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Review Article

Conservative Management of Hemothorax Following Thoracic Surgery in 3 Horses

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Abstract

Case description: Hemothorax is rare in horses, most commonly arising from thoracic trauma. Hemothorax has also been reported to be a complication of intrathoracic surgery. This report documents the management of 3 episodes of hemothorax that occurred following thoracic surgery.

Clinical findings: Two horses developed hemothorax following thoracic surgery. Hemothorax occurred twice in one horse with equine pasture asthma (aka summer pasture-associated recurrent airway obstruction, SPARAO) following two identical surgical procedures performed 8 months apart. The second horse, a clinically normal control, also underwent two surgical procedures, and developed hemothorax following the second surgery. Tachypnea was the initial clinical sign of pleural effusion in both horses and was identified within 8 hours of surgery. Bilateral pleural effusion indicative of hemorrhage was confirmed using thoracic ultrasound in all three instances.

Treatment and outcome: All horses were supplemented with oxygen using nasal insufflation. Antimicrobial therapy was initiated and maintained for 14-16 days. Attempts to drain or remove the hemorrhage were not performed. Hemothorax resolved within 14-16 days in all instances and horses were returned to pasture turnout by day 16 without incident. Three to 11 months following ultrasonographic resolution of the effusion, no evidence of complication was identified in either horse.

Clinical relevance: Hemothorax is a complication of thoracic surgery in horses which may be effectively managed conservatively. Clinical improvement occurred rapidly with resolution of effusion and return to normal function within 14-16 days of the inciting event in horses described in this report.

INTRODUCTION

Thoracoscopic surgery in the horse, though limited in its current uses, has improved pulmonary tissue sampling techniques1, 2. Thoracoscopy allows for increased visualization of thoracic cavity aiding in clinical cases by facilitating diagnosis of neoplasia, treatment of thoracic trauma, and evaluation of pulmonary tissue 3-6. Several studies have demonstrated how thoracoscopic surgery can increase pulmonary tissue sample size with reduced risk of fatal hemorrhage that results from percutaneous lung biopsy techniques 2. Hemothorax is reported as a complication to thoracoscopic surgery. The following case report documents iatrogenic hemothorax in 3 cases following wedge resection lung biopsy and their successful outcomes with conservative management.

CASE PRESENTATION

History & clinical findings case 1

Right thoracoscopic surgery was performed on a 15-year-old, 476 kg Tennessee walking horse gelding to obtain a lung biopsy. The horse had been diagnosed with equine pasture asthma (aka summer pasture-associated recurrent airway obstruction, SPARAO) three years previously and was being biopsied for a research project during seasonal disease exacerbation. All procedures were approved by the Animal Care and Use Committee of Mississippi State University (Protocol# 14-106). Commensurate with the research project, at the time of the surgery the horse had just entered seasonal disease exacerbation with a clinical score of respiratory effort (CSRE) of 5 on an 8 point scale [1]. Congruent with airway obstruction and bronchoconstriction that characterize equine pasture asthma, the maximal change in pleural pressure (ΔPpl_{max}), and resistance of the lung (R_L) were assessed to be increased using conventional pulmonary mechanics (esophageal balloon), ΔPpl_{max}=31.70 +/- 3.23 (Normal = <10cm H20)[1,2] and R_L= 3.09+/- 0.37 (Normal = 0.49+/-0.30 cmH_2O/L per sec) [2].The horse was sedated with 0.004 mg//kg butorphanol, 0.004 mg/kg detomidine followed by administration of a detomidine constant rate infusion (20 µg/kg/hour) via an intravenous catheter in the left jugular vein. Lactated ringers solution supplemented with 20 Meq/L KCl and 2.76 G/L of calcium gluconate was administered throughout the surgical procedure (4 ml/kg/hour). Caudal margins of the lung and diaphragm were identified using ultrasound. Following surgical preparation of the right hemithorax, three surgical

portals were anesthetized with 2% carbocaine at the 13th and 14th intercostal spaces. A teat cannula was then inserted into the thoracic cavity through a 1.5 cm incision in the dorsal portal site at the 13 intercostal spaces, and the lung was allowed to collapse. Following pulmonary collapse, the camera portal was placed 5 cm distal to the first portal in the 13th intercostal space, 10 cm distal to the dorsal spinous process. The remaining instrument portal was placed in the 14th intercostal space adjacent to the camera portal. Both instrument portals utilized a disposable 12 mm cannula[a]. Placement of the cannulas was difficult and the intercostal space was subjectively narrow relative to 12 other horses that were biopsied with the identical surgical procedure. The lung biopsy was attained by visualizing the caudal lung margin, grasping it with Semm claw forceps[b] (10 mm diameter with ratchet handle, length 39 cm) and deploying 4 endoscopic tissue staple cartridges (45mm-4.1mm)[c] to resect a triangular wedge of pulmonary tissue (approximately 10 cm on each side). Tension was released on the lung tissue and the resection site was observed for 2 minutes. During this time, hemorrhage was not evident. The incisions were closed with 0 Vicryl in two layers and the thoracic cavity was evacuated of free-air with a teat cannula placed in the dorsal incision and connected to a wall mounted suction regulator[d] via tubing. Immediately following resection of the lung tissue the following antimicrobial and anti-inflammatory medications were initiated: gentamicin (6.6 mg/kg IV Q24H), cefazolin (20 mg/kg IV Q8H), and flunixin meglumine (1.1 mg/kg IV Q12H). Immediately following closure of the thorax the horse's physical examination parameters were within normal limits with pink, moist mucous membranes, CRT <2 seconds, pulse rate of 44 beats/minute, and respiratory rate of 12 breaths/minute. Lactated ringers supplemented with 20 Meq/L KCl and 2.76 G/L of calcium gluconate was continued for 10 hours following the surgical procedure (4 ml/kg/hour) and the horse was monitored hourly for 24 hours following surgery with particular attention to changes in respiratory rate and mentation.

Eight hours following surgery, the gelding's respiratory rate increased to 28 breaths/ minute. He was afebrile (T=101.0 F), tachypnic (28-40 breaths/minute), with a normal heart rate (36 beats/minute) and pink moist mucous membranes. Lung sounds were absent ventrally in both hemithoraces. Ultrasound examination revealed hypoechoic fluid bilaterally to a point 5 cm dorsal to the point of the shoulder. The fluid was characterized by the presence of multiple echos consistent with red blood cells (Figure 1). Atelectasis of the ventral portions of the lungs was also noted. A diagnosis of iatrogenic hemorrhage due to laceration of an intercostal vessel during the lung biopsy procedure was considered most likely because of the subjectively small intercostal space of the patient. Bleeding from a pulmonary vessel could not be ruled out, but was considered less likely because the biopsy site was thoroughly inspected intra-operatively and had no evidence of bleeding. Nasal oxygen insufflation was initiated at 10L/min.

Twenty-four hours after surgery the hematocrit and plasma total protein concentration had decreased from preoperative values of 34% and 8.1 g/dL to 28% and 6.3 g/dL, respectively. The gelding appeared mildly depressed and uncomfortable, demonstrating mild colic signs including restlessness and pawing. Physical examination findings revealed a normal body temperature (101.3 F), tachycardia (72 beats/minutes), and persistent tachypnea (28-44 breaths/minute). Thoracic ultrasound was unchanged. In the absence of gastric reflux, 2 liters of mineral oil and 3 liters of water were administered via nasogastric tube. Intravenous fluids supplemented with KCl and calcium gluconate as described were re-initiated (2 ml/kg/hour). Forty-eight hours following surgery the gelding's respiratory rate was only mildly elevated (24 breaths/ minute). Oxygen insufflation was discontinued. Day 3 post-operatively the gelding was bright and alert, with a good appetite. The hematocrit and plasma total protein concentration had fallen to 23% and 6.0 g/dL, respectively. Fluid therapy was discontinued

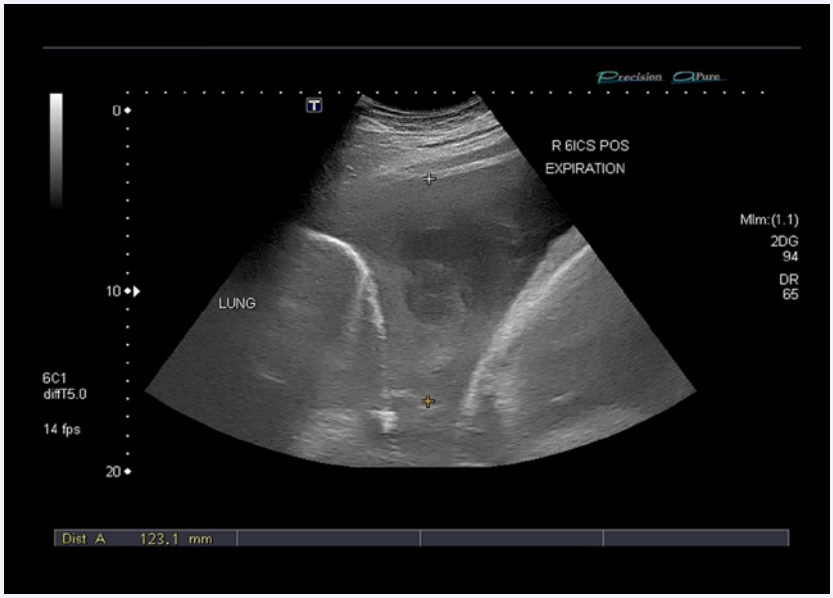

Figure 1 Ultrasound image demonstrating hypoechoic fluid to a point 5 cm dorsal to the point of the shoulder. The fluid was characterized by the presence of multiple echoes consistent with red blood cells.

and antimicrobial therapy and flunixin meglumine were continued as previously described. Nine days following surgery the gelding's antimicrobial therapy was changed to trimethoprim sulfamethoxazole 30mg/kg orally every 12 hours. By day 14 thoracic ultrasound demonstrated resolution of the hemothorax. Antibiotic therapy was discontinued, skin sutures were removed, and the gelding was allowed to turnout in a small paddock.

Left thoracoscopic surgery was repeated eight months later on the same 15 year old Tennessee walking horse gelding during clinical remission of pasture asthma. Due to the development of hemothorax following the previous thoracic surgery, the surgical plan for this gelding was to use smaller cannulas and move the portals into the wider more caudal intercostal spaces. The camera and the first instrument portal were moved to the 14th intercostal space, and 10 mm cannulas[e] were utilized in these spaces. The second instrument portal was positioned in the 15th intercostal space to accommodate the larger 12 mm portal required for the stapling device. Intravenous fluids, antibiotics, and non-steroidal anti-inflammatory therapy were administered as previously described. A smaller lung biopsy was obtained using only 3 staple deployments. The biopsy site and staple line were observed closely for 4 minutes following tissue resection for hemorrhage. The lung biopsy was retracted into the 12 mm cannula and removed from the thorax. All portals were closed with 0 vicryl in a single cruciate suture and the thoracic cavity evacuated as before.

Eight hours following surgery, the gelding again developed tachypnea (56 breaths/ minute). Heart rate (36 beats/minute), mucous membrane color, capillary refill time (<2 sec) and hydration were all assessed as normal. Lung sounds were absent ventrally. Thoracic ultrasound examination demonstrated hypoechoic fluid consistent with red blood cells in both hemithoraces to a level 5 cm above the point of the shoulder.

Ten liters of Lactated Ringer's containing 20 Meq/L KCl and 2.76 G/L of calcium gluconate solution was administered IV at 4 ml/kg/hour. Nasal oxygen insufflation was provided (10L/min) and 32 capsules (8 grams; 2-16 count boxes) of Yunnan Baiyo were administered. Twenty-four hours after surgery the hematocrit had decreased from pre-operative levels of 37% and plasma total protein of 7.4 g/dL to 32% and 5.5 g/dL, respectively. Colic signs identified following the prior surgery were not observed but the gelding was mildly depressed. Reluctance to ambulate and eat from the ground was considered evidence of pleurodynia. A lidocaine CRI (bolus 1.3 mg/kg administered over 10 minutes: followed by 50 ug/kg/min) with 0.5L/hour lactated Ringer's was administered IV to address the pain. The respiratory rate decreased to 20 breaths/ minute within 60 minutes of starting lidocaine administration. Forty-eight hours following surgery the gelding's respiratory rate was consistently within 24-28 breaths per minute and lidocaine therapy was discontinued. Three days following surgery nasal oxygen was reduced to 5 liters/hour for 12 hours and then discontinued without a change in respiratory rate or effort. Antimicrobial therapy was changed to oral trimethoprim sulfamethoxazole (30 mg/kg Q12H). Thoracic ultrasound examination on day 10 demonstrated reduced intrathoracic fluid bilaterally to 2 cm below the point of the shoulder. Flunixin meglumine therapy was discontinued. Sixteen days following surgery skin sutures were removed and thoracic ultrasound examination confirmed bilateral resolution of hemothorax. Antimicrobial therapy was discontinued and the horse was released to pasture turnout.

History & clinical findings case 2

A clinically normal 15 year old, 530 kg Quarter Horse mare acting as a control horse on the aforementioned research protocol underwent a right lung biopsy via thoracoscopy performed similarly to case 1. The camera and first instrument portal were placed in the 13th intercostal space with 10 mm cannulas, with the second larger 12mm instrument portal placed in the 14th intercostal space. The lung biopsy was obtained using 3 staple deployments, but upon retraction of the biopsy into the cannula, the biopsy was dislodged from the Babcock forceps and dropped within the thoracic cavity. The first instrument portal was elongated to a small (6 cm) thoracotomy and the biopsy was retrieved. The biopsy site and staple line were observed closely for 4 minutes following tissue resection for hemorrhage. The thorax was closed in two layers and thoracic cavity evacuated as in case 1. Intravenous fluids, antibiotics, and non-steroidal anti-inflammatory therapy were administered as described for the previous case.

Eight hours following surgery the mare became depressed, febrile (T=103.1°F) and tachypnic (44 breaths/ minute). Her heart rate was elevated (48 beats/ minute), mucous membranes were injected, and the CRT was prolonged (3 seconds). Digital pulses were increased and gastrointestinal borborgmi were reduced. Thoracic ultrasound examination demonstrated bilateral hypoechoic pleural effusion with echoes consistent with red blood cells. The fluid extended to the level of the point of the shoulder in both hemithoraces, with atelectasis of ventral lung fields. Due to the clinical evidence of endotoxemia and the concerns of impending colitis, a fecal gram stain was performed. The gram stain revealed a predominance of large gram positive rods, some with eccentric spores, supporting a presumptive diagnosis of Clostridial enterocolitis.

The treatment plan was modified to include metronidazole 25 mg/kg orally every 6 hours, continuation of intravenous lactated Ringer's solution supplemented with 20 Meq/L KCl and 2.76 G/L of calcium gluconate (4 ml/kg/hour), and oxygen by nasal insufflation (10L/min). To address signs consistent with sepsis, two treatments of polymyxin B (5,000 IU/kg in 1 Liter NaCl IV) were administered intravenously at 8 hour intervals and all four distal limbs were placed in ice boots consisting of rectal sleeves packed with ice and tied around the distal limb.

Twenty-four hours following surgery the hematocrit had decreased from 39% to 34% and the total protein changed from 6.6 g/dL to 6.2 g/dL. CBC demonstrated a leukocytosis (12,300/ul) with a mature neutrophilia 10,000/ul and hyperfibrinogenemia (700 g/dl). By 48 hours post-operatively, the mare was a febrile with a normal respiratory rate (24 breaths/ min) and normal heart rate (36-40 beats/min). Digital pulses were within normal limits. Intravenous fluids and nasal oxygen supplementation were discontinued on the third post-operative day. On day 4 following surgery, the mare became depressed, inappetant, had decreased manure production and was mildly febrile (T=101.8°F). Rectal examination revealed a soft pelvic flexure impaction. The mare was leukopenic (WBC=4,600/ul) and the hematocrit and plasma total protein concentration had decreased to 26% and 5.8 g/dL, respectively. Balanced polyionic fluid boluses (6L) were

administered via nasogastric tube every 2 hours for a 24 hour period. Treatment with metronidazole was discontinued. The following antimicrobial and anti-inflammatory medications were maintained until 7 days post-operatively: gentamicin (6.6 mg/kg IV Q24H), cefazolin (20 mg/kg IV Q8H), and flunixin meglumine (1.1 mg/kg IV Q12H). On day 7, ultrasound demonstrated retraction of the pleural fluid line to the level of the point of the elbow. Treatment at this time was limited to gentamicin (6.6 mg/kg IV Q24H) and flunixin meglumine (1.1mg/kg Q24H). On Day 10, antimicrobial therapy was changed to trimethoprim sulfamethoxazole (30 mg/kg PO Q12H). On Day 14, skin staples were removed and thoracic ultrasound demonstrated minimal pleural fluid. The mare was discharged from the hospital into pasture turnout.

DISCUSSION

Hemothorax is a rare condition in horses that most commonly arises from thoracic trauma [3,4]. Hemothorax has also been reported in association with pneumonia, neoplastic disease, complications from phenylephrine administration, and a complication to intrathoracic surgery and lung biopsy techniques [3-7]. Hemothorax results in two potential emergency conditions. The first is hypovolemic shock due to blood loss. The second is impaired ventilation as a result of pulmonary compression.

Normally, a small volume of serous pleural fluid envelopes the lung. This fluid decreases friction and provides a cohesive force between the chest wall and lung parenchyma that contributes to the mechanical coupling of lung parenchyma to chest wall excusions [3,4]. In human patients, pleural fluid produces a relative expansion of the chest wall as well as compression of the lung with a net restrictive ventilatory defect that reduces vital capacity, functional residual capacity, and total lung capacity [9]. Horses are very susceptible to the accumulation of fluid within the thorax with a subsequent reduction in total lung capacity. Hemothorax is frequently bilateral because of an incomplete mediastinum in most horses [8].

Clinical signs of pleural effusion include tachypnea, dyspnea, increased abdominal effort, and cyanosis in severe cases. Thoracic auscultation reveals absence of normal lung sounds ventrally [10]. Blood or fluid within the pleural cavity attenuates lung sounds ventrally but causes cardiac sounds to radiate over a wider range [10]. Thoracic percussion reveals attenuation of the normally resonant sound of aerated lungs [10]. Horses with hemothorax may demonstrate pain in response to thoracic percussion. In this report, tachypnea with loss of lung sounds ventrally were the first abnormal clinical findings in all patients. These clinical signs developed 8 hours post operatively in all cases. Mild signs of colic and depression did not become apparent until 24 hours following surgery. Clinical signs of hypovolemic shock were not apparent.

Wilkins et al, demonstrated that nasal insufflation of oxygen (15 L/min) is indicated when hypoxemia is characterized by PaO_2<80 mm Hg, percent oxygen saturation [$\%O_2$sat] <90%, or if dyspnea is present [11].Clinical indicators of insufficient oxygen-carrying capacity are tachycardia, tachypnea, lethargy, and altered mucous membrane color (pale to greyish or white). In the context of acute loss of oxygen carrying capacity, indicators of insufficient tissue oxygenation include venous partial pressure of oxygen <30 mm Hg, venous hemoglobin saturation <50%, and oxygen extraction ratio >40% [10,11]. In the cases presented here, horses with signs of hypoxemia demonstrated overt improvement in response to nasal oxygen insufflation which was initiated rapidly at the first signs of tachypnea. In all cases oxygen insufflation was maintained for 3-4 days at a rate of 10 L/minute. The flow rate of 10L/minute was due to limitation of the available oxygen delivery system that had a maximal rate achievable of 10L/minute. Although the flow rate was lower than the recommended rate of 15L/minute, both horses responded rapidly to oxygen insufflation.

Ultrasonography was essential in diagnosing and monitoring the progression of hemothorax in all cases. In these cases, hemothorax was identified as either a homogenously echogenic effusion with diffuse echoes of uniform grey appearance indicative of cellularity, or by the presence of swirling echoes in fluid of mixed echogenicity. Settling of the cellular components into the dependent parts of the pleural space, termed 'the hematocrit sign' was also noted [12] (Figure 1). Fluid is easily measured in reference to body landmarks to monitor changes over time. Atelectasis of the lung may be noted ultrasonographically [13,14] and was identified in both cases in this series. Pleural effusions cause a loss of the diaphragmatic and cardiac silhouettes and appearance of a horizontal fluid line in thoracic radiographs [15]. These findings are considered to be of minimal benefit with ultrasound providing far superior diagnostic information without the risks of high exposures necessary to image the equine thorax. With the removal of pleural fluid however, thoracic radiographs have diagnostic utility to identify pulmonary pathology. In these 3 instances, the risk factor of thoracic surgery combined with ultrasound imaging precluded the need for thoracic radiographs.

Iatrogenic hemorrhage from thoracic surgery is most likely to originate from pulmonary or intercostal vasculature [5-7]. Most significant bleeds have been associated with pulmonary tissue being inappropriately ligated [5,6]. Often a concurrent pneumothorax occurs in such instances due to corresponding failure to fully occlude the bronchioles as well as vessels [16]. In all 3 occurrences of hemothorax in this report, none of the horses experienced pneumothorax. Furthermore, all biopsy sites and staple lines were observed for 2-4 minutes for hemorrhage following tissue resection. Based on these findings, bleeding in these cases is presumed to reflect hemorrhage from the intercostal vessels. Additionally, hemorrhage was not identified in the ventral thorax during surgery, leading to the supposition that the intercostal vessels were compressed by the cannulas, effectively preventing hemorrhage until the cannulas were removed and the thorax was closed. Though hemorrhage was of an acute nature and with signs of respiratory compromise, these cases responded to conservative management with rest and oxygen insufflation. Blood transfusions were not necessary.

No attempts were made to evacuate the hemorrhage from the thoracic cavity. In all horses the hemothorax fluid line appeared to be at a maximal level 24 hours following surgery and resolved by day 14 following surgery. Case 1 underwent thoroscopy in the opposite hemithorax 8 months following the first procedure. Though hemothorax was bilateral in this case, no evidence of fibrin accumulation or adhesions was identified. In all cases, hemothorax was considered resolved based upon

ultrasonographic evaluation 14-16 days following surgery. Antimicrobial therapy was discontinued at this time and horses were returned to pasture with unrestricted exercise without adverse effect. Follow-up thoracic ultrasound examination of both horses 3 months after their final hemothoracic event identified no abnormalities of the pleura, superficial lung parenchyma or thoracic cavities.

In conclusion bilateral hemothorax is not an uncommon complication from thoracic surgery. Drainage is considered the standard of care in human patients with hemothorax [17]. However, the clinical course of cases in this report indicate that horses with hemothorax, whose respiratory compromise is effectively addressed with oxygen insufflation, can be successfully managed conservatively without drainage. Invasive evacuation techniques are not necessary for a positive clinical outcome and may be contraindicated because of the risk of iatrogenic infection. The potential to induce iatrogenic infection while performing diagnostic centesis or drainage was a major factor that influenced the management of these cases. Concerns regarding hematogenous bacteremia as a source of pleural infection also influenced the choice to maintain horses in this case series on antimicrobial therapy either prophylactically, or as directed by co-morbid disease, until the time of resolution of the hemothorax. The importance of prophylactic antimicrobial therapy to the case outcomes in this series cannot be determined.

FOOTNOTES

a. 12mm Ethicon disposable cannula, Ethicon Endopath, Somerville, NJ, USA.

b. 10 mm Semm claw forcep with Ratchet Handle, Length 39 cm (Ref 10BB), Ethicon Endopath, Somerville, NJ, USA.

c. ETS 45mm-4.1mm Reloads, Green. Catalog# TR45G, Ethicon Endopath, Somerville, NJ, USA.

d. Vacutron surgical continuous suction regulator, model 22-12-1106. Allied Healthcare Products, Inc., St. Louis, MO 63110 USA.

e. 10 mm Karl Storz Stainless Cannula and blunt trocar, **KARL STORZ Veterinary Endoscopy America, Inc.** Goleta CA, USA.

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CONFLICT OF INTEREST

The authors declare no conflict of interest related to this report.

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