



Pericardial diseases

Pericardial anatomy and function

Anatomy

The pericardium is composed of 2 layers surrounding the heart. The external layer (pericardium) is attached cranially on the adventitia of the ascending aorta, the pulmonary artery, and the vena cava and pulmonary veins. Caudally, it is attached to the ventral portion of the diaphragm by the phrenopericardiac ligament. The internal layer (epicardium) adheres to the myocardium. A virtual space exists normally between these 2 layers, containing 0.5 to 15 ml of serous liquid. The quantity of this liquid is regulated by osmosis, diffusion and lymphatic drainage.¹

Function

The goals of the pericardium are to prevent excessive dilation of the cardiac cavities, to maintain the heart in a fixed and central position, to harmonize the stroke volumes of both ventricles and to protect the heart from infections and adhesions.^{2,3}

Intrapericardial pressure and ventricular interdependence

The pericardium being a poorly compliant structure, any rapid increase in the volume of the intrapericardial fluid or of the intracardiac structures will result in a rapid increase of the intrapericardial pressure. Therefore, an acute dilation of the right ventricular volume will reduce the left ventricular compliance.⁴ The opposite is observed when the cardiac filling is reduced with sodium nitroprusside. However, when the fluid accumulation or the cardiac dilation is progressive, the pericardium can stretch and maintain a normal intrapericardial pressure.⁵

Pericardial effusions

Diseases of pericardium represent 1 % of canine cardiopathies.⁶ Pericardial effusion are the most common manifestation of pericardial disease.⁶ The accumulation of fluid in the pericardial space leads to an elevation of the intrapericardial pressure and a collapse of the cardiac cavities, responsible for the cardiac tamponade syndrome.

Etiologies

The most common causes of pericardial effusion in the dog are intrapericardial hemorrhages from intrapericardial tumors and idiopathic hemorrhagic pericarditis. The various etiologies in the dog are summarized in Table I.⁷⁻¹¹

Table I. Etiologies and prevalence of 42 cases of pericardial effusion in the dog. ⁷

Etiology	% of total
Neoplasia	56%
- Right atrial hemangiosarcoma	33 %
- chemodectoma	12 %
- metastatic adenocarcinoma	5 %
- lymphosarcoma	2 %
- thymoma	2 %
- non classifié	2 %
Idiopathic (hemorrhagic pericarditis)	19 %
Secondary to a cardiopathy	14 %
- dilated cardiomyopathy	7 %
- mitral regurgitation	5 %
- left atrial tear	2 %
Miscellaneous	11 %
- Traumatic	5 %
- Infectious (coccidioïdomycosis)	2 %
- Uremic	2 %

In cats, pericardial effusion is usually secondary to an underlying cardiopathy, but infectious diseases (feline infectious peritonitis), uremia, and neoplasia can also be involved (Table II).⁶⁻¹²

Table II. Etiologies and prevalence of pericardial diseases in the cat.^{6,12}

Etiology	% of total
Underlying cardiopathy:	25%⁶-77.5%¹²
- Hypertrophic cardiomyopathy	
- Dilated cardiomyopathy	
- Restrictive cardiomyopathy	
- Mitral valve dysplasia	
- Hyperthyroidism	
Infectious disease :	3,4%¹²-28%⁶
- Feline infectious peritonitis	
- Systemic infection	

Renal failure ± fluid overload	3,4%¹²-11%⁶
Coagulopathy	0%¹²-11%⁶
Neoplasia	0%¹²-15%⁶
-Lymphosarcoma	
-Metastasis	
Iatrogenic	0%¹²-3%⁶
Peritoneo-pericardial diaphragmatic hernia	0%⁶-0,7%¹²
Miscellaneous	0%¹²-1%⁶

Cardiac tamponade

Cardiac tamponade is the phenomenon that explains all the symptomatology associated with pericardial effusions. Under normal conditions, the intrapericardial pressure varies between - 4 and + 4 mmHg during the respiratory cycle. The right and left ventricular diastolic pressures exceed by several mm Hg the intrapericardial pressure.^{3,8} The accumulation of pericardial fluid leads to a progressive increase of the intrapericardial pressure (phase 1).⁸ When this pressure reaches the level of the diastolic pressures of the right atria and ventricle, their filling becomes impeded, and the right cavities begin to collapse: this is phase 2 of cardiac tamponade.⁸ This leads to hypotension, ascites and/or pleural effusion due to increased right atrial pressure and systemic venous hypertension. When the intrapericardial and right ventricular diastolic pressures reach the level of the left ventricular diastolic pressure, cardiac output falls precipitously, resulting in tachycardia and peripheral vasoconstriction: it is phase of cardiac tamponade.⁸ This is when cardiogenic shock happens, leading to death.^{3,8}

During cardiac tamponade, the ventricular stroke volume is markedly influenced by the phase of the respiratory cycle. During inspiration, the intrapleural pressure becomes negative, thus improving the right ventricular filling. This increase of the diastolic dimensions of the right ventricle is done to the detriment of the left ventricle, leading to a decrease of the left ventricular stroke volume, and a fall of the systolic arterial pressure of more than 10 mm Hg. The opposite phenomenon is observed in expiration. This exaggerated fluctuation of the pulse amplitude with respiration is called *pulsus paradoxus*.^{2,3,8}

The development of cardiac tamponade depends on the rate of accumulation of the pericardial fluid. In acute pericardial effusions, amounts as small as 50 or 100 ml may suffice because the pericardium has not had time to distend. On the other hand, progressive effusions allow the pericardium to distend, and large quantities (500 ml or more) may accumulate before reaching a critical volume from which intrapericardial pressure starts to rise. The rate of increase of the pressure is very rapid once this critical volume exceeded.^{3,8}

Physical exam reveals ascites, jugular distention and pulsation, weak femoral pulses, tachycardia, muffled heart sounds, and dyspnea if pleural effusion is present.

Radiography may reveal a spherical heart with a distended caudal vena cava, if not obscured by pleural effusion, hepatomegaly and ascites. Electrocardiography may reveal small complexes and cyclical variation of the amplitude of the R waves called *electrical alternans*.

The diagnosis is clearly established by echocardiography, which reveals the presence of pericardial effusion and the collapse of the right atrial and ventricular walls.¹⁵ In severe cases, even the left sided cavities are collapsed, and the heart is “dancing” in the pericardial fluid.

The treatment of cardiac tamponade is drainage of the pericardial fluid by pericardiocentesis (see below).

Identification of the etiology

- Advanced myocardial or valvular diseases

Cats with hypertrophic or restrictive cardiomyopathies,¹² or dogs with advanced mitral regurgitation with pulmonary hypertension may develop a serous pericardial effusion, resulting from increased pericardial veins diastolic pressure. Overhydration in this context may be a triggering factor.¹²

The effusion is usually mild or moderate and rarely leads to cardiac tamponade requiring pericardiocentesis. The underlying pathology is readily identifiable during the echocardiographic exam.

- Left atrial wall tear

In cases of severe mitral regurgitation, the jet lesions of the left atrial wall could lead to a tear and acute severe bleeding into the pericardium.¹⁷⁻¹⁹ Echocardiography reveals pericardial effusion with tamponade, a dilated left atrium and the presence of a mitral regurgitation jet (usually lateral). An intrapericardial thrombus may be present.^{17,18}

- Idiopathic pericarditis

Idiopathic hemorrhagic pericarditis most commonly occurs in middle aged large breed dogs, usually males.⁷⁻¹¹ This disease is characterized by thickening, inflammation and fibrosis of the parietal layer of the pericardium (and sometimes of the epicardium as well). This inflammation is associated with a neovascularization with fibrin deposits. Intrapericardial hemorrhages lead to blood accumulation in the pericardium and eventually cardiac tamponade. The intrapericardial blood is usually non-clotting due to the consumption of the coagulation factors. Therefore, an intrapericardial thrombus is almost never seen.

This diagnosis is suspected in the case of hemorrhagic pericardial effusion without any identifiable etiology (underlying cardiopathy, tumor...). Final diagnosis requires histopathology of the pericardium.

Pericardial effusion secondary to intrapericardial tumors

Thirty-one to 57% of pericardial effusion have a neoplastic etiology in the dog.^{7,9} Therefore, a meticulous examination of the heart for the presence of any suspicious mass by echocardiography is mandatory when evaluating a dog with pericardial effusion.²⁰ The most common tumors include hemangiosarcomas, typically located on the right atrial wall or involving the right atrial appendage, and heart base tumors (chemodectomas, ectopic

thyroid carcinomas), typically wrapped around the ascending aorta.^{21,23} It is important to remember that not all masses seen at echocardiography are necessarily neoplastic. Some severe idiopathic pericarditis²⁴ as well as left atrial wall tear^{17,18} can be associated with intrapericardial thrombus, floating in the pericardial cavity or attached to the epicardium. Intrapericardial cysts can also mimick hemangiosarcomas.²⁵ Fibrin masses may form in the case of cholesterol-rich pericardial effusions.²⁶

Constrictive pericarditis

Constrictive pericarditis is characterized by a thickened and fibrous pericardium, impeding the ventricular filling. Histologically, moderate chronic inflammation is present in the pericardium. The external layer is the most frequently involved, but the epicardium may also be affected. A small pericardial effusion is usually present (the disease is then named effusive-constrictive pericarditis). Sometimes, inflammatory granulomas are present, compressing the ventricular outflow chambers. Constrictive pericarditis is rare in dogs and cats.²⁷⁻²⁹ In the great majority of cases, the etiology is unknown.²⁷ Specific etiologies include metallic foreign bodies, actinomycosis and coccidiomycosis. Idiopathic hemorrhagic pericarditis may sometimes evolve into constrictive pericarditis.⁸ Chylothorax in cats deserves a special mention. Chyle is very irritant to the pleura and the pericardium and may induce constrictive pericarditis, which worsens further the chylothorax.³⁰

Peritoneo-pericardial diaphragmatic hernia

This is the most common congenital anomaly of the pericardium in dogs and cats. Its origin is either a defective fusion between the lateral pleuroperitoneal layers and the sternal region of the diaphragm, or an abnormal development of the transverse septum.^{6,8} The result is an abnormal communication between the peritoneal and pericardial cavities, through which abdominal organs may pass. The degree of herniation is variable, and goes from minor herniation of adipose tissue to herniation of abdominal organs such as liver, spleen, intestines or stomach. This hernia may be abruptly aggravated by a trauma.³¹ Other associated congenital anomalies may be present, such as umbilical hernia, sternal anomalies (septum bifidus) or cardiac anomalies. The diagnosis is usually radiographic (major cardiomegaly, wide pericardio-diaphragmatic contact, and intestinal gas bubbles seen within the pericardium). A baryum study may facilitate the diagnosis. Echocardiography may also be helpful, by revealing the presence of portions of hepatic lobes, peritoneal fat or intestinal loops within the pericardium.³²

Treatment of pericardial diseases

Pericardiocentesis

Drainage of the pericardial effusion with a needle introduced percutaneously into the pericardial sac is required when cardiac tamponade is present. It allows immediate hemodynamic improvement and analysis of the pericardial fluid (if it different than blood). This procedure can be done under sedation and local anesthesia. Echocardiographic guidance minimizes the risk of perforating the ventricular wall.

Pericardiectomy

Pericardiectomy is required in most primary pericardial diseases (idiopathic pericarditis, neoplastic pericardial effusion, constructive pericarditis). It can be achieved via a thoracotomy or through thoracoscopy. This approach allows a definitive diagnosis, with histopathology. In the case of idiopathic pericarditis, this is the only approach that will prevent for sure a relapse. In the case of a cardiac tumor, pericardiectomy can prevent recurrent cardiac tamponades due to repeat bleeding of the tumor. Resection of a pediculated hemangiosarcoma attached to the tip of the right auricle, or a heart base tumor may also be possible at that time.

Pericardiectomy in conjunction with thoracic duct ligation is now considered the best approach to treat chylothorax in cats.

Pericardiotomy

Palliative pericardiotomies (either by thoracoscopy or by percutaneous creation of a pericardial hole with a balloon catheter) may be considered in the case of a neoplastic pericardial effusion with a non-resectable tumor. This will prevent tamponade by allowing the blood to escape from the pericardium into the chest cavity, where it will be reabsorbed.

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