



Abstract

Pneumothorax of many etiologies can affect dogs and cats. For many patients, a single thoracocentesis will resolve the pneumothorax; however, for those with a persistent air leak, more invasive options such as continuous suction through a thoracostomy tube or surgery are often necessary. For select patients, a less invasive, less expensive option may be autologous blood patch pleurodesis. Blood patch pleurodesis is not difficult to perform and, despite a limited amount of published information, it seems to be reasonably successful with minimal complications.



EMERGENCY MEDICINE/CRITICAL CARE

Blood Patch Pleurodesis for Pneumothorax

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Pneumothorax is the presence of free air within the pleural cavity, most often resulting from rupture of a portion of an air-containing viscus (e.g., lung, airway, less commonly esophagus) and may be frequently encountered in the veterinary emergency hospital. Pneumothorax may be either spontaneous or acquired.

Spontaneous: Primary spontaneous pneumothorax occurs in the absence of primary lung disease and, in dogs, may result from rupture of pulmonary bullae or blebs. Primary spontaneous pneumothorax is more common in large, deep-chested breeds, especially Siberian huskies.¹ Secondary spontaneous pneumothorax occurs because of a variety of underlying

pulmonary conditions, including infection (parasitic, viral, bacterial, or fungal), neoplasia, migrating foreign objects, thromboembolism, and lower airway disease.^{1,2}

Acquired: Acquired pneumothorax may occur as a result of blunt force or penetrating trauma,^{1,3,4} iatrogenic injury during thoracocentesis or thoracostomy tube placement, an adverse anesthetic event (e.g., barotrauma), or a surgical complication following thoracotomy. Tension pneumothorax occurs when a 1-way valve effect leads to significantly increased intrathoracic pressure, compressing the lungs, heart, and large vessels and leading to cardiovascular compromise.

Take-Home Points

- In veterinary medicine, pneumothorax is reportedly associated with a large range of etiologies.
- When pneumothorax recurs or does not resolve, additional options for therapy include prolonged continuous suction, surgery, or blood patch pleurodesis.
- Before blood patch pleurodesis is performed, patients should undergo appropriate diagnostics; after the procedure, they should be closely monitored.
- Blood patch pleurodesis is not a complex procedure to perform and has been reported to have a reasonably high success rate with minimal complications.
- Other methods of chemical or mechanical pleurodesis have not been shown to be superior to blood patch pleurodesis in veterinary patients.



Clinical signs of pneumothorax may include increased respiratory rate and effort, often with an abdominal component. Patients with mild cases may exhibit cough, weight loss, and lethargy. Signs of severe pneumothorax may include grunting, gasping, anxiety, barrel-shaped chest, cardiovascular collapse, cyanosis, vomiting, or even cardiopulmonary arrest. Physical examination may also detect quiet or muffled cardiac and pulmonary sounds, which may be more pronounced dorsally, as well as signs associated with shock resulting from diminished cardiac output (e.g., diminished pulse quality, tachycardia, cyanotic or pale mucous membranes, prolonged capillary refill time, decreased blood pressure). Pneumothorax reduces tidal volume, which may result in (sometimes very rapid and progressive) hypoxemia, hypercarbia, respiratory acidosis, and death.

Urgent treatment for pneumothorax requires relief of increased intrathoracic pressure via thoracocentesis, which may need to be performed before imaging studies to ensure that the patient is stable. A single thoracocentesis is easily accomplished after shaving, aseptic preparation, and aspiration with a closed collection system (**FIGURE 1**). Although in some patients the pneumothorax may accumulate slowly and require a thoracocentesis every few days or weeks, in other patients the air will commonly accumulate more rapidly. For patients that require more than 2 thoracocenteses within 24 hours, or if negative suction (complete resolution of the pneumothorax) is never achieved, more aggressive intervention is required, which may include placement of an indwelling thoracostomy tube for pleural drainage with a continuous suction device (**FIGURES 2 AND 3**). An alternative treatment for patients in which air accumulates only intermittently, although rarely reported, is placement of a subcutaneous pleural access port to facilitate intermittent air removal.⁵

A more invasive and expensive, but sometimes necessary, option is either a thoracoscopic or open-chest surgical procedure, most often performed with the goal of removing affected tissue (lung lobectomy). To identify and treat the underlying cause, samples for histopathology or culture should be collected during those procedures. Computed tomography (CT) (**FIGURE 4**) is often performed before thoracic surgery to help determine if a cause of secondary spontaneous pneumothorax can be identified and to guide surgical planning. Thoracotomy is not without surgical and anesthetic risks, and pneumothorax may persist

postoperatively,⁵ particularly if the underlying cause affects multiple lung lobes. For human patients, persistent pneumothorax after thoracotomy is a common reason to consider blood patch pleurodesis (BPP).⁶

More aggressive surgical options may be limited by client wishes, financial constraints, or other patient factors. Pleurodesis as a sole method of treating pneumothorax may be considered a less invasive and less expensive option; however, it will not resolve underlying pathology. Pleurodesis eliminates the pleural space by creating a permanent physical adhesion between the visceral and parietal pleura, often by inciting inflammation through physical or chemical methods.⁷ When inflammation is incited, the permanent adhesion may take several days to complete. BPP has been hypothesized to create inflammation similar to other pleurodesis methods; however, it has also been theorized to result in formation of a small patch of coagulated blood over the air leak site, resulting in more rapid pneumothorax resolution.^{7,8} BPP can be performed by using autologous or allogenic blood.

BLOOD PATCH PLEURODESIS

Patient Evaluation

To ensure that the patient has no additional conditions or comorbidities, a thorough history and physical



FIGURE 1. Dog in left lateral recumbency, shaved, aseptically prepared, and undergoing thoracocentesis via a closed collection system. To avoid blood vessels, the needle is generally inserted between the 7th to 9th intercostal space, dorsal to the costochondral junction, cranial to the rib, and with the bevel pointing up. Repeated suction and emptying the air into the room is performed until negative suction (no further air removed) is achieved.



examination are necessary. A patient that has sustained trauma may need analgesia and should be evaluated for conditions such as hemorrhage, fractures, wounds, internal injury, and head injury.

Diagnostics

Before autologous blood patch pleurodesis (ABPP), the workup should include a complete blood count (CBC), blood chemistry, and lactate levels. For select patients, additional workup may include arterial or venous blood gas measurements; fecal examinations (Baermann test); evaluation of coagulation with either prothrombin time (PT) and activated partial thromboplastin time (aPTT) or viscoelastic assessment; and sample collection from the lung for cytology, culture, or additional testing.

Additional diagnostics for a pneumothorax patient may include imaging. Pneumothorax is readily and often diagnosed on thoracic radiography (**FIGURE 5**), which is part of a routine workup if the patient is stable enough to undergo radiography. CT is considered the gold standard for thoracic cavity evaluation and is recommended for patients with recurrent pneumothorax.¹ CT is much more sensitive than radiography for diagnosing pulmonary disease such as bullae.⁹ If CT is not available, horizontal beam radiography may increase detection of pneumothorax,¹⁰ but it is not commonly performed due to limited familiarity with this technique or limitations of radiology equipment. Point-of-care ultrasonography (POCUS) can be performed immediately (e.g., during other interventions such as thoracocentesis, IV catheter placement) and has the advantages of being rapid, repeatable, less expensive, and good for detecting

pleural fluid, as well as not requiring patient sedation. Compared with radiography, POCUS sensitivity and specificity for the diagnosis of pneumothorax are reasonably high¹¹; however, compared with CT, thoracic POCUS is not as sensitive for detecting pleural air and may be limited by the training and skill of the user.¹²⁻¹⁴ The most common sign used to diagnose pneumothorax with POCUS is lack of a glide sign. Glide sign is the normal dynamic interface between the visceral (lung) and parietal pleura, moving back and forth with each breath.¹¹ When air is present in the pleural space, the glide sign will be absent. Additional signs have been described, and the complete technique of thoracic POCUS, along with normal and abnormal findings, is well described elsewhere.¹²⁻¹⁵



FIGURE 3. Dog with a left-sided thoracostomy tube, placed due to continuous pneumothorax secondary to trauma (being hit by a car). Patient management included oxygen, analgesia, and continuous suction for several days.



FIGURE 2. Single-lumen pleural catheter placed in the right hemithorax of a cat.



FIGURE 4. Computed tomography image of a dog with a significant bilateral pneumothorax.



Patient Preparation

Autologous Blood

ABPP is collection of venous blood from the same patient that will receive the pleural infusion. The normal patient should be able to sustain, without injury or hypovolemia, the loss of 5 to 10 mL/kg used for ABPP; patients with other comorbidities or hypovolemia may not be able to sustain this volume of blood loss. It is appropriate to assess the patient for physical changes associated with shock by performing a complete physical examination along with blood work as noted above, particularly in patients that have pneumothorax secondary to trauma. That assessment ensures that the patient will not have complications associated with collection venipuncture or hypovolemia. Coagulation testing helps ensure that the blood is able to effectively and normally go through the process of clot formation, 1 of the attributes contributing to the success of ABPP.⁷

If the patient is not able to tolerate the required loss of 5 to 10 mL/kg of blood because of coagulopathy, anemia, shock, or other critical illness, alternative options may be considered. Before blood is collected for BPP, anemic patients may receive a transfusion of packed red blood cells, coagulopathic patients may receive fresh frozen plasma, and some patients may require whole blood. Patients that receive an allogeneic transfusion before collection of autologous blood for ABPP should undergo standard pretransfusion testing

(e.g., blood typing, cross-matching) and be closely monitored according to routine guidelines during transfusion administration.^{16,17} Blood work (e.g., CBC or packed cell volume/total solids, platelet assessment, PT and aPTT or viscoelastography) along with a blood gas and electrolyte panel (e.g., sodium, potassium, calcium, chloride) should be performed after the transfusion but before ABPP.

ABPP is rarely considered an emergency procedure and should only be performed on a stable patient. In human medicine, ABPP is more commonly recommended when the air leak is persistent (>5 days).¹⁸ The patient should be provided oxygen, appropriate systemic and/or local analgesia or sedation, and be closely monitored by a trained person using standard monitoring techniques (e.g., electrocardiography, pulse oximetry, blood pressure measurement) (**FIGURE 6**).

Allogenic Blood

Allogenic BPP, in which the blood is collected from a separate donor, has also been reported.¹⁹ Allogenic BPP carries a potential higher risk for adverse transfusion reactions; therefore, prepleurodesis diagnostics (e.g., blood typing, cross-matching, other standard prescreening), along with close postpleurodesis monitoring, using current consensus guidelines for standard allogeneic transfusion are recommended.^{16,17}



FIGURE 5. Right lateral thoracic radiograph of a dog with pneumothorax, demonstrating an air density between the heart and the sternum along with retraction of the lung lobes from the costophrenic recess of the pleural cavity.



FIGURE 6. A patient with recurrent pneumothorax, sedated and monitored in preparation for blood pleurodesis. Note that the right jugular vein has been shaved and aseptically prepared; the patient is receiving oxygen during the procedure and being monitored by a trained person.



Venous Blood Collection

The procedure of collecting blood for patch pleurodesis as well as administering it to the patient should be performed aseptically. The venipuncture and thoracic infusion sites should be prepared in standard aseptic fashion by shaving hair, using chlorhexidine or another suitable antiseptic solution to scrub the area, donning sterile gloves, using sterile supplies, and wiping any IV injection ports with alcohol and allowing to air dry.

The procedure of collecting blood from the patient is similar to that of blood donation. For the collected blood, it is crucial that it not contain any additives commonly used to preserve stored blood products (e.g., heparin, citrate/phosphorus/dextrose/adenine solution).¹⁸ A section of the ventrolateral cervical region over the jugular vein is prepared (**FIGURES 6 AND 7**), and a needle or catheter (preferably 18 gauge or larger) is inserted into the vein to collect whole blood through a short extension of IV tubing directly into a syringe (**FIGURE 7**).

If the patient already has a large-bore IV catheter in place, such as a central line, the blood can be collected from that catheter. When a central line is used, the 3-syringe technique is recommended. The first syringe is used to remove 2 to 3 times the volume of the catheter (usually 2 to 5 mL) of blood and infusate present in the line. Next, the autologous blood intended for pleurodesis is then collected into the second syringe (multiple syringes may be required, depending on the volume to be collected). Last, the blood and infusate in the first saved syringe are flushed into the port, followed by a saline flush from the third syringe.



FIGURE 7. Aseptic collection of autologous blood from the left jugular vein directly into a syringe, using an 18-gauge butterfly needle.

Although an ideal amount to administer has not been determined, 5 mL/kg per hemithorax to be treated (maximum of 10 mL/kg) is conventionally recommended on the basis of previous retrospective evaluations in dogs and cats.^{19,20} A small experimental study in rats demonstrated that more adhesions formed in those that received 2 or 3 mL/kg of blood than in those that received saline or 1 mL/kg of blood.²¹ Two studies performed in humans identified that 120 mL was more effective than 60 mL of infused blood.^{22,23}

After the volume of blood is collected, the needle or catheter is removed from the venous site if no longer needed and digital pressure should be applied to the area for at least 5 minutes to ensure complete coagulation at the site and prevention of hematoma. A light wrap may be used, and the site should be monitored closely for several hours.

Administration of Blood for Patch Pleurodesis

As with blood collection, blood administration should be aseptic. Blood may be administered through a thoracocentesis needle (**FIGURE 1**), a preplaced pleural



FIGURE 8. Administration of autologous blood into the left hemithorax of a dog through a thoracostomy tube after aspiration of air to a negative pressure.



catheter (**FIGURE 2**), or a thoracostomy tube (**FIGURE 8**). If several syringes of blood are collected, 1 person can continue to collect while another person can administer the blood through the thoracic port.

Immediately before administration of blood for patch pleurodesis, the chest cavity should be suctioned free of any air or fluid. The blood for pleurodesis (5 mL/kg per hemithorax) should be administered within 2 to 3 minutes after collection to optimize blood distribution into the pleural space before clot formation.

A small amount of saline may be used to flush the tube, but no more saline should be used than is necessary to ensure that all the blood is delivered into the pleural space. It is recommended that the clinician determine the volume of the administration set before beginning the procedure.

After the blood is administered, it is recommended to gently, repeatedly (2 to 4 times), and safely roll the patient from sternal to both right and left lateral recumbency to help distribute the blood to all regions of the pleural space. Reaspiration of the pleural space or reconnection to a continuous suction device should be avoided for a minimum of 2 to 6 hours unless the patient's condition dictates otherwise.⁶

Postprocedure Monitoring

The patient should be closely monitored (i.e., respiratory rate, respiratory effort, and oxygen saturation) every 1 to 2 hours for a minimum of 6 hours. Many patients are hospitalized for additional comorbidities and may require additional monitoring. If allogenic blood is used, the patient may need to be monitored more intensely (e.g., temperature, pulse or heart rate, blood pressure) according to consensus guidelines, as the potential for adverse transfusion reactions is higher with allogenic blood.^{16,17}

The success level of ABPP is variable.^{20,24} If the procedure is to be repeated, the patient should be reassessed to determine the location and volume of blood to be administered and whether additional venous blood loss would be tolerated. The procedure can be repeated in as little as 1 day; however, the author suggests waiting a minimum of 2 to 4 days.

Administration of antimicrobials for BPP should be judicious and should be based on the success of the aseptic technique, the underlying etiology, and the fact

that empyema is a reported complication of this procedure.¹⁸ A short course of antimicrobials may be administered, similar to that used perioperatively²⁴; however, there is no consensus on this recommendation.

Alternative Indications

Pneumothorax is not the only recurrent pleural space disease; in human medicine, there are rare reports of ABPP being used to treat persistent chylothorax²⁵ and 2 larger case series in which outcomes after ABPP were similar to outcomes after pleurodesis with oxytetracycline or talc for malignant pleural effusion.^{26,27} Use of BPP for conditions other than pneumothorax in clinical veterinary medicine has not been reported; the author has attempted ABPP for malignant pleural effusion, with no success.

Successes and Complications

Case series in both human and veterinary medicine report successful use of BPP for pneumothorax. In 2007, Andreotti et al reported that human patients in whom prolonged (>5 days) pneumothorax developed after thoracotomy experienced more rapid resolution of persistent pneumothorax (1.5 to 2.3 days) when ABPP was used compared with historical controls without ABPP (6.3 days).²⁸ Similarly, Andres et al reported resolution within 24 hours after ABPP in 6 human patients in whom air leak developed after thoracotomy and continued for more than 10 days.²⁹ When used for postoperative air leaks, ABPP has been reported to seal the air leak within 48 hours 84% of the time.³⁰

In 2014, Oppenheimer et al published a case series of 8 dogs.²⁴ Air leak resolved after a single ABPP procedure for 62.5% of dogs and after 1 or 2 repeated procedures for 87.5% of dogs; 1 dog was euthanized. Theron et al reported that among 5 dogs with pneumothorax with a variety of etiologies, ABPP was successful in 4 of 5 dogs; a second ABPP was attempted for the fifth dog, but that patient died.²⁰

Complications after BPP are uncommonly reported in the veterinary literature, but those reported include persistent air leak,^{20,24} fever, infection, blood coming from an endotracheal tube,²⁴ and persistent tachypnea in a cat.¹⁹ A recent meta-analysis of human cases reported very low complication rates; a pooled rate among 198 patients indicated empyema in 1.5% of patients and persistent fever in 8.6%.³⁰



Alternatives to Blood Patch Pleurodesis

Other methods of accomplishing pleurodesis without using autologous or allogenic blood include infusing a variety of compounds, rather than blood, into the pleural space or performing surgical pleurodesis by using gauze to debride the entire pleural lining during a thoracotomy or thoracoscopy. Those options have been examined experimentally and clinically. An experimental study in dogs showed that neither mechanical nor talc pleurodesis sufficiently obliterated the pleural space.³¹ In an experimental rat model, the effectiveness of iodopovidone and mistletoe extract were similar to that of talc slurry.^{32,33} In another experimental trial with rats, oxytetracycline resulted in more acute-phase pulmonary pathology than talc.³⁴ Additional experimental studies in rats demonstrated that hydroxyethyl starch was not as effective as talc³⁵ and that hydrophilic silica may be more effective than some antibiotic solutions.³⁶ Among human patients, outcomes after administration of 50% dextrose were similar to outcomes after administration of autologous blood.³⁷ None of these alternative chemical pleurodesis methods are commonly used for veterinary patients, and the safety of some chemicals in the pleural space has not been clearly demonstrated.

SUMMARY

ABPP is a minimally invasive, inexpensive treatment option for persistent pneumothorax. Venous blood is collected from the patient and aseptically administered into the pleural space, where it presumably forms a small patch of coagulated blood and creates inflammation, which seals the site of the air leak. After the procedure, the patient's respiratory rate, respiratory effort, and oxygen saturation should be closely monitored. Success rates are reasonably high and complications are few. However, if unsuccessful, the procedure can be repeated if the patient can tolerate collection of another 5 to 10 mL/kg of blood. **TV**

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