DIAGNOSTIC APPROACH TO PLEURAL EFFUSION

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Pleural effusion occurs due to an abnormal accumulation of fluid in the pleural space secondary to a multitude of pathologies which include but are not limited to: pyothorax, feline infectious peritonitis (FIP), congestive heart failure, and neoplasia. Presentation can be acute or acute-on-chronic and these patients require a prompt stabilisation and diagnostic work up. This article will provide an overview of the stabilisation, diagnostic procedures, pathophysiology, and classification of pleural effusions in cats and dogs.

Presentation and physical examination

The most consistent clinical signs associated with pleural effusion include dyspnoea and exercise intolerance[1]. However, early in the disease process, patients may present with more non-specific signs such as lethargy or inappetence. Other manifestations of pleural effusion depend on the underlying disease process but may also include weight loss, dehydration, pallor, pyrexia, and cough. Obtaining a thorough history is imperative, as this will influence your differential diagnosis and test selection. For example, a history of coughing in animals with pleural effusion may indicate tracheal compression by a mediastinal mass, or chronic gastrointestinal signs and weight loss in a purebred cat may suggest FIP[1].

Physical examination

Physical examination findings can vary between patients. Animals often display a short, shallow, or restrictive breathing pattern with or without abdominal effort[2]. Cats commonly present with open mouth breathing and tachypnoea. These patients are particularly fragile so placing them in an oxygen kennel to stabilise while preparing sedation is often a better approach.

Auscultation generally reveals muffled or inaudible heart and lung sounds ventrally due to the accumulation of fluid, while breath sounds are preserved dorsally. An important differential for a paroxysmal breathing pattern is pneumothorax which can often be differentiated on auscultation as breath sounds will be absent dorsally due to the rising air[1]. Careful thoracic auscultation may reveal a left or right-sided heart murmur; however, it is important to note that up to 22 per cent of cats with hypertrophic cardiomyopathy may not have an audible murmur[3]. Additional findings may include: an outstretched head or neck, orthopnoea, and abdominal distension[2].

Initial stabilisation

Patients presenting with pleural effusion are unable to expand their lungs sufficiently and this leads to a decrease in lung volume and reduced gas exchange so rapid stabilisation is crucial. Oxygen supplementation can be provided via flow-by, a face mask if tolerated, or oxygen cage. It is important that patient anxiety is reduced as this can worsen respiratory distress. Do not compromise the patient to place an intravenous catheter, instead use appropriate sedation to allow safe patient handling. Once sedated, further diagnostics such as thoracic ultrasonography/radiography can be pursued to confirm pleural effusion.

Thoracocentesis is the stabilisation technique of choice and is both therapeutic and diagnostic. If you do not have access to diagnostic imaging modalities in your practice, you may perform a diagnostic thoracocentesis to confirm pleural effusion.

Diagnostic imaging findings

Thoracic point-of-care ultrasound (TPOCUS) is a useful tool to assist clinical examination in emergency settings. To assess for pleural effusion, place the ultrasound probe in the intercostal space and move between spaces, starting cranially and working caudally. Fluid will accumulate ventrally and air dorsally, so it is important to scan in both directions.

Pleural effusions can accumulate unevenly in both hemithoraxes; therefore, both sides should be assessed and the degree of effusion noted (mild, moderate, or severe). Usually, pleural effusion will appear as an abnormal volume of anechoic fluid between the thoracic wall and lung surface. In any inflammatory processes (chylothorax, neoplasm, etc.) the fluid may be more hyperechoic or contain hyperechoic strands of fibrin[4] .

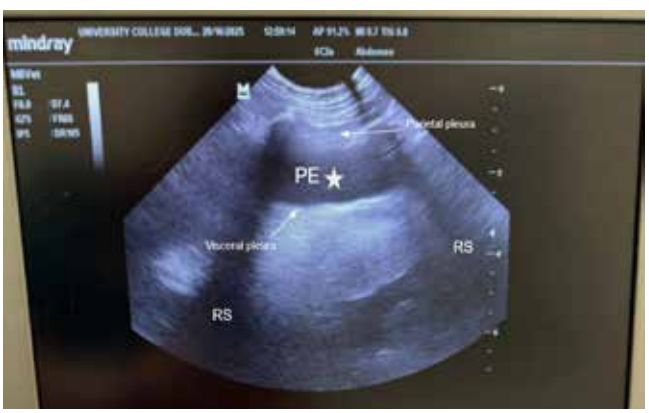

Figure 1: Ultrasound of a pleural effusion in a dog. PE = pleural effusion, RS = ribspace.

Thoracocentesis procedure

Supplies required:

- adequate sedation to allow safe procedure;
- lidocaine 2 per cent;
- sterile prep solution;
- clippers;
- 21-22g butterfly or 18-22g intravenous catheter (for obese patients);
- syringe (10-20ml);
- three-way tap;
- short extension set;
- sterile gloves; and,
- ethylenediaminetetraacetic acid (EDTA) and plain top tube for samples.

The animal is positioned in sternal recumbency and adequately sedated. Before clipping or prepping, the

anatomical landmarks should be palpated (7th-9th intercostal space at the level of the costochondral junction). The area should be clipped and lidocaine injected subcutaneously at the site of entry to provide additional analgesia, then aseptically prepare the site. Select an appropriate needle width and length; in very obese animals, an intravenous catheter is often required to access the pleural space. Palpate the rib and insert the needle cranial to this to avoid any nerves and blood vessels which run caudally. Advance the needle through the skin, subcutaneous tissue, and intercostal muscles in a perpendicular manner; once you approach the pleural space, carefully advance forward until fluid is obtained. You will typically feel a 'pop' which indicates that you have punctured the pleura[5]. Attach your syringe and three-way tap and continue aspirating until you see an improvement in respiration. Remember to collect samples for cytology and culture as they may be necessary at a later time. The procedure can be performed ultrasound-guided or blind, however, ultrasound is preferred in cases with a lesser volume of fluid or in smaller patients to avoid inadvertently puncturing other structures. Record the volume of fluid removed and post-procedural imaging is recommended to assess the reduction in pleural effusion.

Diagnosis

Once the patient has been stabilised, further diagnostics such as imaging and cytology can be carried out to investigate the underlying cause of the pleural effusion. Pleural effusions may develop through several different mechanisms, and characterising the fluid based on its cytologic properties is helpful in determining the underlying aetiology, guiding treatment, and establishing prognosis. Fluid analysis can also guide the selection of an appropriate imaging modality which preserves client finances. For example, echocardiography is useful for identifying primary cardiac disease, noting that pleural effusion is more commonly associated with left-sided heart failure in cats and right-sided heart failure in dogs. Where available, computed tomography can be particularly valuable for confirming mediastinal masses and potentially identifying penetrating foreign bodies in cases of pyothorax.

A small amount of pleural fluid is normally produced to lubricate the pleural surfaces and allow smooth movement between the lungs and thoracic wall. This fluid is maintained at a subatmospheric pressure, helping to

Transudation	**Caused by altered fluid dynamics, including increased hydrostatic pressure, reduced lymphatic drainage, or decreased plasma oncotic pressure[8].**
Exudation	**Formed due to the action of inflammatory mediators that increase endothelial permeability, capillary hydrostatic pressure and chemostaxis[8].**
Vessel or viscus rupture or leakage	**Vascular rupture secondary to trauma or haemorrhaging neoplasia. In peritoneal fluid you may see contents from the gastrointestinal tract, urinary or gall bladder[7].**
Neoplastic exfoliation	**Neoplastic proliferation or irritation of the mesothelium by a foreign substance or accumulating fluid[7].**

Table 1: An overview of the mechanisms of effusion production.

preserve the negative pressure within the thoracic cavity[6]. Its production and removal are regulated by Starling's forces, which describe the balance between hydrostatic and oncotic pressures within the capillaries and surrounding tissues[7]. Disruption of this balance – such as in heart failure (increased hydrostatic pressure), hypoproteinaemia (decreased plasma oncotic pressure), inflammation (increased capillary permeability), or impaired lymphatic drainage – can result in excessive accumulation of fluid within the pleural space. The main mechanisms by which an effusion can occur are summarised in Table 1.

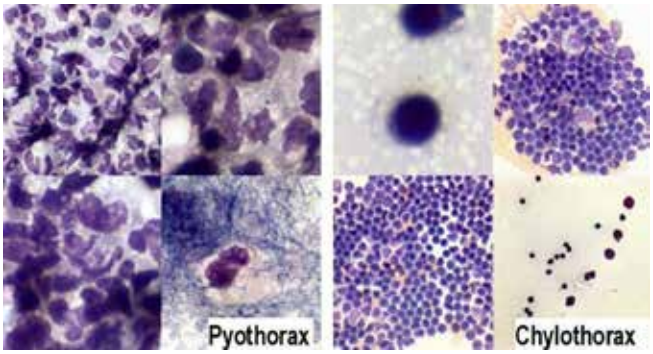

Figure 2: Courtesy of Dr Peter O'Brien, UCDVH.

Fluid samples and analysis

When collecting fluid from the pleural space during thoracocentesis the following samples should be prepared: EDTA, serum, and plain tube. These samples will cover a broad range of diagnostic tests such as cytology, total protein, biochemistry, culture etc. It is best to prepare all samples initially in cases where antibiotics are initiated or owners change their mind and request referral as this may avoid repeated patient sampling or equivocal culture results. The initial assessment of pleural fluid should include evaluation of its colour, clarity, and viscosity. Fluid appearance can provide valuable clues to the underlying diagnosis. For example, a white, opaque pleural effusion in a cat should raise suspicion for chylothorax. This can be confirmed by comparing the triglyceride and cholesterol concentrations of the pleural fluid with those of peripheral blood. A chylous effusion is typically characterised by a triglyceride concentration in the fluid that exceeds that of serum (commonly >3g/L), while the cholesterol concentration is usually lower than that of serum. Fluid appearance may also support other differential diagnoses. For instance, in an older dog with a heart murmur, a clear pleural effusion may increase suspicion for congestive heart failure. Blood-tinged samples may represent either peripheral blood contamination during collection or true haemorrhage into the pleural space. Measuring the packed cell volume (PCV) of the fluid and comparing it with a peripheral blood sample can help distinguish active haemorrhage from sample contamination. Protein concentration and total nucleated cell counts (TNCC) can be used to initially differentiate pleural effusions. The protein content can be estimated from the supernatant of a centrifuged sample using a refractometer. Do not use the EDTA sample for this step as it may falsely elevate the protein content[9]. Normal protein concentrations are usually

Type of Effusion	Total Protein (g/L)	TNCC (×103/mcL)	Cytology	Causes (non-exhaustive)
Transudation				
Transudate (low-protein)	<25	<5	Macrophages; Neutrophils; Lymphocytes; Few RBCs	Uncommon in pleural fluid: neoplasia, cardiac disease, lung lobe torsion
Transudate (high-protein)	>25	<5	Macrophages; Neutrophils	Neoplasia, cardiac disease, and lung lobe torsion
			Lymphocytes; Few RBCs	
Chylous effusion	>25	Variable, >3	High proportion of small lymphocytes; Lipid vacuoles	Cardiomyopathy (cats), idiopathic (dogs/cats), neoplasia (e.g., thymoma), parasitic, granuloma
Exudation				
Classic Exudate	>25	>5	Neutrophils predominate	Infectious (bacterial, fungal, parasitic), inflammation (pancreatitis, pneumonia secondary to ruptured viscus)
Feline Infectious Peritonitis	>25, often >50	<5	Can be of low cellularity** Mixture of neutrophils (60-80%) and macrophages (20-40%), fibrin clots, proteinaceous background, few mesothelial cells and lymphocytes.	
Vessel Rupture				
Haemorrhage	>25	Depends on peripheral blood count	Many RBCs, no or very few platelets	*Angiostrongylus vasorum, Streptococcus zooepidemicus*
Various mechanisms				
Neoplasia	Variable, often >25	Variable	Neoplastic cells in fluid (more common with round or epithelial cell tumours), usually fluid is transudative, but can be exudative (tumour necrosis, inflammatory cytokines, sepsis) with concurrent haemorrhage	Lymphoma, carcinoma, mast cell tumour, mesothelioma etc.

Table 2: Summary of the main mechanisms and causes of pleural effusion. This table has been simplified from Ettinger's Textbook of Veterinary Internal Medicine: Diseases of the Dog and Cat.

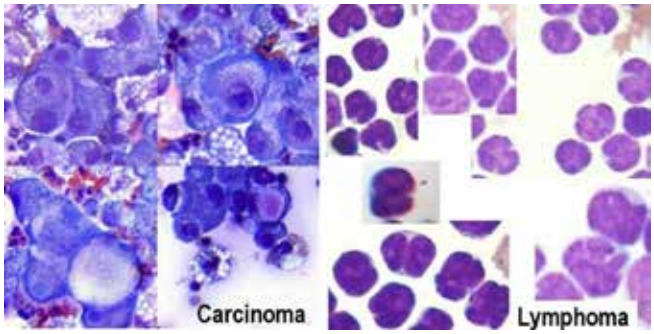

Figure 3: **Courtesy of Dr Peter O'Brien, UCDVH.**

<25g/L which corresponds to a urine specific gravity refractometer scale of 1.020[7].

For cytology, EDTA is preferred as it prevents clotting and cell clumping, gives two times higher cell counts than using plain tubes, and gives better cell morphology preservation. Total nucleated cell counts can be obtained from in-house haematology analysers but this is said with caution as thick effusions may clog the analyser. A manual count can be carried out on a direct smear instead. Using the 100x oil objective, count the average nucleated cells per field over 10 fields; total the numbers up and divide by 10 to estimate the total nucleated cells per field and then multiply by 100[2] (TNCC/uL).

Cytology can then be made from a direct smear, however, if the fluid is very clear it may be poorly cellular. Spinning the sample down in a centrifuge at 1000rpm for three minutes can improve diagnostic yield; a higher rpm may damage fragile cells. After spinning down the sample, discard the supernatant liquid leaving the concentrated solution at the bottom. Place a small drop of this fluid on a clear, labelled microscope slide and gently smear the sample with a second slide overlaying this. It is important not to apply too much pressure as this can also damage the sample. The slide should be dried promptly and thoroughly, before staining using the Diff-Quik staining protocol and evaluating under the microscope.

Classification

Effusions have traditionally been classified by protein and total cell count (transudate, modified transudate, etc.), this system can often be misleading as it does not account for the underlying disease process[10]. For example, the "modified transudate" category became a poorly defined grey zone, grouping together conditions such as neoplasia, lymphatic obstruction, and early inflammation, despite their distinct and fundamentally different underlying mechanisms and prognosis. O'Brien et al. first identified the issues with this system in 1988 and proposed a mechanistic approach. Table 2 can be followed in practice to help you understand the classification of pleural effusions in veterinary medicine.

Conclusion

Pleural effusion is a common cause of respiratory emergencies in small animal practice and this article provides an overview of a basic, step-by-step approach to these often overwhelming cases. Prompt stabilisation and broad categorisation of the effusion can help initiate treatment sooner. While the clinical presentation is similar, the underlying causes are diverse, ranging from cardiac disease to infection, inflammation, and neoplasia. A thorough diagnostic work-up can be performed in primary care using an understanding of point-of-care ultrasound, thoracocentesis, and basic fluid analysis. Additionally, these techniques can provide important markers of prognosis which will help both practitioners and clients in the management of these cases. Definitive diagnosis may not always be possible and when advanced imaging, intensive monitoring, or specialist input is required, early referral should be discussed with owners.

References available on request

READER QUESTIONS AND ANSWERS

1. WHAT IS THE MOST COMMON FINDING ON THORACIC AUSCULTATION OF A PATIENT WITH PLEURAL EFFUSION?

A. Diffuse pulmonary crackles
B. Absent breath sounds dorsally
C. Muffled heart and lung sounds ventrally
D. Increased bronchovesicular sounds

2. WHAT ARE THE ANATOMICAL LANDMARKS FOR THORACOCENTESIS AND NEEDLE ENTRY POINT?

A. 7th-9th intercostal space at the level of the costochondral junction; insert needle cranial to the rib
B. 5th-7th intercostal space at the level of the costochondral junction; insert needle cranial to the rib
C. 7th-9th intercostal space at the level of the costochondral junction; insert needle caudal to the rib
D. 5th–7th intercostal space at the mid-thoracic region; insert needle caudal to the rib

3. WHICH OF THE FOLLOWING CONDITIONS IS MOST LIKELY TO FORM PLEURAL EFFUSION THROUGH THE MECHANISM OF EXUDATION?

A. Congestive heart failure
B. *Angiostrongylus vasorum*
C. Pyothorax
D. Mediastinal lymphoma

4. WHAT CUT-OFF IS USED FOR A HIGH PROTEIN TRANSUDATE?

A. >50 g/L
B. >25 g/L
C. >10 g/L
D. >30 g/L

ANSWERS: 1C; 2A; 3C; 4B.