Canine Pericardial Effusion: Pathophysiology and Cause*

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ABSTRACT: Pericardial effusion is the abnormal accumulation of fluid in the pericardial space. As the fluid volume and intrapericardial pressure increase, cardiac tamponade can develop. The most common causes of pericardial effusion include cardiac hemangiosarcoma, idiopathic pericardial effusion, and chemodectoma. Understanding the underlying cause is important in providing treatment recommendations and an accurate prognosis.

Pericardial effusion is the abnormal accumulation of fluid within the pericardial space. It is the most common disease of the pericardium in dogs. Small volumes of pericardial effusion may not cause clinical signs; however, as the volume and pressure in the pericardial space increase, cardiac tamponade can develop. Cardiac tamponade occurs when the rise in intrapericardial pressure is sufficient to cause hemodynamic compromise due to decreased diastolic filling. Cardiac tamponade can result in a life-threatening clinical condition that may require emergency treatment. Reported causes of pericardial effusion in dogs include neoplasia, idiopathic pericardial effusion, right-sided heart failure, and cardiac rupture (see box on p. 401).

THE NORMAL PERICARDIUM

The normal pericardium is composed of the outermost fibrous pericardium and the parietal and visceral layers of the serous pericardium. The pericardial cavity lies between the parietal and visceral layers of the serous pericardium. The pericardial cavity is normally filled with 1 to 15 ml of fluid that is an ultrafiltrate of plasma. The pericardium fixes the heart in the thorax, preventing excessive motion; provides a nearly frictionless anatomic barrier; prevents extension of infection or neoplasia into the heart; aids in ventricular coupling; and limits acute cardiac dilation. However, humans and animals lacking an intact pericardium can function normally.

PATHOPHYSIOLOGY

Normal intrapericardial pressure approximates intrapleural pressure (varying by ±4 mm Hg with respiration). In pathologic states, as fluid accumulates in the pericardial space, the ability of the pericardium to stretch is eventually exceeded, and further fluid accumulation subsequently results in increases in intrapericardial pressure. When the intrapericardial pressure increases to the pressure of the right atrium and ventricle (normally 4 to 8 mm Hg), cardiac tamponade develops (Figure 2). Cardiac tamponade results in decreases in venous

*A companion article on diagnosis, treatment, and prognosis begins on p. 405.
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An In-Depth Look

Causes of Pericardial Effusion

Neoplastic
- Hemangiosarcoma
- Aortic body tumor (chemodectoma)
- Heart-base tumor
- Mesothelioma
- Thyroid carcinoma
- Lymphosarcoma
- Connective tissue tumor
- Other metastatic tumors

Congenital
- Peritoneopericardial diaphragmatic hernia
- Pericardial cyst

Other
- Right-sided heart failure
- Left atrial rupture
- Traumatic atrial rupture
- Anticoagulant rodenticide toxicosis
- Uremic pericarditis
- Bacterial or fungal infection
- Constrictive pericarditis

Idiopathic

The pericardium normally has minimal elasticity due to its fibrous nature. However, the pericardium can stretch when pressure is slowly placed on it. The volume of fluid required to cause cardiac tamponade varies greatly, depending on the speed with which the fluid accumulates. In experimental canine models, as little as 25 to 100 ml of fluid rapidly injected into the pericardial space can raise intrapericardial pressure high enough to cause tamponade. In contrast, pericardial effusion that slowly increases in volume can result in a volume as high as 2 L in a large-breed dog before cardiac tamponade manifests.

CAUSES

Congenital

Peritoneopericardial diaphragmatic hernia (PPDH) is the most common congenital pericardial defect in dogs and cats. PPDH occurs when the septum transversum improperly fuses with the pleuroperitoneal folds during

Figure 1. Layers of the normal pericardium as well as the normal intrapericardial and right-sided heart pressures.

Figure 2. Changes in the intrapericardial pressure (diastolic/systolic) due to pericardial effusion, resulting in cardiac tamponade.
embryonic development, resulting in incomplete separation of the abdominal and thoracic cavities. PPDH is frequently asymptomatic and identified incidentally when radiography is conducted for other reasons (Figure 3). If clinical signs occur, they are usually referable to the gastrointestinal tract (vomiting, diarrhea, anorexia, weight loss). Only a small volume of fluid is typically associated with PPDH. Respiratory signs, including cough, tachypnea, and dyspnea, are less common.

Pericardial cysts result from entrapment of the omentum or falciform ligament in the pericardium during embryonic development. They are rare and usually asymptomatic but can occasionally result in clinically significant pericardial effusion.

**Acquired**

Acquired pericardial effusion in dogs is most frequently due to neoplastic and idiopathic causes. In one study, these causes represented 58% and 19%, respectively, of cases of pericardial effusion. The three most common neoplasms resulting in pericardial effusion are hemangiosarcoma, aortic body tumors, and mesothelioma. Hemangiosarcoma represents 60% to 75% of all neoplasms resulting in pericardial effusion. Hemangiosarcoma commonly arises from the right atrial appendage, resulting in pericardial effusion from hemorrhage into the pericardial space; however, hemangiosarcoma may also arise from the wall of the right atrium, especially near or above the atrioventricular groove (Figure 4). German shepherds and golden retrievers are reportedly predisposed to right atrial hemangiosarcoma. Cardiac hemangiosarcoma has virtually a 100% metastatic rate by the time of diagnosis.

Aortic body tumors are found in approximately 10% and mesotheliomas in approximately 5% of dogs with pericardial effusion secondary to neoplasia. Aortic body tumors arise from chemoreceptors in the pulmonary artery and aortic outflow tract. These tumors are also called *chemodectomas*. Brachycephalic breeds are believed to be predisposed to aortic body tumors. This has been hypothesized to be due to chronic hypoxia caused by nasopharyngeal conformation in these breeds. These tumors tend to be slow growing and locally invasive. One report found that 81% of dogs diagnosed with heart-base tumors had pericardial effusion at the time of diagnosis.

Mesotheliomas are diffuse tumors arising from the pleura, peritoneum, and pericardium. Clinical signs usually result from accumulation of a large volume of malignant effusion. Pericardial involvement may occur in isolation or be combined with other mesothelial surfaces. A male predisposition for the development of mesothelioma has been reported. Other types of tumors are rarely associated with pericardial effusion.

Infectious pericardial effusion occurs infrequently. It may result from multiple causes, including bacterial infection secondary to migrating foreign bodies, partic-
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Key Points

• Cardiac tamponade develops when intrapericardial pressure exceeds right atrial pressure.
• Hemangiosarcoma and idiopathic pericardial effusion are the most common causes of pericardial effusion in dogs.
• The prognosis for dogs with pericardial effusion varies greatly, depending on the cause.

AN IN-DEPTH LOOK

Clinical signs of pericardial effusion result from a combination of the volume of effusion, speed with which it accumulated, and underlying cause. The inter-

ularly grass awns. The most commonly isolated bacteria associated with the condition are Actinomyces and Nocardia. Coccidioides immitis, a soil fungus endemic to the southwestern United States, has also reportedly resulted in pericardial effusion.

Pericardial effusion secondary to right-sided heart failure is due to passive congestion and decreased drainage from the pericardial space. It rarely results in a volume large enough to cause tamponade and require pericardiocentesis. Left atrial rupture can occur secondary to myxomatous degeneration of the mitral valve. It is believed to occur when the jet of regurgitant blood into the left atrium gradually weakens the left atrial wall, resulting in its perforation. Traumatic right atrial rupture is well described in the human literature. There is one case report of successful management of a traumatic right atrial rupture in a dog. Exposure to anticoagulant rodenticides has also reportedly resulted in pericardial effusion. Uremic pericarditis can result from seerositis and myocarditis caused by exposure to toxic metabolites normally eliminated by the kidneys.

Idiopathic pericardial effusion refers to sterile, often hemorrhagic effusion in the pericardial space. No evidence of neoplasia, cardiac disease, trauma, infection, or uremia is found in these cases. Histologic examination of idiopathic pericardial effusion reveals thickening of the epicardium and pericardium with associated inflammation. German shepherds, golden retrievers, Great Danes, and Saint Bernards appear to be predisposed to idiopathic pericardial effusion. The age at the time of diagnosis varies widely, ranging from 1 to 14 years, with a mean of 6 years. Males appear to be affected more frequently than females.

CONCLUSION

Clinical signs of pericardial effusion result from a combination of the volume of effusion, speed with which it accumulated, and underlying cause. The inter-

play among these factors determines when, in the clinical course, intrapericardial pressure rises high enough to cause cardiac tamponade. Pericardial effusion can result from multiple causes. Neoplasia and idiopathic pericardial effusion are the most common causes.

REFERENCES

1. The normal pericardium
   a. is filled with 1 to 15 ml of blood.
   b. is essential to normal cardiac function.
   c. contains a cavity between the parietal and visceral pericardium.
   d. ensures the normal orientation of the lungs in the thoracic cavity.

2. Which statement regarding the normal pericardium is correct?
   a. Normal intrapericardial pressure is 4 mm Hg or less.
   b. The pericardium is inelastic.
   c. Intrapleural pressure normally exceeds intrapericardial pressure.
   d. The pericardium may rupture due to the development of pericardial effusion.

3. Which statement regarding cardiac tamponade is correct?
   a. A minimum of 500 ml of fluid is required to cause cardiac tamponade in most dogs.
   b. The volume of pericardial fluid is directly related to the severity of the cardiac tamponade.
   c. Cardiac tamponade results in decreased venous return and cardiac output.
   d. Cardiac tamponade is typically characterized by bradycardia.

4. Which statement regarding PPDH is correct?
   a. It is the most common congenital defect in dogs and cats.
   b. It usually causes pericardial effusion by the end of the first year of life.
   c. The most common clinical signs are referable to cardiac tamponade.
   d. The long-term prognosis is generally poor.

5. Which is the most common cause of acquired pericardial effusion?
   a. mesothelioma
   b. hemangiosarcoma
   c. idiopathic effusion
   d. heart-base tumor

6. Which statement regarding hemangiosarcoma is correct?
   a. Norfolk terriers are predisposed to hemangiosarcoma resulting in pericardial effusion.
   b. The prognosis for dogs with right atrial hemangiosarcoma is generally good.
   c. Cardiac hemangiosarcoma most commonly develops from the right atrial appendage.
   d. Hemangiosarcoma is usually associated with a pericardial fluid volume larger than 500 ml.

7. Which statement regarding heart-base tumors is correct?
   a. Dolichocephalic breeds are predisposed.
   b. They arise from the smooth muscle cells of the aorta.
   c. They rarely cause pericardial effusion.
   d. They are slow growing and locally invasive.

8. Infectious pericardial effusion
   a. is frequently caused by migrating foreign bodies.
   b. results from extension of infection from the pleural space.
   c. is the most common cause of pericardial effusion.
   d. is most commonly caused by C. immitis.

9. Which statement regarding pericardial effusion is correct?
   a. Pericardial effusion secondary to right-sided heart failure commonly results in cardiac tamponade.
   b. Uremic pericarditis commonly results in cardiac tamponade.
   c. Anticoagulant rodenticide toxicosis may result in pericardial effusion.
   d. Viral infection frequently results in pericardial effusion.

10. Idiopathic pericardial effusion
    a. occurs exclusively in young dogs.
    b. is characterized by sterile inflammation of the pericardium.
    c. is most common in German shepherds.
    d. is frequently associated with mitral valvular disease.