflux of contrast material within the IVC, reflux of contrast material within the azygos vein, and
  5. Enlargement of hepatic and renal veins,
  6. Compressed small heart
Cardiac tamponade MRI

- clinical / US diagnosis - role of MRI limited
- increase in intrapericardial pressure depends on: (1) absolute volume / (2) rate of fluid accumulation / (3) degree of pericardial stretching.
  1. cardiac chamber compression
  2. paradoxical motion of the interventricular septum
  3. collapse in diastole of the right atrium
Constrictive pericarditis

- Patients with constrictive pericarditis frequently present with symptoms of heart failure, such as dyspnea, orthopnea, and fatigability, and occasionally may present with liver enlargement and ascites. The causes of constrictive pericarditis have changed over time; at present, the most frequent causes are cardiac surgery and radiation therapy.

- In constriction during inspiration, right ventricular systolic pressure increases, while left ventricular systolic pressure decreases. The inverse occurs during expiration. This finding had 90% sensitivity and specificity in recognizing constrictive pericarditis versus restriction in a series of 36 patients from the Mayo Clinic.76
Constrictive pericarditis

Causes

<table>
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<td>Mediastinal irradiation</td>
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<td>Infection</td>
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<td>Mesothelioma</td>
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Constrictive pericarditis

Constrictive pericarditis is a rare but severely disabling consequence of the chronic inflammation of the pericardium, leading to an impaired filling of the ventricles and reduced ventricular function. Until recently, increased pericardial thickness has been considered an essential diagnostic feature of constrictive pericarditis. However, in the large surgical series from the Mayo clinic constriction was present in 18% of the patients with normal pericardial thickness.

Clinically, it is difficult to differentiate between constrictive pericarditis and restrictive cardiomyopathy. These two entities are characterized by similar clinical manifestations and similar findings at cardiac catheterization and echocardiography. In both conditions, ventricular filling is restricted, leading to an increase in diastolic pressure in all four cardiac chambers and to equalization of atrial and ventricular pressure. It is important, however, to distinguish between constrictive pericarditis and restrictive cardiomyopathy, because patients with constrictive pericarditis might benefit from pericardial stripping, whereas those with restrictive disease would not.
Pathoanatomical forms of pericardial constriction

(a) **Annular** form with bilateral thickening of the pericardium along the atrial ventricular grooves with normal configuration of both ventricles and enlargement of both atria. 

(b) **Leftsided** form with thickened pericardium along the left ventricle and right sided bending of the interventricular septum with tube-like configuration of mainly left ventricle and enlargement of both atria. (lateral sternotomy and partial pericardiectomy is indicated).

(c) **Rightsided** form with thickened pericardium along the right ventricle and left sided bending of the interventricular septum with tube-like configuration of mainly right ventricle and enlargement of both atria (median sternotomy and partial pericardiectomy is indicated).
(d) **Myocardial atrophy** and global form with bilateral thickening of the pericardium along both ventricles separated from the right myocardial wall by a thin layer of sub-epicardial fat. Tube-like configuration of both ventricles and enlargement of both atria, however, thinning of the interventricular septum and posterolateral wall of the left ventricle below 1 cm is suggesting myocardial atrophy (pericardiectomy is contraindicated).

(e) **Perimyocardial fibrosis** and global form with bilateral thickening of the pericardium along both ventricles, however, the right sided thickened pericardium cannot be separated from the wave-like thin form of right sided ventricular wall suggesting perimyocardial fibrosis (pericardiectomy is contraindicated).

(f) **Global form** with bilateral thickening of the pericardium along both ventricles separated from the right myocardial wall by a thin layer of subepicardial fat. Tube-like configuration of both ventricles and enlargement of both atria (median sternotomy and pericardiectomy is indicated).
(g) Restrictive cardiomyopathy with normal thin pericardium along both ventricles that show normal configuration and with enlargement of both atria.
Constrictive pericarditis

- Normal pericardial thickness is less than 2 mm. Pericardial thickness of 4 mm or more indicates abnormal thickening and, when it is accompanied by clinical findings of heart failure, is highly suggestive of constrictive pericarditis. MR imaging has a reported accuracy of 93% for differentiation between constrictive pericarditis and restrictive cardiomyopathy on the basis of depiction of thickened pericardium (4 mm). Pericardial thickening may be limited to the right side of the heart or to an even smaller area, such as the right atrioventricular groove.

- An additional advantage of CT is its high sensitivity in depicting pericardial calcification, which is also associated with constrictive pericarditis. It is important to remember, however, that neither pericardial thickening nor calcification is diagnostic of constrictive pericarditis unless the patient also has symptoms of physiologic constriction or restriction.
Constrictive pericarditis

Constrictive pericarditis in a 55-year-old man who presented with symptoms of heart failure after mediastinal irradiation for Hodgkin lymphoma. Axial contrast-enhanced CT scan shows pericardial thickening (arrows).

Constrictive pericarditis in a 51-year-old man who presented with symptoms of constriction. Coronal ECG-gated T1-weighted SE image shows abnormally thickened pericardium (arrows) outlined by epicardial and anterior mediastinal fat.
Constrictive pericarditis in a 45-year-old man with a history of hemopericardium. Axial contrast-enhanced CT scan shows dense pericardial calcification (arrows).

Four chamber SSFP (Steady State Free Precession) cine view - pericardial constriction.
Pericarditis without constriction

Pericardial thickening may occur in the absence of constrictive pericarditis. Pericardial thickening may result from inflammation caused by a variety of conditions, including acute pericarditis, uremia, rheumatic heart disease, rheumatoid arthritis, sarcoidosis, and mediastinal irradiation. At contrast-enhanced CT, enhancement of the thickened pericardium indicates inflammation.

Infectious pericarditis in a 59-year-old woman with shortness of breath and chest pain. Axial contrast-enhanced CT scan shows enhancement of the pericardium (arrows), indicative of inflammation. Note the associated small pericardial effusion and large bilateral pleural effusions (P). Findings at subsequent pericardiocentesis confirmed exudative effusion.
Effusive-constrictive pericarditis

- Normal pericardium is composed primarily of fibrous tissue and has a low signal intensity on both T1- and T2-weighted MR images. The purely fibrous or calcified pericardium in chronic pericardial disease also has low signal intensity. However, in subacute forms of pericarditis, the thickened pericardium has moderate to high signal intensity on SE images. Enhancement of the thickened pericardium after the administration of gadolinium-based contrast material also suggests inflammation. The effusive-constrictive form of pericarditis involves both pericardial thickening and pericardial effusion.
The term **effusive-constrictive pericarditis** refers to an uncommon pericardial syndrome characterized by concomitant tamponade and constriction. The tamponade is caused by tense pericardial effusion; the constriction is caused by scarring or calcification of the visceral pericardium or epicardium. Patients with effusive-constrictive pericarditis may be erroneously believed to have only tamponade; however, in the former entity the central venous pressure typically remains elevated after drainage of the pericardial effusion.
Effusive-constrictive pericarditis

Effusive constrictive pericarditis secondary to viral infection in a 65-year-old man with symptoms of heart failure. (a) Axial ECG-gated T1-weighted SE image shows a crescent-shaped area of intermediate signal intensity (arrows) surrounding the ventricles, which indicates either pericardial thickening or pericardial effusion. (b) Axial gadolinium-enhanced fat-saturated T1-weighted SE image shows marked thickening and enhancement in the pericardium (arrows), findings consistent with inflammation. A moderate-sized pericardial effusion is also depicted.
### Pericardial masses

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Blunt chest trauma is the major risk of car accident. The deceleration force can lead to myocardial contusion with intrapericardial haemorrhage, cardiac rupture, pericardial rupture, or herniation. Transesophageal echocardiography in the emergency room or immediate computed tomography should be performed. Pericardial laceration and partial extrusion of the heart into the mediastinum and pleural space may also occur after injury.

In dissection of the ascending aorta pericardial effusion can be found in 17–45% of the patients and in 48% of the autopsy cases. In a clinical series of aortic dissection, pericardial tamponade was found by CT, MRI or echocardiography in 17–33% of patients with type I dissection and 18–45% in type II dissection and 6% in type III dissection.

Pericardio-centesis is contraindicated, due to the risk of intensified bleeding and extension of the dissection. Surgery should be performed immediately.
The differential diagnosis of pericardial masses includes pericardial cyst, hematoma, and neoplasm. Although pericardial masses are often detected initially with echocardiography, CT and MR imaging are useful for the further evaluation of these masses.

CT attenuation or MR signal intensity characteristics, degree of contrast enhancement, and presence or absence of blood flow on cine MR images can help differentiate among pericardial masses.

CT and MR imaging also can be used to accurately define the site and extent of masses.
Pericardial Cysts

• Pericardial cysts (white arrows) often are located at the right diaphragmatic border and are characterized with $T1$ weighted and $T2$ weighted turbo spin echos ($TSE$).

• $T1$ weighted TSE sequences (Image 1) demonstrate hypointense (dark) signal in the pericardial cyst.

• $T2$ weighted TSE sequences (Image 2) demonstrate hyperintense (bright) signal in the pericardial cyst which contains proteinaceous fluid.
Diagnostic imaging landmarks for evaluation of the pericardium

- **Pericardial width** *(normal or increased)*, **position**, and **extent** *(focal, multiloculated or diffuse)*
- **Pericardial delineation** *(smooth or irregular)*
- **Signal characteristics** *(T1- & T2-weighted MRI/gradient echo; signal void – low, inhomogeneous or high)*, **density**, **calcifications**.
- **Thickness and enhancement pattern of pericardial layers** *(SE-MRI/cine MRI/CE-IR MRI)* and CT.
- **Pericardial motion** *(cine MRI, CT; normal, rigid or immobile)*
- **Ventricular septal shape and motion during early diastolic filling** *(short-axis view, using real-time cine MRI or CT, US; convex to RV, flattened or inverted)*
- **RV Morphology** *(normal, compressed or enlarged)*
- **Right atrial and inferior vena caval size** *(normal or enlarged)*
- **Pleural fluid**
- **Inflow patterns** *(pulmonary/caval veins and atrioventricular valves; normal or restrictive physiology)*.
Conclusion

- The diagnostic imaging is an important tool in the work-up of patients with suspected pericardial disease.
- With a variety of different techniques and methods used to interrogate structure, function and composition of the pericardium and associated structures, it helps delineate the cause, define the extent of the pericardial disease and may assist in the timing and necessity of surgical intervention for pericardial disease.
- This role of especially CMR and modern multidetector CT is likely to mature as further assessment techniques for CMR become available and access becomes more widespread.
Thank you for your attention!