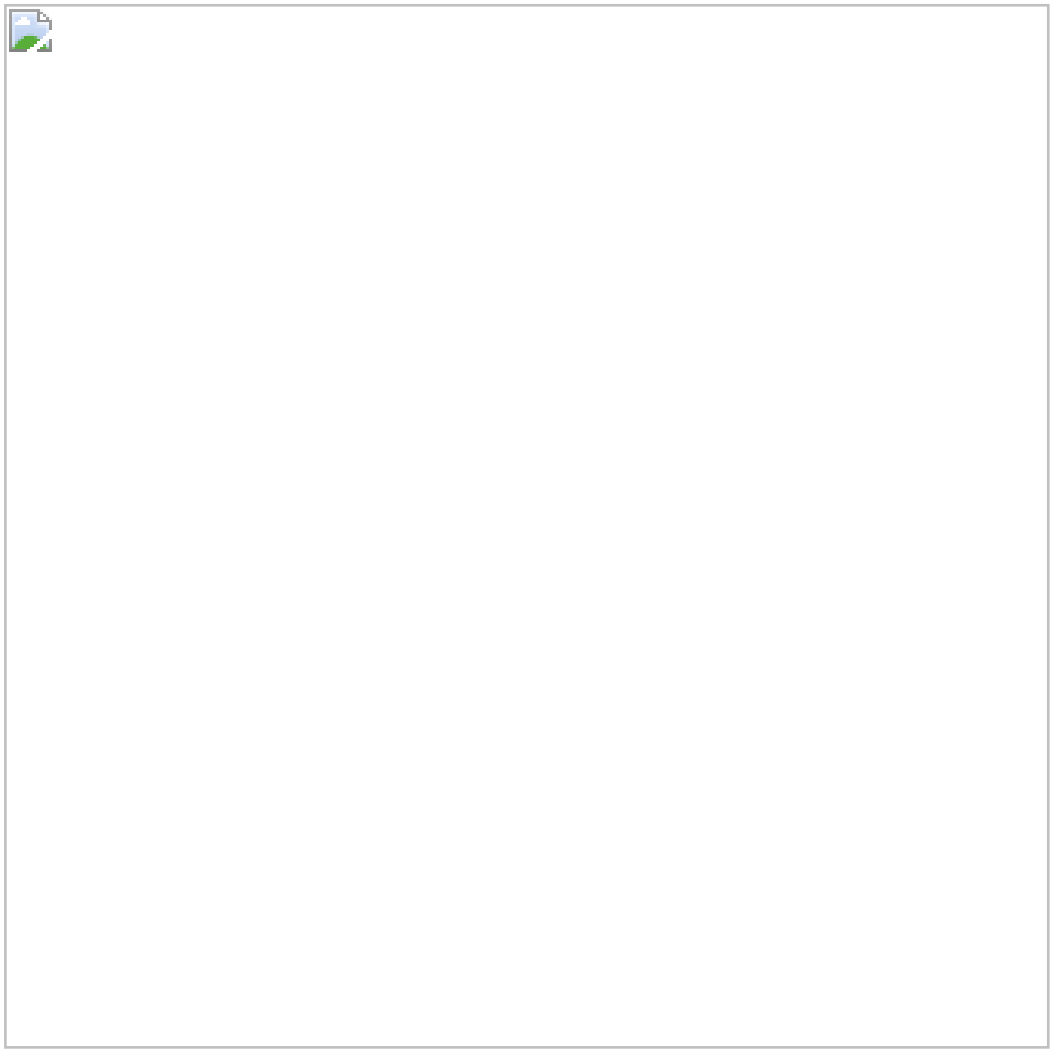

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Allogenic blood patch pleurodesis for continuous pneumothorax in three cats

Alexa M Bersenas[1] and Katie L Hoddinott[2]

Abstract

Case series summary Following diaphragmatic herniorrhaphy, three cats developed a continuous pneumothorax. All three cats required continuous suction to evacuate air from the thoracic cavity. Despite continuous suction, the pneumothorax persisted for all cats and blood patch pleurodesis (BPP) was performed using blood donor cats. All three cats had resolution of their pneumothorax within 24 h of BPP.

Relevance and novel information This is the first report of BPP used in feline patients. More recently autologous BPP has been reported for use in dogs and humans, with a reportedly high success rate. BPP may allow timely resolution of continuous pneumothorax in cats and provide an alternative treatment option to prolonged medical management or surgical intervention. Allogenic blood from a donor cat may be necessitated in feline BPP when cardiovascular instability is appreciated in these small patients.

Keywords: Pleurodesis; blood patch; pneumothorax; continuous suction

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Introduction

Continuous pneumothorax may occur as a primary or secondary disease. In cats, primary spontaneous pneumothorax related to pulmonary bullae is rarely reported.[1–3] Secondary pneumothorax may occur following trauma, iatrogenic intervention, or may be spontaneous and a sequela to underlying lung pathology such as asthma, neoplasia, pneumonia and parasitic disease.[1,2] Continuous pneumothorax is rarely reported in feline patients.[1,2,4,5] When encountered, continuous pneumothorax can be medically managed with intermittent or continuous suction. More aggressive intervention is required for veterinary patients that fail conservative management, typically involving exploratory thoracotomy to identify and treat the site of leakage by lung lobectomy and/or pleurodesis. As such, continuous pneumothorax can be frustrating and costly to treat. More recently, the use of blood patch pleurodesis (BPP) for continuous pneumothorax has been reported in humans and dogs.[6–19]

Pleurodesis involves inciting adhesions between the parietal and visceral pulmonary pleura. Several methods of pleurodesis, including mechanical abrasion and intrathoracic delivery of pleurodesing agents such as talc and tetracyclines, have been attempted in dogs and experimental animals with disappointing results.[15,20–22] The efficacy of pleurodesis varies between species and pleurodesis in cats has been minimally investigated or reported at this time.[23]

BPP is an alternative method to previously reported pleurodesis techniques and involves delivery of fresh whole blood into the pleural space. It is a simple, painless and inexpensive treatment, with reported success in humans[6–11,14,17–19,24] and dogs,[12,13] that warrants investigation in cats.

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Case series description

The medical records of the Ontario Veterinary College were searched. Three cats with severe continuous pneumothorax necessitating continuous suction and treated with allogenic BPP were identified; all cats were treated from 2013 to 2014. All three cats were diagnosed with a diaphragmatic hernia (DH) and underwent primary herniorrhaphy (Table 1). All cats received perioperative antibiotics and positive pressure ventilation throughout surgery. Intraoperatively, airway pressures were closely monitored. Postoperatively, the cats developed respiratory distress. All cats had thoracostomy tubes (14G; MILA International) connected to continuous suction (Sentinel Seal Chaist Drainage Unit; Covidien) owing to rapid air accumulation and the need for frequent repeat intermittent aspiration.

Cat 1

Cat 1, a 5-year-old spayed female domestic shorthair, was diagnosed with an acute DH post-vehicular trauma. The cat was cardiovascularly stable but dyspneic on presentation. Thoracic radiographs confirmed DH and concurrent mild-to-moderate pneumothorax, minimal pneumomediastinum, multiple left-sided rib fractures (ribs 5, 6, 9 and 10) with cranial rib displacement, and a cranially subluxated 11th rib. A focal cranioventral alveolar pulmonary pattern, which was most consistent with pulmonary contusion, was also noted. Ampicillin was initiated at the time of admission owing to superficial lacerations associated with vehicular trauma and mucopurulent nasal discharge. Diaphragmatic herniorrhaphy was performed without event (see Table 1). Intraoperatively, a single thoracostomy tube (14G; MILA International) was placed under direct visualization prior to closure of the diaphragm.

During the first 1.5h of recovery dyspnea prompted repeated pleural evacuation (140ml air × 2). Repeat thoracic radiographs identified a moderate pneumothorax in the face of repeated aspiration confirming continuous pneumothorax necessitating continuous suction. Over the following 3 days, daily attempts at cessation of continuous suction failed within 1–3h, based on recurring signs of tachypnea and dyspnea, therefore necessitating ongoing continuous suction. BPP was elected on the third postoperative day.

Following BPP, signs of increased respiratory effort prompted aspiration of the thoracostomy tube within 1h (retrieving 40ml of air and 10ml of clear fluid [serum]), resulting in resolution of the respiratory signs. Aspiration of the thoracostomy tube was repeated 16h later owing to similar clinical signs (retrieving 105ml of air). Thereafter, the cat remained eupneic. At 24h post-BPP, no air was retrieved from the thoracostomy tube and thoracic radiographs revealed only a scant pneumothorax, as well as newly identified subcutaneous emphysema. No further aspiration of the thoracostomy tube was required, as the cat remained bright and eupneic.

The thoracostomy tube was removed 72 h following BPP, and the cat was discharged from hospital 60h after BPP. The cat remained eupneic at recheck 2 weeks following discharge, with no respiratory complications 6 years after the trauma.

Cat 2

Cat 2, an 8-year-old spayed female domestic longhair, had a DH diagnosed radiographically at routine annual physical examination, following identification of decreased heart and lung sounds bilaterally on thoracic auscultation and 'empty' abdominal palpation. The cat was asymptomatic and had no known history of trauma at the time of referral for DH repair. At presentation, the physical examination was unremarkable with a respiratory rate of 20 breaths/min. Referral thoracic radiographs were consistent with DH, with cranial displacement of the liver and numerous intestinal loops into the thoracic cavity, as well as a healed fracture of the 10th left rib. The visible portion of the pulmonary parenchyma appeared normal. During laparotomy, the lungs were noted to be atelectatic and did not expand with gentle manual breath holding. Following diaphragmatic herniorrhaphy, a transdiaphragmatic thoracocentesis was performed with a 19G butterfly needle. Negative pressure was achieved and 10ml of air was re-introduced into the thoracic cavity to reduce the risk of re-expansion pulmonary edema.

Postoperatively, a severe pneumothorax was identified radiographically and a single thoracostomy tube (14G; MILA International) was placed. Negative pressure was unable to be achieved despite repeated aspiration of the thoracostomy tube and continuous suction was required to abate clinical signs. For the next 60 h the respiratory rate ranged between 32 and 60 breaths/min. Despite effective air production within the continuous suction unit, intermittent manual aspiration of the thoracostomy tube was required when tachypnea developed, retrieving up to 300ml of additional air. Owing to ongoing tachypnea, oxygen supplementation was initiated and $PvCO_2$ was noted to increase over this time (from 44mmHg to 55mmHg). On the third day postoperatively, thoracic radiographs documented a moderate-to-severe pneumothorax, mild subcutaneous emphysema and a mild increase in pulmonary opacity attributed to pulmonary atelectasis. BPP was subsequently performed.

Aspiration of the thoracostomy tube was required 1h after BPP, at which time 195ml of air was retrieved. Respiratory rate remained between 32 and 44 breaths/min thereafter with air retrieval diminishing at each 4h interval post-BPP, and no further air retrieval after 18h. The following day the cat developed dyspnea, tachypnea (48–72 breaths/min), aggravated hypercapnea ($pvCO_2$ 61mmHg) and transient oxygen desaturation (SpO_2 90–92%), despite oxygen supplementation. Following removal of 10ml, and later 20ml of blood from the thoracostomy tube, saturation improved and remained normal (SpO_2 98–100%) with continued oxygen supplementation. However, tachypnea

Table 1 Surgical data

Cat number.	Signalment (weight [kg])	Etiology	Preoperative respiratory status/PTX (yes/no)	Surgical findings	Thoracostomy tube used (yes/no)	Continuous suction (yes/no)	Time from surgery to BPP (days)	BPP success (yes/no)
1	5 yo FS DSH (3.2)	Traumatic DH. Multiple left-sided rib fractures (ribs 5, 6, 9–11), atelectatic right middle lung lobe and pneumothorax	Respiratory signs, PTX and DH on TXR at time of presentation	5 cm rent in diaphragm. Falciform ligament and liver herniated. Several small liver fractures. Adhesions noted in abdomen	Yes – MILA placed intraoperatively Left side	Yes – following anesthetic recovery	3	Yes
2	8 yo FS DLH (3.6)	Chronic DH of unknown cause	No PTX. Asymptomatic cat with radiographic evidence of DH	Small intestine, proximal colon, spleen, all liver lobes and gall bladder in thorax, easily retracted. Lungs atelectatic	Yes – placed postoperatively, removed owing to suspected malfunction. Replaced 18 h post-anesthetic recovery	Yes – initiated 18 h after recovery. Augmented with intermittent suction when clinically indicated	3	Yes
3	6 yo FI DSH (2.6)	Chronic DH. Radiographic confirmation of DH 6 years prior. Mild tachypnea lifelong. Acute recent worsening tachypnea and mild dyspnea	No PTX. Tachypnea, progressive dyspnea, shallow breathing	Radial diaphragmatic tear. Small intestine, proximal colon, spleen, all liver lobes and gall bladder located within thoracic cavity retracted without difficulty	Yes – placed prior to anesthetic recovery following TXR	Yes – following anesthetic recovery	1 (24 h)	Yes

PTX = pneumothorax; BPP = blood patch pleurodesis; yo = years old; FS = female spayed; DSH = domestic shorthair; DH = diaphragmatic hernia; TXR = thoracic radiographs; DLH = domestic longhair; FI = female intact

(respiratory rate 50–76 breaths/min) and hypercapnea ($PvCO_2$ 58–61 mmHg) persisted. Thoracic radiographs at this time demonstrated minimal pneumothorax, multifocal pleural fissure lines, focal alveolar pulmonary pattern in the accessory lobe, and a diffuse mild-to-moderate bronchial pulmonary pattern. The thoracostomy tube remained non-productive, despite the tachypnea, and clinical signs persisted over the next 36 h of hospitalization. During this time oxygen supplementation was discontinued and the respiratory acidosis normalized ($PvCO_2$ 47 mmHg). Thoracic radiographs performed on day 3 post-BPP, prior to thoracostomy tube removal, were noted to have a progressive multifocal alveolar lung pattern within both the right cranial and accessory lung lobes. The right cranial lung lobe was reduced in size with a mediastinal shift to the right suggestive of atelectasis. Pleural fissure lines and diffuse bronchial pattern were unchanged.

The cat was discharged on day 4 post-BPP, with persistent tachypnea (respiratory rate 48 breaths/min). At recheck examination on day 5 following BPP, the cat remained mildly tachypneic and radiographically unchanged. One week after discharge the cat was bright and alert, and eating well but had a persistent mild tachypnea reported. Long term, the cat was reported to recover without further complications and was euthanized 4.5 years following discharge owing to illness unrelated to surgery or the BPP procedure.

Cat 3

Cat 3, a 6-year-old spayed female domestic shorthair, was radiographically diagnosed with DH at 1 year of age and was reported to have had lifelong mild tachypnea. An episode of dyspnea after general anesthesia, followed by transient aggravation of clinical signs, prompted referral for DH repair. On presentation, the cat was cardiovascularly stable despite tachypnea (50 breaths/min). Primary diaphragmatic herniorrhaphy was performed without event (see Table 1). The thoracic cavity was evacuated via transdiaphragmatic thoracocentesis.

Postoperative thoracic radiographs identified a moderate-to-marked pneumothorax. This was suspected to have developed secondary to digital disruption of a pulmonary–hepatic adhesion. A single thoracostomy tube (14 G; MILA International) was placed prior to recovery from general anesthesia. Immediate persistent air accumulation caused tachypnea and thus necessitated continuous suction. Transient pyrexia was noted 8 h postoperatively (39.5–39.7°C) at which time cefoxitin was initiated. Overnight, the cat remained tachypneic despite continuous suction (respiratory rate 32–60 breaths/min). The following day, repeat thoracic radiographs demonstrated a mild pneumothorax and a mild pneumomediastinum at the time of active continuous suction. The cat had BPP performed 24 h postoperatively owing to the requirement for continuous suction along with clinical signs of restlessness and tachypnea that persisted despite air removal.

Supplemental oxygen was required for 7 h following BPP and aspiration of the thoracostomy tube was required 2 h following BPP, at which time 64 ml of air was retrieved. No further air was retrieved from the thoracostomy tube 8 h post-BPP. Thoracic radiographs performed on day 1 post-BPP revealed a minimal amount of air in the pleural space (significantly improved from previously) and mild pleural effusion. The cat's respiratory rate was improved but remained elevated at 36–44 breaths/min until the time of discharge on day 2 post-BPP.

Cat 3 was reported to recover with no further respiratory signs and robust weight gain following DH repair. The cat continued to have no respiratory concerns at the time of writing (7 years post-BPP).

BPP procedure

Owner consent for recipient and donor cats was obtained prior to performing the procedure. Blood for pleurodesis was collected from blood type-matched, heavily sedated feline donors from the Ontario Veterinary College blood donor program. Jugular venipuncture was performed aseptically to collect ~5–10 ml/kg (based on recipient body weight) of blood using a 19 G butterfly needle. Syringe sizes were selected based on the collection volume required while considering a rapid enough blood draw to avoid clotting of the non-anticoagulated samples (eg, aliquoted into 6–12 ml syringes). The blood was immediately delivered to the recipient. Donor cats were monitored throughout and following the collection.

All recipient cats received intrapleural instillation of allogenic blood. All recipient cats were receiving opioids for postoperative pain management at the time of BPP. Additional sedation may be required based on patient temperament (see Table 2 for detailed management of each patient). The in situ thoracostomy tube was used for blood administration in all cats. The tubes were clamped and disconnected from continuous suction. Connections were scrubbed with chlorhexidine soap and alcohol and sterile injection ports were replaced. The thorax was evacuated prior to BPP. Using aseptic technique, the collected allogenic venous blood was immediately injected through the thoracostomy tube into the pleural cavity. Blood was injected quickly to prevent clotting prior to its instillation, and the chest tube flushed with a small volume of saline. The patient's demeanor, heart rate and respiratory rate were monitored. All cats tolerated the instillation of fresh whole blood without event. Cats remained in the intensive care unit under direct supervision following allogenic BPP, with respiratory rate monitored hourly. Vital parameters and oxygen saturation were reassessed at 6 h and every 12 h thereafter. Pleural evacuation following BPP should be withheld as long as possible to prevent removal of instilled blood. All cats required manual aspiration of the thoracostomy tube within 1–2 h of BPP owing to clinical signs of increased respiratory rate or effort.

Table 2 Blood patch pleurodesis (BPP) procedure

Cat number	Sedation (yes/no)	Pre-procedure air production (12 h leading up to BPP)	ml/kg blood injected (total blood volume [ml])	Time to first manual air evacuation (h)	Post-procedure air production (12 h)	Time to resolution*	Time to thoracostomy tube removal (hours following BPP)	Number of BPP treatments	Complications	Time to discharge (hours following BPP)
1	No – receiving buprenorphine in the postoperative period	260 ml plus continuous suction persistently bubbling worse during cat activity	7.3 (24)	1 h	105 ml (in 24 h, 0 in 12 h; ie, 100 came out at 16 h post-BPP)	24 h	50	1	Dyspnea requiring thoracocentesis 1 h following BPP. Subsequent intermittent mild dyspnea for 15 h until air evacuation (respiratory rate 24–32 breaths/min)	60
2	Yes – midazolam 0.4 mg/kg (+ previously scheduled buprenorphine)	1.7 L – in addition to continuous suction	6.9 (24)	1 h	155 ml with decreasing volumes noted at each 4 h period	18 h	54	1	Tachypnea/ desaturation See text	99
3	No – receiving fentanyl and ketamine infusions in the postoperative period	48 ml in addition to intermittent bubbles on continuous suction and clinical signs of respiratory distress	7.0 (18)	2 h	64 ml	4 h	20	1	Persistent tachypnea (36–44 breaths/min)	50

*Time to resolution was based on no further air retrieval on manual thoracostomy tube aspiration, which was confirmed radiographically.

Cats in this series each received only one BPP treatment. Resolution of pneumothorax was noted in all three cats within 24 h of BPP as evidenced by lack of air retrieval via the thoracostomy tube (see Table 2), as well as radiographic documentation of resolved pneumothorax.

Discussion

Fresh allogenic blood for feline BPP was tolerated and resolution of pneumothorax was noted in the three cases reported herein. This is the first report of BPP in cats. Sealing of the air leak by BPP is believed to work by a mechanical action of coagulated blood adhering to the affected site and providing an immediate mechanical 'blood patch effect'. This is followed by subsequent inflammation and fibrinous pleuritis promoting formation of adhesions, whereas actual pleurodesis occurs in a later phase.[8,25]

In this case series, all cats developed continuous pneumothorax following diaphragmatic herniorrhaphy. Continuous pneumothorax following diaphragmatic herniorrhaphy may be attributed to pulmonary trauma from the inciting cause of DH, intraoperatively from breakdown of pulmonary adhesions, iatrogenically from blind chest tube placement or transdiaphragmatic thoracocentesis, or associated with re-expansion injury.[26]

Two cats within this case series required intermittent thoracostomy tube aspiration despite continuous suction. This may occur owing to lack of sufficient suction from the suction unit, or intermittent occlusion of the chest tube or collection tubing. Suction units were set up according to the manufacturer's instructions, and suction pressure was increased until distinct bubbling was noted within the water chamber compartment of the suction unit. Suction of approximately 10–15 cmH_2O was needed to successfully evacuate air from the thorax via the 14G thoracostomy tubes used in this case series. The suction units were regularly assessed and bubbling noted in all cats. The requirement for manual aspiration was based on clinical signs of increased respiratory rate or effort and were likely attributed to rapid air accumulation beyond that evacuated by the closed suction units. Cat 2 continued to have moderate-to-severe pneumothorax prior to BPP in the face of continuous suction.

BPP has been described in humans[6–10,18,19,24] and dogs,[12,13] with some investigative research in rats and rabbits.[22,25] Human indications for BPP include continuous pneumothorax secondary to lung resection and in primary and secondary spontaneous pneumothorax.[6–8,10,11,14,15,17,19] Continuous pneumothorax is defined in human medicine as extending beyond 5–7 days.[17,18,27] A cut-off point of 5 days has been widely advocated in the past but is identified as arbitrary.[27] In veterinary medicine, BPP has been reported for traumatic, primary and secondary spontaneous pneumothorax in eight dogs whose continuous pneumothorax did not respond to two or more days of conservative management.[13]

The time to initiate BPP remains undetermined. Surgical intervention for continuous pneumothorax has been recommended in veterinary medicine when pneumothorax persists for more than 3–5 days.[28,29] In human medicine, ongoing medical management of pneumothorax may be considered based on volume, duration and trend of air accumulation.[17] A large leak with lack of improvement over several days justifies intervention. Recently, early BPP trials at 48 and 72 h for treatment of pneumothorax have been reported in human medicine.[19,30] Financial considerations may also dictate attempts at BPP in human and veterinary medicine.[19] BPP was elected in the cats reported herein based on severe, continuous pneumothorax necessitating continuous suction. Cats, unlike dogs, develop spontaneous pneumothorax from secondary etiologies. Medical management is often appropriate,[1,2] with a reported favorable outcome and discharge from hospital, particularly for pneumothorax secondary to asthma.[2] Surgical intervention has previously been sought when clinically appropriate;[1,2] however, cats rarely develop continuous pneumothorax, and as such early BPP may not be indicated. In one case series, 10% of cats and dogs developed a postoperative pneumothorax following chronic DH repair; only 1/16 cats developed this complication.[31] Pneumothorax resolved in all cases within 2–5 days with the use of intermittent or continuous suction.[31] In our case series, cat 3 had BPP performed 24 h after institution of continuous suction. It is uncertain whether the pneumothorax would have resolved without BPP; however, resolution of the pneumothorax occurred 4 h post-BPP with no complications. Despite previous recommendations for longer times to definitive intervention, early intervention with BPP may allow earlier resolution of pneumothorax and earlier discharge from hospital.

In dogs, 10% body weight (~5–10 ml/kg) of autologous whole blood has been recommended for BPP.[12,13] Similar volumes were elected in this feline case series (6.9–7.3 ml/kg). Autologous whole blood was not collected in these cats as heavy sedation/anesthesia and blood collection of 10% blood volume was not considered to be safe in these compromised cats based on pre-BPP anemia (2/3 cats) and respiratory compromise (3/3 cats). For these reasons allogenic blood from donor cats was used. This has not previously been reported; therefore, the possibility of immunologic blood transfusion reactions must be considered when electing for allogenic blood use for BPP.

The appropriate volume of intrapleural blood instillation for successful BPP has been explored in human medicine. Interestingly, in adult human medicine autologous BPP recommendations include the use of 50–100 ml total (roughly $\leqslant$1 ml/kg).[17,18,30] Studies have reported that higher blood volumes (100 ml or 1–2 ml/kg) had more rapid resolution of continuous pneumothorax than lower blood volumes (50 ml).[11,16] In children, the volume of fresh whole blood for BBP has been reported and ranged from 1 to 2.5 ml/kg.[14] Although the cats in this study fared well,

perhaps smaller volumes of 2 ml/kg of whole blood would provide similar outcomes and allow autologous blood use in small or unstable patients mitigating the exposure to donor foreign antigens. Repeat allogenic BPP should also prompt concerns for immunologic transfusion reaction. Blood typing ± cross match assessment for compatibility are indicated prior to allogenic BPP.

No negative cardiovascular or respiratory signs were noted at the time of allogenic BPP administration in the cats in this report. BPP is well tolerated and no reports of pain or respiratory difficulty are reported in the human literature. Complications associated with autologous BPP in both human and canine patients include transient fever[7,8,13] and rare reports of infection, empyema and pleural effusion.[6,8,9,13,17,24,30] One human report noted tension pneumothorax secondary to an occluding clot in the thoracostomy tube, emphasizing the need to flush the chest tube once BPP is completed.[32] The canine case series also reported a BPP recipient with hemorrhage into the endotracheal tube encountered during instillation of the autologous blood using a 19 G butterfly needle.[13]

In the present case series, antibiotic administration varied for all three cats and was based on each cat's underlying condition. Pyrexia and identifiable infection were not encountered with allogenic BPP administration. However, respiratory signs secondary to re-accumulation of intrathoracic air was encountered in all three cats within 1–2 h of the procedure. Pleural evacuation following BPP should be withheld as long as possible; a minimum of 4 h was recommended in a case series of canine BPP.[13] Clinically, this may not be possible. In human BPP reports, the application of passive air release set-ups, which use no externally applied suction, are advised.[7,8,10,11,19] In veterinary patients, the application of passive air release set-ups could be considered. Cats 1 and 3 had resolution of their respiratory signs following aspiration of the thoracostomy tube; however, delayed respiratory complications were noted in cat 2, despite the resolution of pneumothorax.

Twenty-four hours after BPP, tachypnea, transient hypercapnia and a need for oxygen supplementation developed in cat 2. The definitive cause for these clinical signs was not determined and may be related to complications associated with re-expansion of pulmonary parenchyma in a patient with chronic DH or may represent a reaction to donor foreign antigens secondary to allogenic BPP. The progressive radiographic changes in this cat included pleural fissure lines, diffuse bronchial pulmonary pattern following pulmonary re-expansion and focal, and subsequently multi-focal, areas of alveolar pulmonary pattern, the latter as the cat was clinically improving. Differential diagnosis for the respiratory signs and pulmonary changes included re-expansion pulmonary edema/hemorrhage, progressive atelectasis, inflammatory pulmonary reaction, pleural clots associated with pleurodesis, and – less likely – pneumonia or pulmonary fibrosis. This cat had a chronic DH, and repair may be associated with postoperative complications, including re-expansion pulmonary edema.[26] Complete re-expansion of atelectatic lungs may have been delayed in this cat until resolution of the pneumothorax. Re-expansion can induce mechanical injury to alveolar capillary membranes and reperfusion injury of collapsed vascular beds with the potential for intrapulmonary hemorrhage and pulmonary edema several hours following re-expansion.[26] Subsequently, mismatched ventilation and perfusion result in the clinical signs of hypoxia and hypercapnia, which were noted in this cat. It is important to recognize that clinical signs may precede radiographic changes.[26] Therefore, chronically atelectatic lungs should be re-inflated by gradual re-expansion to avoid such complications. The 4-day hospitalization required following allogenic BPP and the complications encountered may not have reduced hospitalization time for this cat; however, the reduced cost associated with BPP vs surgical treatment saved this cat from euthanasia.

Conclusions

Therapeutic options for continuous pneumothorax include conservative management with a thoracostomy tube, exploratory thoracotomy and/or pleurodesis. Unfortunately, a continuous pneumothorax in a patient is associated with increased morbidity and duration of hospitalization, and prolonged medical intervention, which are taxing on both the patient and owner and have financial implications. The opportunity to avoid surgical intervention is inviting. Given the findings of this case series, and the previous literature in both dogs and humans, BPP has the potential to resolve air leaks in cats. In veterinary medicine, the amount of blood to instill, the technique of blood delivery, the post-pleurodesis care, the need for repeat treatments, as well as indications, remain to be explored. Keeping this in mind, BPP should be considered for treatment of continuous pneumothorax. Allogenic BPP can be considered in small, unstable patients and was successful in three cats in this case series.

Conflict of interest The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Ethical approval This work involved the use of non-experimental animals only (including owned or unowned animals and data from prospective or retrospective studies). Established internationally recognised high standards ('best practice') of individual veterinary clinical patient care were followed. Ethical approval from a committee was therefore not necessarily required.

Informed consent Informed consent (either verbal or written) was obtained from the owner or legal custodian of all animal(s) described in this work (either experimental or non-experimental animals) for the procedure(s) undertaken (either prospective or retrospective studies). For any animals or humans individually identifiable within this publication, informed consent (either verbal or written) for their use in the publication was obtained from the people involved.

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