Review Article

Equine haemothorax

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Summary

Haemothorax is an uncommon, although clinically important, condition in horses of all ages and has a wide range of aetiologies. Clinical signs can include tachypnoea, dyspnoea, tachycardia, absence of bronchovesicular sounds, haemoptysis, colic and death. The most common aetiologies are associated with trauma, neoplasia, coagulation disorders, iatrogenic causes and vessel rupture. Diagnosis is made if there is evidence of thoracic fluid on ultrasonography and confirmation of haemorrhage by thoracocentesis. The goals of treatment are to address the primary cause and provide supportive care. Prognosis depends on aetiology, severity of active bleeding and volume of blood loss.

Introduction

Haemothorax is the accumulation of blood within the thoracic cavity. In human medicine, haemothorax is initially categorised as retained (blood contained within the thorax) as compared to blood that is lost externally and is then subcategorised as spontaneous (blood accumulates within the thorax secondary to malignancies, vascular rupture, coagulation disorders or other lesions) or iatrogenic (blood accumulates secondary to medical procedures such as thoracoscopy, thoracocentesis or lung biopsy). While this categorisation has not been applied to equine cases, it can be valuable for case management. Potential sources for haemorrhage include the intervertebral or intercostal vasculature, thoracic wall, heart, pericardium or lung parenchyma.

Although haemothorax has been identified in case reports in the equine literature (Brown *et al*. 1988; Perkins *et al*. 1999; Southwood *et al*. 2000; Lugo *et al*. 2002; Schambourg *et al*. 2003; Frederick *et al*. 2010; Lyle *et al*. 2011), a comprehensive review regarding the specific disease processes or risk factors associated with haemothorax in horses has not been performed. The purpose of this article is to provide a review of findings associated with the presence of haemothorax in horses.

History and clinical signs

Historical findings in horses with haemothorax commonly relate to observed or suspected trauma to the thorax or abdomen, recent strenuous exercise, recent medical procedures or sudden death (Perkins *et al*. 1999; Schambourg *et al*. 2003; Relave *et al*. 2008; Frederick *et al*. 2010). In the case of spontaneous haemothorax, historical findings may relate to the primary underlying cause for the evaluation of the animal (e.g. weight loss in cases of neoplasia or epistaxis in the case of coagulation disorders).

Horses with haemothorax exhibit a variety of clinical signs and the nature of onset of the haemothorax directly affects the clinical presentation. Horses with acute onset of haemothorax may exhibit signs of haemorrhagic shock that develop over hours followed by collapse and death. These signs are more dramatic with great vessel rupture, as horses collapse and die rapidly, without time for veterinary intervention (Brown *et al*. 1988; Perkins *et al*. 1999; Frederick *et al*. 2010). Horses with slowly progressive accumulation of blood, as occurs with neoplasia, exhibit nonspecific clinical signs consistent with respiratory disease (Southwood *et al*. 2000). To the author's knowledge, there is no information in the literature regarding the presentation of horses with unilateral haemothorax; however, if the mediastinum is intact, a horse may present with unilateral accumulation of blood and possibly less severe clinical signs.

Typically, accumulation of blood within the pleural space restricts inflation of the lungs resulting in tachypnoea and dyspnoea. In these cases, decreased bronchovesicular sounds are evident in the cranioventral lung field on auscultation, dull sounds are produced ventrally on thoracic percussion and the heart sounds radiate. If concurrent pericardial fluid is present, the heart sounds are muffled. In most cases, mucous membrane pallor and tachycardia are identified on physical examination. Depending on the primary aetiology of the haemothorax, additional clinical signs may be apparent. Thoracic trauma may cause signs of thoracic pain exhibited as abnormal gait, splinting of the abdominal muscles or flinching in response to palpation. In horses with neoplasia, nonspecific clinical signs may be apparent. In horses diagnosed with disseminated haemangiosarcoma, clinical signs included depression (52%), tachycardia (79%), tachypnoea (62%), and pale or icteric mucous membranes (85%) with rapid progression of clinical disease (median time to euthanasia of 17 days) (Southwood *et al*. 2000). At the time of euthanasia, 20% of the horses were diagnosed with haemothorax on *post mortem* examination (Southwood *et al*. 2000). Spontaneous haemorrhage (epistaxis and haemoptysis), haemothorax, haemoabdomen and death have been identified as a risk associated with the administration of phenylephrine for the treatment of nephrosplenic entrapment (Frederick *et al*. 2010). In this study, 4 of 5 aged geldings died of haemorrhagic shock following administration of phenylephrine (Frederick *et al*. 2010).

Diagnostic evaluation

Thorough diagnostic evaluation of the thorax is warranted in any horse exhibiting signs referable to the pleural space, pulmonary system or haemorrhagic shock of unexplained cause. Diagnostic evaluation is necessary to characterise the nature and extent of the signs and develop an appropriate therapeutic regimen and prognosis.

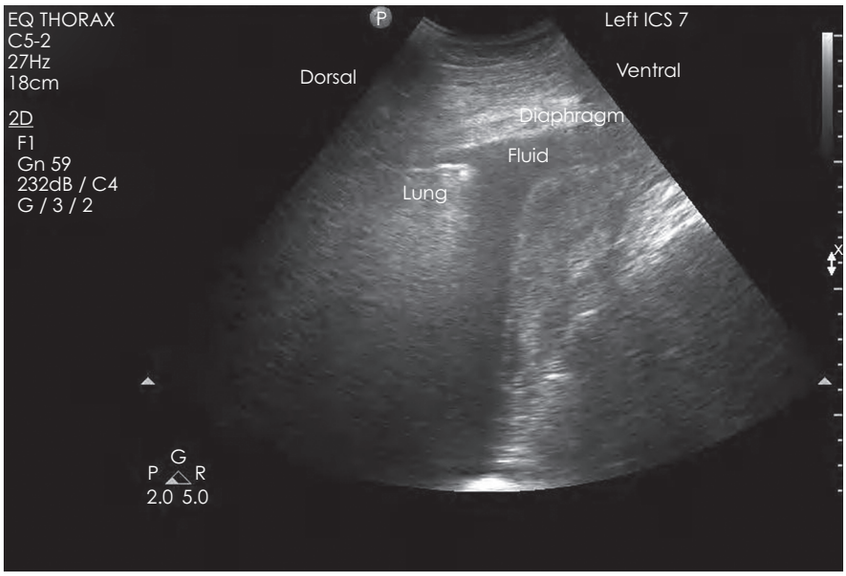

Fig 1: Thoracic ultrasonographic image at the left 7th intercostal space. Hyperechoic fluid indicating haemorrhagic fluid within the pleural space (image courtesy of Auburn University).

Ultrasonographic examination of the thoracic cavity confirms the presence of fluid within the pleural space. Nonhaemorrhagic pleural effusions in horses are typically hypoechoic with varying degrees of fibrinous or cellular debris contributing to echogenicity. Haemorrhage within body cavities (**Fig 1**) exhibits a hyperechoic swirling pattern (Reef 1998). Ultrasonography may also allow the identification of neoplastic masses or abscesses in the lung, or pleural or pericardial masses serving as a source for haemorrhage (Butler *et al*. 2000). Rib fractures are common causes of haemothorax in foals and ultrasonography is the diagnostic modality of choice (Jean *et al*. 2007) and may be beneficial in adults.

Once fluid accumulation in the thorax is identified, further characterisation is accomplished by cytological analysis of fluid collected by thoracocentesis. In human medicine, pleural fluid indicative of haemothorax is defined as having a packed cell volume (PCV) of at least 50% of the peripheral PCV (Light and Lee 2010); however, because this information dictates neither a change in the diagnostic evaluation or the therapeutic regimen when large volumes of blood are present in the thoracic cavity, controversy exists as to whether or not this distinction is clinically relevant. It also has been suggested that a PCV of >5% with a clear supernatant fluid and red sediment would indicate recent, frank haemorrhage (Latimer 2011). Additional cytological findings vary based on the acute or chronic nature of the disease process and the aetiology. Horses with haemothorax of longer duration may have classic cytological findings of erythrophagocytosis, haemosiderin accumulation and degenerative neutrophils (DeHeer *et al*. 2002; Latimer 2011). Fluid retrieved from horses with longstanding blood accumulation may also show lack of platelets and a red discolouration of the supernatant consistent with haemolysis (DeHeer *et al*. 2002). Commonly, horses with acute blood loss into the thorax will exhibit little to none of the above cytological changes.

Fluid collected via thoracocentesis should be submitted for bacterial culture and susceptibility testing, especially if the thoracic cavity is open or has been penetrated due to a traumatic wound or medical procedure. Bacterial infection would also be suspected if cytological analysis reveals the presence of severe neutrophilic inflammation or bacteria. As it is often difficult to culture bacteria from thoracic fluid, transtracheal aspiration with cytological analysis and culture may be indicated in horses in which pulmonary infection is suspected (Chaffin *et al*. 1994).

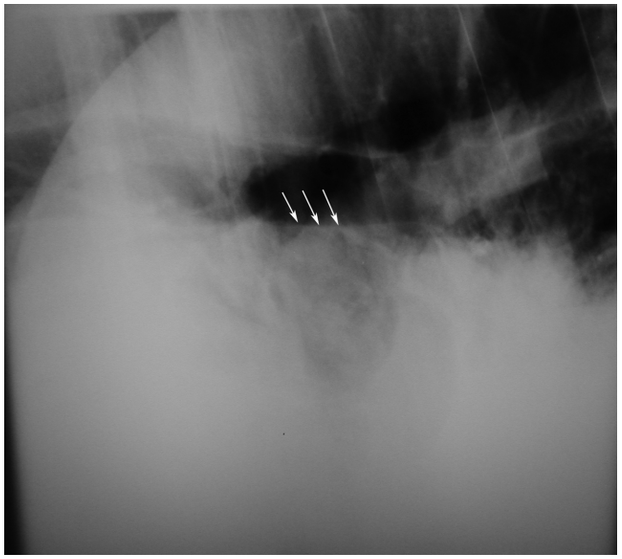

Fig 2: Thoracic radiograph. Accumulation of fluid within the pleural space obscuring the ventral thoracic structures including the ribs, sternum, cardiac silhouette, mediastinum and diaphragm. Arrows indicate the fluid line (image courtesy of Auburn University).

Thoracic radiography is useful in evaluating the lung parenchyma, axial skeleton and mediastinum for identification of possible aetiologies; however, the presence of blood within the pleural space (**Fig 2**) may prevent thorough evaluation. Radiography cannot be used to identify a location for thoracocentesis or to evaluate the volume or character of the

fluid. While it would be ideal to perform radiographs after the blood has been removed, thoracic drainage is not always the therapy of choice. Additionally, thoracic radiographs of adult horses are difficult to obtain in the field. The value of thoracic radiography in foals for identifying rib fractures is questionable as it is less sensitive than ultrasonography in detecting fractures (Jean *et al*. 2007).

Evaluation of the complete blood count (CBC) can provide information about the relative severity of the blood loss, the chronicity of blood loss and when paired with coagulation profiles can be helpful in determining if primary clotting disorders are present. Red blood cell indices often will not reflect acute blood loss, unless very severe, because all blood components are lost simultaneously; however, anaemia and hypoproteinaemia become apparent as fluid shifts within the body in response to hypovolaemia (Latimer 2011). Evidence of more chronic blood loss on a CBC includes anaemia, possible thrombocytosis, and hypoproteinaemia without clinical signs of hypovolaemia (Latimer 2011). Large volume haemorrhage could be associated with clotting abnormalities such as prolonged prothrombin time and/or activated partial thromboplastin time. Severe thrombocytopenia (<20,000 cells/μl) or platelet dysfunction could also lead to blood loss.

Data from serum chemistry profiles can be informative in horses with haemothorax associated with coagulopathy secondary to liver dysfunction or neoplasia (Southwood *et al*. 2000; Tripodi and Mannucci 2011). Additionally, serum chemistry analysis can provide valuable information about electrolyte balance, lactate concentration, anion gap and systemic reactions to the blood loss. Blood gas analysis (arterial or central venous) provides data such as partial pressure of venous oxygen (P_vO_2), arterial oxygen saturation and central venous oxygen saturation, which are all indicators of perfusion. These data, in conjunction with clinical signs, can provide valuable information to guide therapy, such as when the horse may require blood transfusion (Magdesian 2008).

Thoracoscopy is a valuable technique to examine the thorax for abnormalities and assist in collection of lung parenchyma samples for histopathological analysis. Ultrasound-guided lung biopsy is also a valuable diagnostic tool when parenchymal disease is considered a likely aetiology for intrathoracic haemorrhage; however, care must be taken when using these procedures, as they are associated with the development of haemothorax (Perkins *et al*. 1999; Lugo *et al*. 2002).

Aetiologies

Thoracic trauma

Thoracic trauma is cited as a cause for haemothorax in man and occasionally reported as a cause in horses (Hassel 2007; Radcliffe *et al*. 2009). Trauma to the great vessels or the intercostal, intervertebral, pleural or cardiac vasculature can lead to accumulation of blood within the thorax. Thoracic trauma in foals, as a result of dystocia, rib fracture, diaphragmatic rupture or blunt injury, can also result in haemothorax. In one study, haemothorax with pulmonary collapse was identified as the most frequent cause of death (53%) of foals evaluated for thoracic trauma (Schambourg *et al*. 2003). Acquired diaphragmatic rupture and subsequent herniation of abdominal contents may cause colic or (rarely) haemothorax. Penetrating chest wounds or lacerations

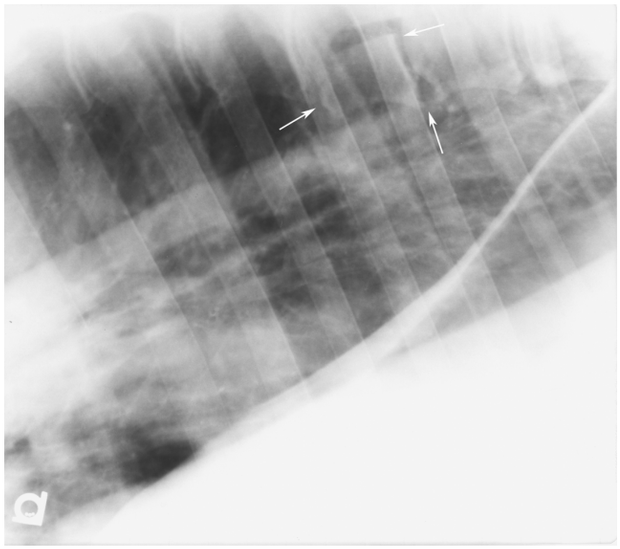

Fig 3: Thoracic radiograph. Ventrally displaced fracture (arrows) of the vertebral body of the 16th thoracic vertebra that resulted in haemothorax (image courtesy of Auburn University).

(Radcliffe *et al*. 2009), trauma to the spine (**Fig 3**) and trauma to the ribs (**Fig 4**) can also result in haemothorax. Horses with thoracic trauma and haemothorax also can have involvement of the abdomen; therefore, completely evaluating the abdomen for evidence of trauma or haemoabdomen would be appropriate (Holcombe and Laverty 1999).

Iatrogenic causes

Haemothorax as a complication of medical procedures is regularly reported in the literature. Thoracocentesis and placement of indwelling chest drains have both been associated with haemothorax possibly through laceration of intercostal or pulmonary vasculature (Chaffin *et al*. 1994). In a recent retrospective study, fatal internal haemorrhage was confirmed in 3 horses after the administration of phenylephrine for treatment of nephrosplenic entrapment of the large colon in elderly horses (Frederick *et al*. 2010). The definitive pathophysiology for development of internal haemorrhage in these cases could not be conclusively determined. Haemothorax has been identified as a complication to thoracoscopic pulmonary wedge resection for histopathological analysis of affected pulmonary tissue (Lugo *et al*. 2002). One of 10 horses in that study developed haemothorax as a complication of iatrogenic injury to the diaphragm but survived (Lugo *et al*. 2002). Thoracotomy with rib resection, often performed for treatment of pleuropneumonia, can also cause haemothorax.

Neoplasia

Pulmonary, mediastinal and thoracic wall neoplasia (primary or metastatic) have been associated with haemothorax. Of these, the most frequently identified is haemangiosarcoma and indicated a grave prognosis (Southwood *et al*. 2000). Although other types of tumours such as lymphosarcoma, bronchiolar adenocarcinoma and metastatic squamous cell carcinoma (Wilkins 2003; Cramer *et al*. 2011) have been

Fig 4: Gross necropsy image of 3 displaced rib fractures (small arrows) and subcutaneous haemorrhage (large arrows) in a neonatal foal following thoracic body wall trauma (image courtesy of Marta Barba Recreo).

identified in the thoracic cavity of horses, haemothorax is not listed among the clinical findings.

Coagulopathy

Coagulopathy has been reported as a risk factor for intracavitary haemorrhage. Coagulopathy resulting in haemothorax in horses is rarely reported; however, disseminated intravascular coagulation is a common sequela to inflammatory diseases in horses (Dallap 2004) and may result in intracavitary bleeding. Additionally, end-stage liver disease has been associated with coagulopathy in people and may result in spontaneous intracavitary haemorrhage (Tripodi and Mannucci 2011).

Ruptured vasculature

Rupture of the great vessels within the thorax is a cause of haemothorax and sudden death in horses (Brown *et al*. 1988; Lyle *et al*. 2011). Risk factors and aetiologies have not been determined in horses. Vascular rupture should be considered when a horse dies suddenly or during intense exercise. Additionally, severe exercise-induced pulmonary haemorrhage can result in both intra- and extra-pulmonary haemorrhage and death (Lyle *et al*. 2011).

Treatment

Treatment for haemothorax is directed toward managing the primary disease process, assessing the relative volume of blood in the thorax and determining if bleeding is ongoing. Initial therapeutic goals include haemostasis, restoring blood volume and improving tissue oxygenation.

TABLE 1: Pharmaceutical haemostasis

Aminocaproic acid: lysine derivative used to inhibit fibrinolysis
Dose: 100 mg/kg bwt i.v. (Heidmann *et al*. 2005)
Loading dose 3.5 mg/kg bwt/min i.v. over 15 min followed by CRI 0.25 mg/kg bwt/min over 4–6 h (Ross *et al*. 2007)
Formalin: definitive mechanism of action is unclear
Dose: 10 ml of 37% buffered formalin in 1 litre LRS over 15 min (Taylor *et al*. 2000)
Tranexamic acid: lysine derivative used to inhibit fibrinolysis
Dose: 5 g i.v. every 12 h or 10 g *per os* every 6 h (Wong *et al*. 2009)

Haemostasis

If the horse is actively bleeding, haemostasis can be achieved by active compression at the site of haemorrhage, surgical ligation of the haemorrhaging vessel or pharmaceutical intervention. While internal haemorrhage may not be amenable to compression or ligation, external wounds of the body wall or surgical wounds may. Pharmaceuticals such as aminocaproic acid (fibrinolysis inhibitor), tranexamic acid (fibrinolysis inhibitor) and formalin (enhanced endothelial or platelet activator) have shown some success for treatment of haemorrhage (Wong *et al*. 2009) due to vascular damage (**Table 1**).

Whole blood transfusion and fluid restoration

Fluid resuscitation with or without whole blood transfusion is an appropriate supportive treatment for horses with haemothorax (Wilkins 2003). For horses with uncontrolled haemorrhage, hypotensive resuscitation should be utilised (Magdesian 2008). This fluid resuscitation technique is centred on maintaining organ perfusion while decreasing the risk for worsening bleeding. In these cases, it is important to avoid use of fluids that cause rapid expansion of blood volume such as hypertonic saline or synthetic colloids or excessive fluid administration; this may worsen bleeding by increasing blood pressure, disrupting clots and diluting clotting factors and platelets (Magdesian 2008). Restoration and maintenance of blood volume should be achieved by administration of whole blood, plasma or isotonic crystalloids at a rate that maintains organ perfusion and a mean arterial pressure of approximately 60 mmHg (Magdesian 2008).

Fluid resuscitation in horses with controlled haemorrhage is centred on restoring cardiac output and blood pressure by restoring blood volume. In the case of acute haemorrhage and subsequent hypovolaemic shock, rapid expansion of blood volume with isotonic crystalloids, hypertonic saline, or colloids is appropriate. Whole blood, packed red blood cells, or plasma transfusions can be administered for correction of anaemia, thrombocytopenia or clotting factor deficiency (Magdesian 2008). Indications for administration of whole blood include clinical and laboratory findings of haemorrhagic shock that persist after adequate restoration of hydration with crystalloid fluids. These signs include persistent hypotension, mucous membrane pallor, lethargy, cool extremities and tachycardia (Magdesian 2008). The need for whole blood transfusion may be based on clinicopathological data, including a PCV of less than 12%, acute blood volume

loss of 30–40%, hyperlactataemia (>0.5 mmol/l), an oxygen extraction ratio of greater than 50% and a decreased P_vO_2 (Magdesian 2008).

Thoracic drainage

Thoracic drainage for treatment of haemothorax is recommended as the standard of care in man to improve lung excursion, tissue perfusion and cardiac output, and to decrease the risk of fibrothorax development (Meyer 2007). Clinical management of horses with mild haemothorax (i.e. lacking clinical signs of dyspnoea or hypoxaemia), can be achieved medically without the need for pleural drainage (Wilkins 2003). Maintaining low volume haemorrhagic effusion within the thoracic cavity facilitates autotransfusion of red blood cells, thereby increasing the peripheral red blood cell concentration more quickly than occurs when the haemorrhagic fluid is removed by drainage. Horses treated in this manner respond favourably to conservative management depending on the nature of the primary disease process and in some cases quickly improve due to autotransfusion. In man, not removing haemorrhagic fluid from the thoracic cavity is a risk factor for the development of adhesions between the visceral and parietal pleurae with subsequent restrictive fibrothorax (Meyer 2007) and it is reasonable to assume this is possible in horses (Perkins *et al*. 1999). Penetration of the thoracic wall to allow drainage of clinically insignificant amounts of haemorrhagic fluid may not outweigh the risks associated with the procedure (i.e. introduction of infection into the pleural space or additional bleeding due to placement of drains) (Chaffin *et al*. 1994). Furthermore, if a horse has a significant volume of haemorrhagic fluid removed from the thorax, it should be monitored closely for evidence of haemorrhagic and hypovolaemic shock (Wilkins 2003).

Thoracic drainage can be performed in a standing, sedated horse. The intercostal space for placement of the cannula or chest drain is preferably identified with ultrasonographic guidance in order to visualise the fluid pocket and avoid the heart and lung parenchyma. After aseptic site preparation, a metal teat cannula, bitch catheter or chest tube fitted with a one-way valve is advanced into the pleural cavity of the cranial aspect of the rib in order to avoid intercostal vasculature located on the caudal aspect of the rib. Concurrent fluid or blood replacement may be required to ensure that the horse does not become hypovolaemic during the procedure (Orsini and Divers 2008).

Supportive care

Supportive care is necessary in horses with haemothorax to ensure adequate blood volume and perfusion and prevent respiratory distress and infection. Horses with intracavitary haemorrhage can rapidly deteriorate due to continued blood loss. Active or continuous haemorrhage causes tachycardia, tachypnoea, shallow breathing, decreased PCV and lethargy. Serial monitoring of the vital parameters, attitude, blood pressure, blood gas analysis and PCV is appropriate to rapidly identify horses needing whole blood transfusion or thoracic drainage. Serial monitoring of the thorax by ultrasonography also allows determination of the rate of blood accumulation.

Antimicrobials are indicated in horses with open thoracic trauma or pulmonary rupture and following thoracocentesis or thoracic drainage (Wilkins 2003). Broad spectrum antimicrobial therapy such as penicillin and an aminoglycoside, ceftiofur or enrofloxacin are appropriate choices. Additional anaerobic coverage with metronidazole is also recommended. Anti-inflammatory medications, such as flunixin meglumine and analgesic therapy may be beneficial in relieving pain associated with the underlying cause of the haemothorax.

Conclusion

Haemothorax should be considered in horses with clinical signs referable to the respiratory system and haemorrhagic shock. Diagnostic evaluation is centred on determining the primary aetiology, followed by initiating appropriate therapy.

Authors' declaration of interests

No conflicts of interest have been declared.

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