Pericardial effusion is the abnormal accumulation of fluid in the pericardium, the membranous, fibroserous sac enclosing the heart and the bases of the great vessels. Fluid accumulation results in increased pericardial pressure, which compresses the heart and prevents it from filling properly during diastole, causing a life-threatening drop in cardiac output and blood pressure that requires immediate treatment. Technicians must be able to recognize the clinical signs of this condition so that proper medical interventions can be initiated.

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KEY POINTS

- Having a full knowledge of the clinical signs of pericardial effusion expedites recognition and treatment.
- Echocardiography is considered the gold standard for diagnosing pericardial effusion.
- The prognosis for dogs with pericardial effusion varies greatly depending on the underlying cause.
The pericardium acts as a protective covering for the heart. It lubricates the myocardium, prevents cardiac overdilation, and regulates stroke volume. It consists of two layers, the fibrous pericardium and the serous pericardium. The fibrous pericardium, which is attached to the diaphragm, ensures that the heart stays in a fixed position within the thorax. The serous pericardium lines the inside of the fibrous pericardium and covers the heart itself.

Between the two layers of the serous pericardium (parietal layer and visceral layer) is the pericardial cavity. The pericardial cavity normally contains a small amount of serosanguineous fluid (about 0.5 to 1.5 ml), which lubricates the myocardium and prevents friction with the pericardium. Osmosis, lymphatic drainage, and diffusion all aid in the maintenance of this fluid.

ETIOLOGY

Neoplasia

Pericardial effusion is most commonly associated with neoplasia in older large-breed dogs. The type of tumor that most often causes hemorrhagic pericardial effusion in dogs is hemangiosarcoma. Golden retrievers and German shepherds are predisposed to hemangiosarcoma, which is usually located at the right atrial wall of the heart. Acute hemorrhagic pericardial effusions are frequently the result of a hemangiosarcoma rupturing the right atrial wall.

Chemodectomas may also be associated with pericardial effusion. These tumors are the most common heart base tumors and are associated with chemoreceptor cells at the base of the aorta. Chemodectomas are generally seen in older, brachycephalic breeds of dogs. Other tumor types that can be linked to pericardial effusion include thyroid and parathyroid tumors, lymphoid tumors, and connective tissue neoplasms.

Nonneoplastic Causes

Larger breeds of dogs may be predisposed to idiopathic pericardial effusion. The term idiopathic pericardial effusion was initially defined as benign or spontaneous pericardial effusion. Today, however, only when there is no evidence of neoplasia and no confirmed infectious source is the accumulated fluid within the pericardium considered idiopathic. Generally, histopathology reveals nonspecific inflammatory hemorrhagic pericarditis in patients with idiopathic pericardial effusion.

Other, less predominant causes of pericardial effusion or hemorrhage are trauma (primarily penetrating trauma), coagulopathy, the presence of a foreign body, constrictive pericarditis with fibrosis, and rupture of the left atrium secondary to severe mitral insufficiency. Congenital defects, heart failure, toxin ingestion, and endocrine disease may also cause pericardial effusion.

PATHOPHYSIOLOGY

Normally, pericardial pressure does not equal or exceed the pressure within the heart, allowing the heart to fill to its
Glossary

Ascites — Abnormal accumulation of edematous fluid within the peritoneal cavity, commonly characterized by a palpable fluid wave

Cardiac decompensation — Inability of the heart to maintain adequate circulation

Cardiogenic shock — Form of shock resulting from heart failure

Coagulopathy — Any disorder of blood coagulation

Costochondral junction — Connection between the costal cartilage and the bony portion of the rib

Hemodynamics — Study of the forces and physical mechanisms concerned with the circulation of blood

Hypoxia — Decreased availability of oxygen to the body tissues

Idiopathic — Occurring without a known cause

Mitra! insufficiency — Regurgitation of blood from the left ventricle to the left atrium during systole or from the great vessels into the left atrium during diastole

Neoplasia — Formation of a tumor (benign or malignant)

Oxygen cage rest — Allowing an animal to rest quietly in an oxygen cage to decrease oxygen requirements

Portal vein hypertension — Increased pressure in the portal circulation caused by impedance of blood flow through a diseased liver or portal vein

QRS complex — Electrocardiographic representation of ventricular depolarization of the heart

Serosanguinous — Composed of serum and blood

ST-segment elevation — Electrocardiographic finding that suggests an epicardial injury current

Stroke volume — Volume of blood ejected by the left ventricle during a single ejection

Tachypnea — Increased or rapid respiration

Ventricular premature beat — Premature contraction of the ventricle that can be easily identified using an electrocardiograph

full capacity with each beat. During pericardial effusion, however, pericardial pressure rises as excess fluid accumulates within the closed space of the pericardium and the chambers of the heart are progressively compressed. Because the chambers on the right side of the heart (right atrium and right ventricle) have thinner walls than the chambers on the left side (left atrium and left ventricle), they are compressed to a greater degree. As the pressure continues to increase, the left side of the heart becomes affected.

The condition of the pericardium and the rate and volume of fluid accumulation in the pericardial sac determine how quickly clinical signs appear. Acute fluid accumulation in the pericardial sac results in increased intracardiac pressure and a drop in cardiac output. In acute effusion, the pericardium cannot stretch enough to accommodate even small volumes of fluid, and clinical signs appear rapidly. In patients with chronic effusion, the accumulation of fluid may be slow enough to allow the pericardium to stretch to accommodate the fluid. However, the pericardium can expand only so far before intrapericardial pressure begins to rise and diastolic compression of the right atrium and ventricle is inevitable.

The consequences of right-sided heart compression include inadequate filling during diastole, which causes jugular distention, and portal vein hypertension resulting from decreased venous return. Stroke volume also decreases, leading to a decrease in cardiac output and systemic blood pressure:

Cardiac output = Stroke volume × Heart rate

Systemic blood pressure = Cardiac output + Vascular resistance

Hypoxia and tachypnea result from significantly decreased blood flow to the lungs.

The body compensates for the drop in cardiac output and systemic blood pressure by retaining sodium and water, which leads to increased blood volume and central venous pressure. This reaction, although meant to improve blood pressure, is maladaptive and actually contributes to the progression of the disease. Central venous pressure measurements of greater than 12 cm H2O are consistent with pericardial effusion (normal range: 0 to 6 cm H2O). Increases in central venous pressure are followed by congestive heart failure with associated pleural effusion and ascites.

When pericardial pressure exceeds intracardiac pressure, cardiac tamponade develops. Tamponade occurs when filling of the heart is obstructed by pressure from a surrounding collection of fluid. Tamponade causes a precipitous drop in blood pressure and is a critical situation. Cardiogenic shock and death may quickly follow tamponade if emergency measures are not taken to relieve the pressure in the pericardium and restore normal hemodynamics.

CLINICAL SIGNS

The severity of clinical signs in patients with pericardial effusion depends on the rate of intrapericardial fluid accumulation. Many dogs that present with pericardial effusion have a vague history of exercise intolerance, listlessness, lethargy, generalized weakness, and inappetence.

Physical examination findings may also vary depending on the severity of the effusion. Mucous membranes may be pale, with a prolonged capillary refill time caused by poor peripheral perfusion and decreased cardiac output. Pulse quality is weak and thready because of hypotension and a decrease in stroke volume. Although often a subtle physical examination finding, pulsus paradoxus, an abnormal inspiratory decrease in arterial blood pressure, is suggestive of pericardial effusion. Dogs with pericardial effusion fre-
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quently assume a sternal or standing position, with their elbows abducted and necks extended in an attempt to maximize air exchange and comfort.

Auscultation of the thorax usually reveals muffled heart sounds. Lung sounds may also be muffled in patients with pleural effusion. The patient may be tachycardic, with a heart rate of 200 bpm or higher. Arrhythmias are not commonly found on auscultation.\(^7\) Jugular distention may be visible if the patient has right-sided heart failure.\(^7\)

DIAGNOSIS

Although stressful for dogs with pericardial effusion, thoracic radiography is often the first diagnostic imaging technique used. Ventrodorsal views of the thorax are preferable to dorsoventral or lateral views because ventrodorsal views lessen the patient’s stress.\(^3\) Forcing a patient into a position in an attempt to obtain a perfect radiograph may cause the patient to decompensate and die and, therefore, should be avoided at all costs.

A large globoid cardiac silhouette is supportive of pericardial effusion unless the effusion is acute and the pericardial sac has not had the time to stretch. It is not unusual for pericardial effusion to be mistaken for dilated cardiomyopathy. Pleural effusion may also be noted on radiographs.\(^8\) Caudal vena cava distention, hepatomegaly, ascites, and pleural effusion may be present if the patient has developed congestive heart failure.\(^7\)

Common electrocardiographic findings in patients with pericardial effusion include sinus tachycardia, ventricular arrhythmias caused by insufficient oxygen delivery to the myocardium or a deviation of electrical conduction activity associated with an underlying disease,\(^4\) low-voltage QRS complexes, and ST segment elevation. The electrocardiogram (ECG) may also reveal electrical alternans, an alternation in the size of the T wave or QRS complex with each beat of the heart.\(^4\) This abnormality is a result of the heart swinging back and forth within the pericardium and is often associated with large volumes of fluid in the pericardial sac.\(^4\)

For the past several years, the echocardiogram has been the diagnostic test of choice in cases of pericardial effusion. It is noninvasive and can provide much more information than radiography because it can distinguish the pericardium, pericardial fluid, and heart, structures that are indistinguishable on a radiograph. Because echocardiography is such a sensitive and specific method, it can detect even a small amount of pericardial effusion.\(^3\) The pericardial effusion itself is helpful during echocardiography because it often acts as a contrast medium to help visualize a cardiac mass if present.\(^6\)

TREATMENT

In patients with pericardial effusion severe enough for cardiac tamponade to exist, pericardiocentesis is the treatment of choice because it provides immediate relief of cardiac compression. The procedure is performed at the fifth

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Electrical alternans. Note that the ECG complexes are regular but alternate in height.

intercostal space just below the costochondral junction; therefore, a large area of the right thorax from the third to the eighth rib near the level of the costochondral junction must be surgically prepared. If the patient is anxious, mild sedation may be required; however, a local anesthetic block is generally sufficient. The patient is placed in sternal or lateral recumbency, and aseptic technique must be practiced.

The method of pericardiocentesis used depends on the preferences of the veterinarian performing the procedure. A number of techniques have been published for pericardiocentesis. A large-gauge, over-the-needle catheter and a syringe are the most common instruments for performing the procedure. Ultrasonic guidance of the needle is preferred, but this technique is not always available. If ultrasonography is not used, ECG monitoring must be employed throughout the procedure. If the catheter tip makes contact with the myocardium, the ECG will show an unusual QRS complex, a ventricular premature beat, or a ventricular arrhythmia.

If the pericardiocentesis procedure is successful, vital signs will improve dramatically. Samples of the pericardial effusion should be placed in red-top and lavender-top tubes so they can be submitted to a reference laboratory for analysis. Placement of a central venous catheter after pericardiocentesis is helpful because it allows central venous pressure to be measured frequently. Increases in central venous pressure may indicate a recurrence of the pericardial effusion.

In cases of atrial tear, pericardiocentesis is contraindicated because the pericardial effusion may act as a “pressure bandage,” resulting in a fibrin plug that will allow scar tissue to form in the ruptured space. If the intrapericardial pressure is relieved, the plug may be blown out and hemorrhage may continue. If an atrial tear is suspected and the patient is not near death, the recommended treatment is strict oxygen cage rest.

Surgical removal of the pericardial sac (total pericardiectomy) or surgical creation of a window within the pericardium (subtotal pericardiectomy) is considered a palliative treatment in patients in which the pericardial effusion is not idiopathic. Drugs should not be used in place of pericardiocentesis, although antibiotics are indicated for infection. Chemotherapy is usually ineffective.

**PROGNOSIS**

The prognosis for patients with pericardial effusion varies depending on the underlying cause and is determined by the veterinarian based on the facts of a particular case. Idiopathic effusions seem to have a much less guarded prognosis than neoplasia-related effusions. Periodic reevaluation of radiographs or echocardiograms is useful in detecting recurrence. Approximately 50% of dogs affected by idiopathic pericardial effusion have a fair prognosis for recovery after one or two pericardiocentesis procedures. Antiinflammatory drugs, such as prednisolone, are commonly prescribed for dogs with idiopathic pericardial effusion. However, there have been no studies to prove the efficacy of such treatment.

Pericardial effusion associated with neoplasia has a varied prognosis. Subtotal pericardiectomy may allow patient survival for up to 3 years if the neoplasia is slow-growing, such as an aortic body tumor. Hemangiosarcoma of the right atrium carries a poor prognosis. It is not unusual for the tumor to have spread to the lung, liver, and spleen by the time of diagnosis, making the patient a poor surgical candidate.

**CONCLUSION**

Proper triage technique and recognition of the clinical signs of pericardial effusion are crucial for the survival of the patient. Rapid identification of clinical signs during the physical examination will aid in initiating further diagnostic methods and treatments. A strong veterinary team is necessary to triage the patient, perform physical examinations, obtain the patient’s medical history from the owner, and perform diagnostic tests and imaging. Listening to the owner of a dog with pericardial effusion for key comments is just as important as looking at the animal itself. Quick response and clear communication between the veterinary team and the owner play key roles in maximizing the likelihood of a positive outcome.

**REFERENCES**


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1. The pericardial sac serves which purpose(s)?
   a. regulation of stroke volume
   b. prevention of cardiac overdilation
   c. myocardial lubrication
   d. all of the above

2. Pericardial effusion diagnosed in brachycephalic breeds of dogs is generally associated with
   a. lymphoid tumors.
   b. chemodectoma.
   c. hemangiosarcoma.
   d. parathyroid tumors.

3. Pericardial effusion is termed idiopathic when
   a. there is no evidence of neoplasia.
   b. the effusion is related to coagulopathy.
   c. no infectious source can be confirmed.
   d. a and c

4. Central venous pressure measurements greater than __________ are consistent with pericardial effusion.
   a. 2 cm H₂O
   b. 6 cm H₂O
   c. 12 cm H₂O
   d. none of the above

5. The consequence(s) of right-sided heart compression is (are)
   a. hypoxia.
   b. pleural effusion and ascites.
   c. jugular distention.
   d. all of the above

6. Cardiac tamponade develops when
   a. pericardial pressure exceeds intracardiac pressure.
   b. central venous pressure decreases.
   c. congestive heart failure is present.
   d. none of the above

7. Electrical alternans
   a. is sometimes seen on an ECG in cases of pericardial effusion.
   b. results from the heart swinging back and forth within the pericardium
   c. is an alternation in the size of the T wave or QRS complex with each beat of the heart.
   d. all of the above

8. Pericardiocentesis is contraindicated in cases in which
   a. hemangiosarcoma is suspected.
   b. the patient is near death.
   c. an atrial tear is suspected.
   d. none of the above

9. Strict oxygen cage rest is recommended
   a. for brachycephalic breeds of dogs.
   b. when ultrasonography is not available for pericardiocentesis.
   c. when an atrial tear is suspected as the cause of pericardial effusion.
   d. when central venous pressure is less than 0 cm H₂O.

10. What percentage of dogs affected by idiopathic pericardial effusion has a fair prognosis for recovery?
   a. 25%
   b. 33%
   c. 50%
   d. 100%

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