Thoracic Trauma:
Tubes and Trachs
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Thoracic trauma in horses can result from either a blunt force injury or a penetrating wound. A thorough physical exam is the first step in evaluation to ensure a patent airway, adequate ventilation and to stabilize the cardiovascular system. The respiratory cycle should be assessed for evidence of splinting, paradoxical chest wall movement, and/or obvious bony deformation of the ribcage. Palpation may sometimes identify fractures and subcutaneous emphysema, and auscultation and percussion can suggest the presence of pleural fluid or a pneumothorax. Additional diagnostics include ultrasound examination of the chest and abdomen, which can easily be performed in the field. If needed, the horse can be referred for radiographs, to further delineate pulmonary damage, fluid or air accumulations which could be consistent with hemothorax, pneumothorax or pneumomediastinum. More extensive diagnostics to consider include an arterial blood gas, blood lactate, central venous oxygen tension and central venous pressure in horses with abnormal physical exam findings.

Appropriate volume resuscitation should be included in initial management of horses in shock. Clinical signs of circulatory shock would include cold extremities, muddy mucous membranes with a delayed capillary refill time, poor peripheral pulses and depression. The “shock dose” of fluids is 60 ml/kg, however, the calculated volume is the divided into 4 equal boluses. Each dose is administered rapidly, and the patient reassessed for a response before administering the next. Successful resolution of circulatory shock can be identified clinically by improved mentation, peripheral pulses and production of urine. Alternatives to this large volume of crystalloid solutions include hypertonic saline (2-4 ml/kg) or colloids (5-10 ml/kg, 6% Hetastarch) followed by crystalloids to replace deficits, losses and maintenance fluid needs. In adults, as well as foals, additional supportive care including supplemental oxygen, nutritional support and adequate analgesia will assist in the recovery from thoracic trauma.

Lacerations and penetrating wounds
Lacerations to the thorax may occur due to sharp or blunt force trauma. Despite the fact that these wounds are often sizable, most lacerations to this area heal well, due to the extensive intrinsic blood supply in this region. On initial exam, the injury should be clipped, aseptically prepared, and explored to determine the involvement of deeper structures including the parietal space and musculoskeletal structures such as the cubital or shoulder joints. It would be advised to avoid cleansing the exposed tissues with anything other than normal saline, to prevent further tissue injury. Investigation of the wound should also proceed with caution, to avoid extending the laceration further into the thorax, or damaging blood vessels or nerves. Foreign objects are often noted within thoracic wounds, and advanced diagnostics to consider include ultrasound and contrast fistulograms. Surgical exploration using thoracoscopy and thoracotomy may be required for definitive identification and treatment, however, in the field, an endoscope is a useful substitute to identify debris.

Primary closure of most thoracic wounds is rarely possible, due to the extensive degree of tissue damage, skin loss, and contamination with debris. Second intention healing will also be required in areas of significant degree of motion or skin tension. Therefore, closed suction drains, stent bandages and/or sterile packing can be used until infection has been brought under control. Debridement to remove foreign contaminants can be performed first using low pressure lavage to prevent dissemination of debris into deeper structures. A 60 cc syringe with an 18 g needle or a saline bottle with holes punctured in the lid are sterile options; for severely contaminated wounds, gentle rinsing with a hose and tap water are adequate. As with any wound, broad spectrum antibiotics and tetanus prophylaxis should be administered.

Complications of thoracic wounds include chronic draining tracts if foreign material is missed, and boney sequestration of the rib or sternum secondary to a fracture and bacterial infection. These fistulae will require injection of contrast (radiopaque for radiographs or new methylene blue at surgery) or ultrasound to help to identify the extent of the tract, followed by aggressive surgical debridement for resolution.

Subcutaneous emphysema
Subcutaneous emphysema is a common complication secondary to deep axillary or pectoral wounds, which result from collision with objects, impalement or kicks by other horses. The pathogenesis is secondary to the movement of air into the subcutaneous tissues due to advancement of the forelimb opening the wound, followed by trapping and forceful compression of the air into the subcutaneous tissues, as the horse advances through the stride. Emphysema can also occur secondary to tracheal or esophageal rupture. Diagnosis of subcutaneous emphysema is by palpation of crepitus in the skin, and severe cases may show changes in contour of the body. While mild emphysema is benign, in severe cases the air may dissect through fascial planes to the head, disrupting airflow through the nasal
passages, and causing dyspnea and eventually asphyxia if untreated. Subcutaneous emphysema may also track into the mediastinum and pleural cavities, resulting in tachypnea or hypoxemia.

Prevention is imperative, and is accomplished by packing and sealing the axillary wound with occlusive dressings, and limiting movement of the horse by strict stall rest or cross ties. In cases where subcutaneous emphysema cannot be controlled or has already developed, it is important to monitor for edema of the nasal passages, which may require a tracheostomy. In addition, swelling of the facial musculature may prevent normal intake of food and water, requiring an indwelling feeding tube. The corneas should also be monitored to ensure that ulceration has not developed due to interference by the emphysema with blinking. Serial monitoring should be performed in all cases of subcutaneous emphysema to identify the development of a secondary pneumothorax or pneumomediastinum, which may occur days or weeks after the injury.

**Pneumothorax and pneumomediastinum**

Pneumothorax is defined as the communication of the pleural space with the environment from an open wound (open pneumothorax), or internal defect in the bronchial tree or lungs (closed pneumothorax). A tension pneumothorax is defined by a flap over this defect, allowing air to gain access on inspiration that is then unable to escape on expiration. This valve can cause a rapid increase in intrathoracic pressure, resulting in collapse of the lungs, compression of the thoracic tissues and a reduction in venous return to the heart. Most cases of pneumothorax are bilateral, but if the normal fenestrations between the pleural cavities are absent or occluded due to pleural effusion, the pneumothorax may be unilateral.

Similarly, pneumomediastinum may occur secondary to an existing pneumothorax, subcutaneous emphysema, rupture of pulmonary bullae, perforation of the thoracic esophagus or trachea, or from direct penetration into the mediastinum by a foreign object. Pneumomediastinum is often a complication of axillary wounds, and air that enters the mediastinum may eventually progress to cause a pneumothorax. Any axillary wound should be monitored for progression to a pneumothorax until the wound has fully healed.

On examination, horses with pneumothorax and pneumomediastinum may display dyspnea, cyanosis, tachycardia, depression or anxiety. With tension pneumothorax, respiratory distress, tachycardia and hypotension may be observed. On auscultation, breath sounds may be dull or absent dorsally in pneumothorax, consistent with compression and collapse of the affected lung. Diagnosis of pneumothorax and pneumomediastinum can be assisted by thoracic radiographs, however ultrasound is often more sensitive in identifying free air in a pneumothorax. For pneumomediastinum, diagnosis is difficult; visualization of the outlines of the aorta, trachea and esophagus on radiographs is pathognomonic for this condition.

Treatment should be pursued for horses exhibiting clinical signs, including dyspnea or hypoxia. For all external chest wounds, an airtight packing should be applied immediately to prevent further air movement into the thorax. If vital parameters are within normal limits, the pneumothorax often will resolve without further treatment. However, clinical signs of respiratory distress or hypoxia require thoracic drainage and oxygen supplementation. A 24-36 French chest tube or a 14 gauge intravenous catheter placed high in the 13th-14th rib space will allow for both diagnosis and removal of air in a pneumothorax. Occlusion of the site of chest tube entry with a finger-trap suture and air-tight bandage is recommended, and a Heimlich valve or continuous mechanical suction may be applied. While barotrauma has not been reported in the adult horse, it would be prudent to use low pressure suction in small horses, foals, and in horses with chronic pneumothorax that may have pulmonary fibrosis. Broad spectrum antibiotics should be provided, and the horse monitored closely for recurrence or decompensation. Nasal oxygen insufflation at 15 L/min would be indicated for sign of tachypnea, hypoventilation and hypoxemia (PaO₂ <80 mmHg).

**Hemothorax**

Hemorrhage into the chest may occur after blunt force trauma or penetrating wounds, resulting in intercostal artery disruption or lacerations to the heart, great vessels or pulmonary parenchyma. With severe hemorrhage, physical examination may reveal pale mucous membranes, cool extremities, signs of colic, or altered mentation. Horses in the late phases of hypovolemic shock may exhibit tachycardia, renal insufficiency and alterations in PCV. Mild bleeding, however, may only be recognized by thoracic ultrasound, where free fluid will appear hypoechoic.

Thoracic hemorrhage should be addressed by fluid therapy (plus or minus transfusion based on clinical signs of hypoxemia); but conservative fluid therapy is recommended for active and uncontrolled bleeding to prevent an increase in hemorrhage due to disruption of clots and further dilution of clotting factors. In cases of uncontrollable hemorrhage, crystalloid fluids are titrated to a maintenance rate, and the acute resuscitation is complete when the horse either urinates, or has a mean blood pressure of 60 mmHg.

Additional medications to promote clot formation or stasis are aminocaproic acid (an anti-fibrinolytic) or a 0.37% formalin solution IV. If active hemorrhage is controlled (by ligating the hemorrhaging vessel or packing off the wound), fluid therapy can be administered at shock rates (20 ml/kg boluses up to 60 ml/kg) as indicated. If hypoxia or dyspnea is noted on clinical exam, drainage of the thorax using a chest tube at the 6-8th intercostal space will improve ventilation. In addition, if the hemothorax was caused by a penetrating wound, drainage and thoracic lavage will allow treatment of infection to prevent secondary pleuritis and constrictive...
fibrothorax due to fibrinous adhesions. Risks of thoracocentesis include recurrence of hemorrhage due to disruption of the thrombus, or pleuritic caused by introduction of bacteria into the thoracic cavity. Because of these side effects, drainage of a hemothorax is only indicated if the horse is showing clinical signs of hypoxia suspected to be due to the fluid accumulation.

**Rib fractures**

Rib fractures may occur subsequent to both penetrating and blunt force trauma, and are commonly caused by dystocia in foals. On physical exam, splinting and tachypnea may be noted, as well as pain on palpation, obvious boney abnormalities and crepitus. Identification of rib fractures in the horse is more difficult than in smaller animals, due to the insensitive nature of both radiographs and external palpation. Ultrasound has been recognized as the most sensitive diagnostic in both adults and foals for positive identification of the fractures, as well as diagnosis of complications including pneumothorax, hemothorax and pleuropneumonia.

Treatment of rib fractures includes wound management, broad spectrum antibiotics, analgesia, supplemental oxygen to improve saturation to >90%, as well as addressing concurrent pneumothorax or hemothorax. The discomfort caused by rib fractures must be alleviated to ensure normal chest excursion and expectoration to reduce the risk of pleuropneumonia. Recommendations for pain management horses include non-steroidal anti-inflammatory medications, and local nerve blocks along the caudal surfaces of the affected ribs. Opioids are advantageous, but should be used with caution at higher doses due to the risk of respiratory depression and colic.

In adults, primary repair of rib fractures is typically not required, due to the stability resulting from the non-compliant nature of the chest wall. However, in neonates fractures are typically at the costrochondral junction of ribs numbered 3-8. Fractures in this area are directly over the heart and great vessels, increasing the risk of hemothorax, pneumothorax, hemopericardium, diaphragmatic herniation, and hemoabdomen. Surgical stabilization can be accomplished in neonates by internal plating, sutures, plastic zip ties or external fixation with a splint.

**Flail chest**

A flail chest is a specific type of rib fracture defined as 2 or more ribs fractured in 3 or more places, creating a free floating segment of the thoracic wall. This creates a paradoxical respiratory pattern, where the flail segment moves in on inspiration, and out with expiration, opposite the normal respiratory cycle. Diagnosis is based on palpation and observation of the paradoxical movement of the flail segment. Morbidity and mortality with flail chest typically results from the pulmonary contusions caused by the injury, rather than directly from the fractures themselves. Although therapy is similar to that of a simple rib fracture, the impact that causes a flail segment in the adult horse is usually fatal due to concurrent cardiac and pulmonary contusions, and additional injuries to the limbs or gastrointestinal organs.

**Diaphragmatic hernia**

Diaphragmatic hernias may result from any condition that results in increased intra-abdominal or intra-thoracic pressures, including falls, dystocia, or blunt force trauma. Clinical signs include acute or chronic intermittent episodes of colic, exercise intolerance, or tachypnea, but may be variable or even asymptomatic depending on the degree of visceral herniation. Diagnosis may be suggestive of a hernia based on rectal palpation (noting an empty caudal abdomen), or imaging including ultrasound or radiographs showing abdominal contents in the lung field. However, diagnostics are often equivocal and surgery is required for a definitive answer. Less invasive methods may include thoracoscopy or laparoscopy, and may facilitate the repair of dorsal tears. Treatment involves either direct suturing or a mesh repair of the defect, and this can be difficult due to limited access by either surgical approach. While immediate recovery from surgery is guarded due to suture breakdown or anesthetic complications from reperfusion injury and barotrauma, survival after recovery from anesthesia is good, with reports of horses returning to high level performance or breeding programs.

**Conclusions**

Thoracic injuries in the horse can have a successful outcome, provided the clinician promptly addresses the complications of penetrating injuries and blunt force trauma. For most thoracic injuries, long term wound management and follow-up is required. Tetanus prophylaxis and appropriate antibiotics are indicated with both internal and external wounds, and serial evaluations will permit early recognition of complications. A common sequela of thoracic trauma is pleuropneumonia, which may require diagnostic cultures and long-term antibiotics. All horses with thoracic trauma should be provided adequate analgesia, and multimodal pain management is preferred.

**References**

22. Fischer AT. Diaphragmatic hernias in the horse. Presented at the American College of Veterinary Surgeons Symposium; October 2005; San Diego, CA.