

Review Article

Interventional Treatment of Pericardial Effusion

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Pericardial effusion involves fluid accumulation within the pericardial sac, and may be a fatal condition pending the volume of accumulated fluid, the chronicity, and whether timely therapy is instituted. The frequency and etiology of pericardial effusion cases can vary quite significantly, not only between different species but also among diverse geographical areas. The often fragile clinical state of patients within this category requires instantaneous and efficacious therapy involving a minimum of stress. The gold standard for immediate ambulatory treatment of compromising pericardial effusion is percutaneous pericardiocentesis, which is the focus of this brief methodology paper. The techniques used for performing pericardiocentesis and pericardial lavage in small and large animals species, respectively, are described.

1. Introduction

A small quantity of pericardial fluid (approximately 0.25 ± 0.15 mL/kg) is contained within the pericardial cavity in the healthy animal, creating a thin serous film which primarily serves a lubricatory function enabling the visceral and parietal layers of the pericardium minimal resistance motion during each cardiac cycle [1, 2]. The pressure within the pericardial space may be inconsistent, since normal pericardial fluid thickness tends to be greater at the atrio- and interventricular grooves, allowing some fluid motion and thus transmission of intrapericardial pressure between different regions of the heart [2]. Accumulation of an abnormal fluid volume within the pericardial space is defined as pericardial effusion—a potential critical clinical condition. Cardiac tamponade refers to a life-threatening state, where the excessive amount of pericardial effusion causes the intrapericardial pressure to either equal or exceed the right ventricular diastolic pressure, thus leading to a diminished cardiac output. Varying degrees of hemodynamic compromise can result, possibly to the point of collapse or death [1, 3]. Therapeutic interventions for the treatment of pericardial effusion include percutaneous pericardiocentesis (pericardial tap), percutaneous balloon pericardiotomy, thoracoscopic partial pericardiectomy (pericardial window), and thoracotomy with subtotal or total pericardiectomy [4–13]. Contrary to most of the above mentioned techniques,

which require specialty equipment and training, pericardiocentesis can be performed in practice as a relatively routine procedure. This paper offers a concise outline of etiologies underlying pericardial effusion, and provides a basic step-by-step approach to performing percutaneous pericardiocentesis in practice.

2. Background

2.1. Etiology. Pericardial effusion may develop as a result of different etiologies (Table 1), with varying frequencies pending on species and geography. Cardiac neoplasia is the most prevalent cause of pericardial effusion in the dog [13, 14]. Hemangiosarcoma is the most common type of primary cardiac neoplasia in dogs, followed by chemodectoma (aortic body tumor), lymphosarcoma, and thyroid carcinoma [15]. In a study including 309 dissections of primary and secondary heart tumors in dogs the most common neoplasia types were hemangiosarcoma (63%), paraganglioma (15%), carcinoma (11%), malignant lymphoma (4%), thyroid heart base tumor (3%), melanoma (2%), mast cell tumor (1%), and blastoma (1%)—all verified on immunohistochemistry [16]. The distribution between neoplastic and nonneoplastic (incl. idiopathic) etiologies in dogs with pericardial effusion varies, and percentages ranging between approximately 30% and 80% neoplasia have been reported [4, 5, 15, 17]. In dogs, however, the overall incidence of cardiac tumors compared

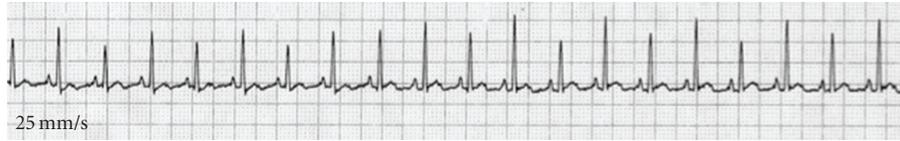


FIGURE 1: Electrocardiography showing “electrical alternans,” as seen in some clinical cases with pericardial effusion occurring due to the pendulous movement of the heart within the fluid-filled pericardial space (paper speed 25 mm/sec).

TABLE 1: Overview on causes of pericardial effusion in veterinary medicine.

Category	Etiology
Neoplastic	Hemangiosarcoma
	Chemodectoma
	Lymphosarcoma
Infectious	Pericarditis (bacterial, fungal, viral)
	Feline infectious peritonitis
Traumatic	Chest trauma
	Cardiac surgery
	Traumatic pericarditis/foreign body (bovine)
	Severe chronic valve disease w/ atrial tear (canine/small breeds)
Organ dysfunction	Chronic renal failure
	Cardiomyopathy w/ congestive heart failure (feline)
Idiopathic	Pericarditis

to total number of canine clinical cases is reportedly as low as 0.19% according to one study, whereas the percentage in cats has been reported to be even lower at 0.03%—with the most frequent diagnosis being lymphosarcoma in this species [15, 18, 19]. Neoplastic cases are very rare in equine medicine—where acquired pericardial disease in general is quite uncommon [20]. Pericarditis (bacterial or idiopathic) may also be seen in horses, with a relatively higher frequency in the US compared to the UK according to one report [20]. In cattle, right-sided congestive heart failure and pericardial effusion are most commonly caused by traumatic reticulopericarditis or cardiac lymphoma [21].

2.2. Indications for Therapy. The main indications for performing pericardiocentesis are as follows: (1) stabilize a patient with life-threatening cardiac tamponade by relieving the excessive intrapericardial pressure, and (2) obtain a fluid sample of the pericardial effusion for fluid analysis and cytology. It is furthermore worth noticing that the amount of pericardial effusion that causes cardiac tamponade may vary pending chronicity [7, 20]. A larger amount of pericardial effusion can thus typically be tolerated if the accumulation develops over a longer period of time—typically leading to a clinical symptomatology consistent with right-sided congestive heart failure (incl. ascites and pleural effusion). A smaller volume, however, may result in cardiac tamponade

and clinical signs consistent with low output failure and cardiac shock (collapse) if the pericardial effusion accumulates acutely [14, 19].

2.3. Clinical Exam and Diagnostics. Patients with pericardial effusion may present with the classical muffled heart sounds and pulsus paradoxus (i.e., exaggeration of the normal variation in the pulse during respiration, including a decrease in pulse strength on inspiration and an increase on expiration) on physical exam, low-voltage complexes and electrical alternans on electrocardiography (Figure 1), and a globoid cardiac silhouette on chest radiographs (Figure 2)—all of which would suggest effusion to the pericardial space. However, physical examination, thoracic radiography, and electrocardiography all have poor diagnostic values in identifying and assessing pericardial effusion overall [22, 23]. The gold standard for diagnosing pericardial effusion is echocardiography (in which case the pericardial effusion is seen as an anechoic or hypoechoic space between the echogenic pericardium and the myocardium), which furthermore allows for accurate assessment of the hemodynamic impact of the fluid accumulation as well as the presence of possible neoplastic lesions [7, 9, 23] (Figure 3). The treatment of choice for pericardial effusion includes immediate invasive drainage of the pericardial space. Unlike the situation in other types of fluid accumulations, diuretics and vasodilators are contraindicated in clinical cases presented with pericardial effusion. The elevated venous pressure is in this patient-category crucial to maintain diastolic pressure in the compressed cardiac chambers, and pharmacological lowering of venous pressure (through vasodilator therapy) may as such decrease stroke volume and cardiac output markedly, possibly leading to pronounced weakness or circulatory collapse [19]. In cases where instantaneous removal of the pericardial effusion for some reason is not feasible, aggressive volume expansion (fluid therapy) accompanied by instant referral for pericardiocentesis is a more productive and rational therapeutic approach [19].

2.4. Therapy. Pericardiocentesis can be performed with the patient restrained in either right or left lateral recumbency [24]. The technique described herein involves placement of the animal in right lateral recumbency, thus allowing access to the left hemi-thorax. It should be noted that many authors, however, prefer a right-sided approach [14, 19, 24]. The main argument for performing pericardiocentesis using the *left-sided* approach is that it practically eliminates the risk of inadvertently advancing the catheter through the thicker myocardial wall on the left side (i.e., the risk of

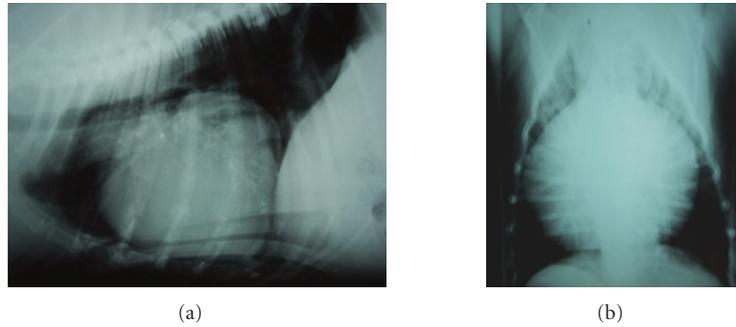


FIGURE 2: Chest radiographs from 10-year-old male Boxer, showing a globoid cardiac silhouette in lateral (a) and dorsoventral (b) views. The globoid cardiac silhouette without any identifiable edges is consistent with effusion to the pericardial space. A heart-base tumor was identified on echocardiography and ~300 mL of hemorrhagic effusion tapped from the pericardial space (X-rays by the Radiology Section at the Matthew J. Ryan Vet Hosp U of Penn, Philadelphia, PA).

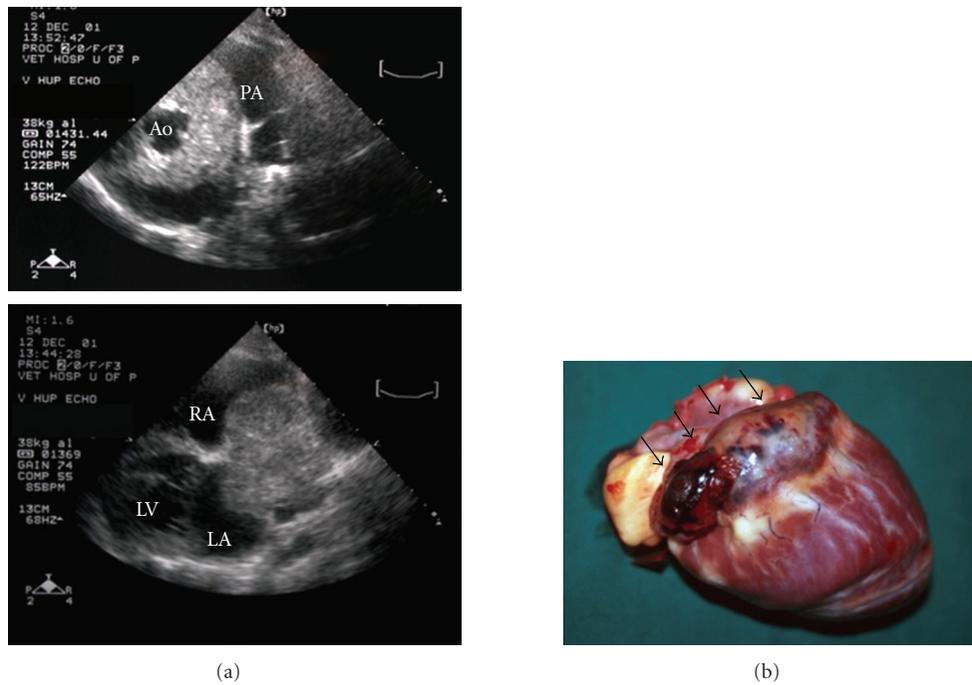


FIGURE 3: Common Heart Tumors in Dogs. (a) Echocardiography showing a hyperechoic mass surrounding the aorta (Ao) at the base of the heart in short axis (top image) and long-axis (image below) views, consistent with a heart base tumor (chemodectoma). PA: pulmonary artery; RA: right atrium; LV: left ventricle; LA: left atrium. (b) Pathology specimen showing (black arrows) a right atrial tumor (hemangiosarcoma).

accidentally draining significant amounts of blood from the heart is virtually null). The chief argument *against* tapping from the left side, however, is the presumed greater risk of hitting a coronary artery using this technique [19]. Potential, although rare, complications are listed in Table 2.

It is recommended that all patients be fitted with an intravenous catheter as a measure of precaution, should complications occur during the procedure. To assess heart rate and rhythm during the procedure continuous ECG monitoring is furthermore advisable. A “pericardiocentesis check list” is provided in Table 3. Pericardiocentesis can be performed with mild sedation of the animal, but local

anesthesia alone generally suffices. It is, however, pivotal to keep the patient restrained for the procedure to avoid complications such as pulmonary laceration or cardiac puncture.

3. Step-by-Step Approach to Percutaneous Pericardiocentesis in Small Animals

(i) The site of catheter entry can be determined using the most caudal rib space where the apex beat remains palpable (typically between the 4th and 6th intercostal space (ICS)). An alternative “rule-of-thumb” for deciding on location of catheter entry uses a fully flexed front limb rotated caudally

TABLE 2: Potential complications of percutaneous pericardiocentesis.

Complication to Procedure	Anatomical site	Clinical Outcome
Puncture or laceration	Myocardium	Hemorrhage
	Coronary arteries	
	Lung	
Arrhythmia	Myocardium	Catheter induced arrhythmia (e.g., VPCs*)
Infection	Pericardial space	Iatrogenic pericarditis
Air intake (via catheter)	Pericardial space	Pneumopericardium

*VPCs: ventricular premature complexes.



FIGURE 4: Schematic of catheter insertion site shown at the 6th intercostal space on the left side. The elbow (blue arrow) can be used as a guiding tool to locate an appropriate site for catheter insertion (red arrow). See text for details.

at the shoulder joint to allow the patient's elbow to act as indicator for approximate catheter insertion site (Figure 4).

(ii) Echocardiographic guidance is generally unnecessary, but the point of catheter insertion would be where the largest amount of effusion between the heart and the thoracic wall is located. The puncture site may also be determined based on the positioning of the cardiac silhouette on radiographs.

(iii) Shave and surgically prepare (using sterile gloves) an area circumscribing the 4th to 6th ICS at the level of the costochondral junction (CCJ) on the left hemithorax (Figure 5).

(iv) Prepare the Angiocath (Multipurpose Angiocath (Cook Corp., Bloomington, IL, USA)) (over-the-needle catheter) using a no.11 scalpel blade (or alternatively use a pericardiocentesis catheter with premade side holes). Create two moderate-size oval cuts with smooth edges on opposite sides towards the tip of the catheter at different levels to optimize the draining process (Figure 6); make sure, however, that the extra holes are made at sufficiently large intervals



FIGURE 5: Drainage of pericardial effusion from the left hemithorax. The angle of the catheter may be repositioned on an as-needed basis pending the ease of effusion flow into the syringe. Before catheter withdrawal it is advisable to check with an ultrasound probe for any remaining effusion (photo by the Emergency & Critical Care Service at the Matthew J. Ryan Vet Hosp U of Penn, Dr. Steven Cole).

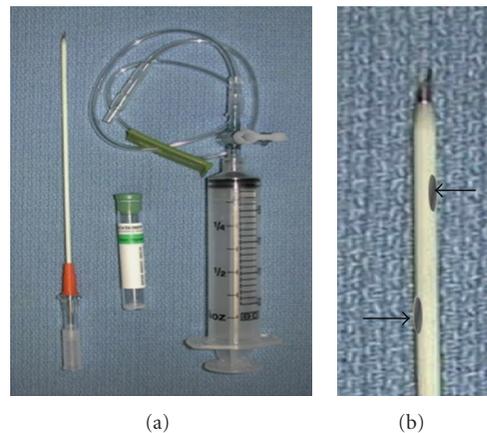


FIGURE 6: Pericardiocentesis Preparation. An over-the-needle catheter (Angiocath), stop-cock, extension set, syringe and green-top test tube are shown as follows. (a) Prepare the Angiocath using a scalpel blade to create two extra holes on opposite sites (indicated by the arrows) towards the end of the catheter. (b) Ensure that all edges are smooth and holes sufficiently far apart to avoid the catheter tip from breaking off.

and that they are not too big to prevent the catheter tip from accidentally breaking off while in the pericardial cavity.

(v) Place a local anesthetic (2% Lidocaine without epinephrine (Lidocaine HCl 1%, Xylocaine (Astra, Westborough, MA, USA))) at the 6th ICS (or which ever ICS has been chosen based on the guidelines provided above) immediately above the level of the CCJ. Avoid the caudal border of the rib—and thus the intercostal vessels—when injecting the Lidocaine. Ensure adequate infiltration of pleura, intercostal musculature, and skin. Inject the last amount of Lidocaine immediately below the skin to create a small swelling, thus serving as a marker for where the catheter is to be inserted.

(vi) Wait a few minutes before making a small cutaneous cut with a scalpel blade at the site where the Lidocaine was

TABLE 3: Pericardiocentesis check list.

Needles and Syringes	Sharps	Accessories	Drugs
25 G and 22 G needles	No.11 scalpel blade	Surgical gloves	2% Lidocaine (without epinephrine)
60 mL and 3 mL syringes	14 G–16 G Angiocath (over-the-needle catheter)*	Eye drape	Aseptic skin preparation material
3-way stopcock		Two liter container (fluid collection)	
20 inch extension set		Test tubes (grey, red and purple tops) for pericardial fluid collection	

*In cats and small dogs use a smaller size catheter (or a butterfly catheter) instead.

placed. Advance the catheter perpendicularly through the cut and keep a thumb on its end upon initial insertion for control as well as to avoid any airflow into the chest cavity.

(vii) Continue carefully advancing the catheter using moderate pressure. Generally a drop in resistance indicates the catheter's transition from the muscle layer to the pleural space.

(viii) Upon continuous advancement of the catheter, a scraping sensation can be appreciated when the tip of the catheter hits the pericardial wall. A back-flash of pericardial fluid will be observed in the catheter when the pericardium is punctured (most effusions are hemorrhagic thus exhibiting a "port-wine" discoloration).

(ix) If resistance is noted (including cardiac pulsations), the catheter should be pulled back slightly and the angle of insertion adjusted. Monitor ECG for any arrhythmias, such as ventricular premature complexes (VPCs).

(x) When pericardial fluid is observed in the catheter, carefully remove the stylet, while simultaneously advancing the catheter further into the pericardial sac at a perpendicular angle.

(xi) Connect the catheter to a stop-cock with a 20-inch extension set attached to a 60 mL syringe.

(xii) Start withdrawing the pericardial effusion. When the syringe is full, close the stop-cock to the patient and collect a small amount of fluid into a red-top test tube (clotting). Empty the remaining amount of effusion into the collection container.

(xiii) If no coagulation is observed in the collection tube within 5 minutes, the procedure can be continued (unless recent hemorrhage has occurred, pericardial effusion should not coagulate). If the source of the fluid remains questionable after this initial assessment, a sample can be centrifuged and the packed cell volume evaluated (pericardial effusion generally has a much lower PCV compared to blood, and its supernatant is typically xanthochromic (i.e., with a yellowish discoloration)).

(xiv) When correct catheter positioning is ascertained, the remaining effusion can be drained from the pericardial space. Collect samples of the effusion for cytology and laboratory analysis.

(xv) Check on echocardiography that all effusion has been aspirated before withdrawing the catheter from the

pericardial space. It may be necessary to gently reposition the catheter towards the end of the procedure when the pericardial sac starts collapsing to ensure removal of all remaining pericardial fluid.

4. Pericardiocentesis and Pericardial Lavage in Large Animals

Echocardiography is generally recommended to decide on optimal site for catheter insertion in equine cases with pericardial effusion [20]. Typically, however, the preferred site is the 5th ICS on the left hemithorax (dorsal from the left lateral thoracic vein and ventral to the point of the shoulder) [25]. In cows, the elbow level at the 5th or 6th ICS is recommended for local infiltration with Lidocaine and catheter insertion [26]. An IV line should be placed prior to the procedure, and ECG monitoring is recommended to assess development of any arrhythmias during the procedure. The equine epicardium is reportedly particularly sensitive to stimulation, and VPCs therefore not uncommon with this procedure [20]. If a significant amount of pericardial effusion is present, a large-bore (between 28 and 32 French (F)) draining catheter (Argyle (Sherwood Medical, St. Louis, MO, USA)) with a trocar needle is placed as an indwelling tube—which can be used for pericardial lavage following the pericardiocentesis. Smaller catheters (12–24 F) can be used in cases with less effusion [25]. Samples of effusion should be submitted for cytology, culture/sensitivity and, if possible, viral isolation (including equine arteritis virus, and influenza in horses, and bovine leukemia virus in cows) [21, 27].

Pericardial lavage improves overall prognosis in large animal patients with pericardial effusions [20, 21, 27, 28]. No less than 2 liters of temperate sterile 0.9% NaCl is recommended to lavage the pericardial sac. After infusion, the lavage fluid is left in the pericardial cavity for 30 minutes to an hour [25]. Once this lavage fluid has been drained, 1-2 liters of sterile 0.9% NaCl containing either 10–20 × 10⁶ IU Sodium Penicillin/L or 1 g Gentamicin/L is infused to the pericardial cavity and left for the following 12 hours. Administration of broad-spectrum systemic antibiotics is recommended until results become available from the culture and sensitivity analysis (long-term antibiotic therapy is

indicated in cases with septic pericarditis). If an infectious etiology is definitely ruled out, corticosteroids may be indicated to treat patients with idiopathic pericarditis [20, 25]. Pericardial lavage (i.e., drainage/lavage/drainage/instillation of NaCl) should be repeated until less than half a liter of pericardial effusion is obtained at the first drainage [25]—which usually is the case after between 24 and 48 hours of treatment [28]. Treatment should as a rule include rest in all cases [28].

5. Conclusion

The hemodynamic compromise caused by pericardial effusion and cardiac tamponade is potentially life-threatening. Performed proficiently, pericardiocentesis is a rather simple procedure that will ensure rapid normalization of the arterial pulse and systemic blood pressure and instantaneously improve the overall well-being of the patient noticeably. Pericardial fluid samples should be submitted for cytological evaluation and additional laboratory analyses. Most types of pericardial infections can be diagnosed fairly reliably on fluid analysis, in which case cultures should be requested. It should be noted, however, that cardiac neoplasia in general does not readily exfoliate, and also that reactive mesothelial cells from the pericardial cavity commonly are misdiagnosed as being neoplastic [19]. Different parameters, including pH and cardiac troponins, have been assessed with varying success as potentially useful indicators of etiology in pericardial effusion [17, 29–33]. Unfortunately, the overall diagnostic value of pericardial fluid analysis remains quite low for detecting most tumors, and results should in general be interpreted cautiously.

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