

Treating Thoracic Injuries

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Abstract: The treatment of equine thoracic trauma often requires rapid emergency measures to save horses from life-threatening sequelae. Complications of thoracic trauma include pneumothorax, pneumomediastinum, hemothorax, pleuritis, diaphragmatic hernia, and damage to the lungs, heart, blood vessels, or abdomen. Patient stabilization is the primary objective before conservative or surgical treatment. Deciding how to manage each case depends on many factors, such as the location, type, and extent of the injury; anesthetic concerns; and response to initial treatment.

Thoracic injuries are relatively uncommon in horses and may follow blunt or penetrating trauma¹ (FIGURE 1). Because these injuries may be life threatening, efficient management of affected patients is necessary to optimize the chance for survival.¹ A review of penetrating thoracic wounds in horses identified collision with an object as the most common cause of trauma.² The many reported sequelae of thoracic injury in horses include subcutaneous emphysema, pneumothorax, pneumomediastinum, hemothorax, pleuritis, diaphragmatic hernia, and damage to the lungs, heart, and blood vessels. Abdominal and spinal injury may also occur in association with thoracic trauma.

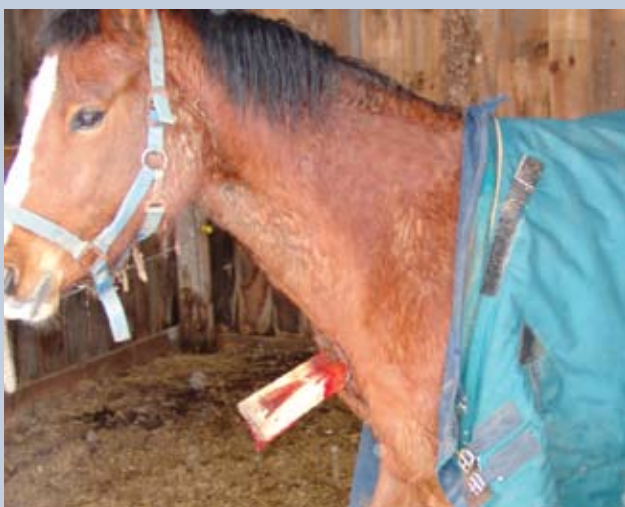
Additional extrathoracic trauma indicated a grave prognosis, with all affected horses requiring euthanasia.² However, an overall satisfactory outcome was reported when thoracic injury occurred alone.

Clinical Signs

Clinical signs may be attributed to damage to internal or external thoracic structures.² External injury may cause soft tissue or muscle damage, blood vessel laceration, and rib fracture, with systemic consequences including pain and shock. Horses with internal thoracic trauma, such as pneumothorax or hemothorax, often present in respiratory distress. Common clinical signs include nostril flaring; dyspnea;

FIGURE 1

Deep penetrating injury near the cranial thoracic cavity caused by a large wooden stake.



A thorough evaluation of the abdomen is indicated when penetrating thoracic injury occurs caudal to the sixth rib. In this case, the stake did not enter the thoracic or abdominal cavities, and conservative treatment with antimicrobials and local wound therapy resulted in complete healing without complications.

tachypnea; accentuated respiratory excursions; and cyanotic mucous membranes.¹ Horses with abdominal trauma may develop colic associated with damage to, or rupture of, abdominal viscera; diaphragmatic hernias; or other organ injury. Determining the location and depth of trauma can guide management decisions regarding thoracic or abdominal involvement; deep wounds and those caudal to the sixth rib are more likely to involve the abdomen.^{1,2} Neurologic signs arising from other extrathoracic injury, such as spinal trauma, have also been reported.²

Emergency Management

Patient stabilization through rapid evaluation and treatment is the cornerstone of effective emergency management. Immediate emergency treatment must be administered during the initial patient evaluation before a more thorough diagnostic evaluation. As with cardiopulmonary resuscitation in humans, emergency triage treatment of equine patients should follow the ABC protocol: **A**irway, **B**reathing, and **C**irculation. Initial treatment should be directed at restoring alveolar ventilation and oxygenation as well as managing shock. In small animal patients with acute thoracic injury, six conditions are immediately addressed: airway obstruction, open and tension pneumothorax, flail chest, massive hemothorax, and cardiac tamponade.³ Pneumothorax, flail chest, hemothorax, hemorrhagic shock, and abdominal injury are the primary complications in horses, requiring immediate action.

Pneumothorax

Chest wounds should be sealed with a sterile, airtight dressing to prevent further movement of air into the thorax. Temporary wound closure or packing, application of petrolatum dressings, or application of plastic wrap over sterile dressings can create an airtight “membrane.” Next, stent bandages or standard bandage materials should be placed fully around the thorax, except in flail chest patients, in which bandaging is contraindicated.³ Severe pain often accompanies trauma to the pleural cavity, ribs, and intercostal nerves, leading to abnormal ventilation (i.e., shallow breathing, tachypnea, hypoventilation) and hypoxemia (P_{aO_2} : <80 mm Hg).^{1,2} Nasal or tracheal insufflation of oxygen (15 L/min) is indicated in

cyanotic or hypoxemic adult equine patients.^{1,4,5} Intratracheal oxygen insufflation improves P_{aO_2} compared with nasal oxygen by providing higher inspired concentrations of oxygen; however, tracheal oxygen delivery may cause coughing, which may be counterproductive.

Emergency evacuation of pleural air should be performed after wound bandage or closure. When tension pneumothorax is suspected, immediate opening of the thorax or placement of a cannula allows supra-atmospheric pressure to return to atmospheric pressure, converting tension pneumothorax to open pneumothorax—a less life-threatening complication of thoracic injury.¹ Immediate removal of air from the thorax is then indicated. Pulmonary reexpansion improves ventilation and helps control hemorrhage from the low-pressure pulmonary vessels. A sterile teat cannula, 14-gauge catheter, or thoracostomy tube is inserted into the dorsal thorax at the 11th to 15th intercostal space^{1,4} (**FIGURE 2**). A thoracostomy tube (24–36 French) placed ventrally is indicated to provide complete drainage if large volumes of pleural fluid or blood clots are present. Cannula placement directly in front of a rib avoids the intercostal blood vessels located caudal to the ribs. An extension line and three-way stopcock are attached to facilitate active suction via a 60-mL syringe or suction device. A Heimlich or other one-way valve allows continuous exiting flow^{1,4} but must be attached firmly and monitored closely because pneumothorax will worsen if the valve becomes dislodged. A continuous flow evacuation device has also been used successfully in cattle to treat pneumothorax secondary to infectious lower airway disease.⁶ These authors reported continuous-flow chest evacuation to be superior to traditional one-time air removal because it avoids the high recurrence rate common in closed pneumothorax, in which air leakage continues from ruptured bullae.

Flail Chest

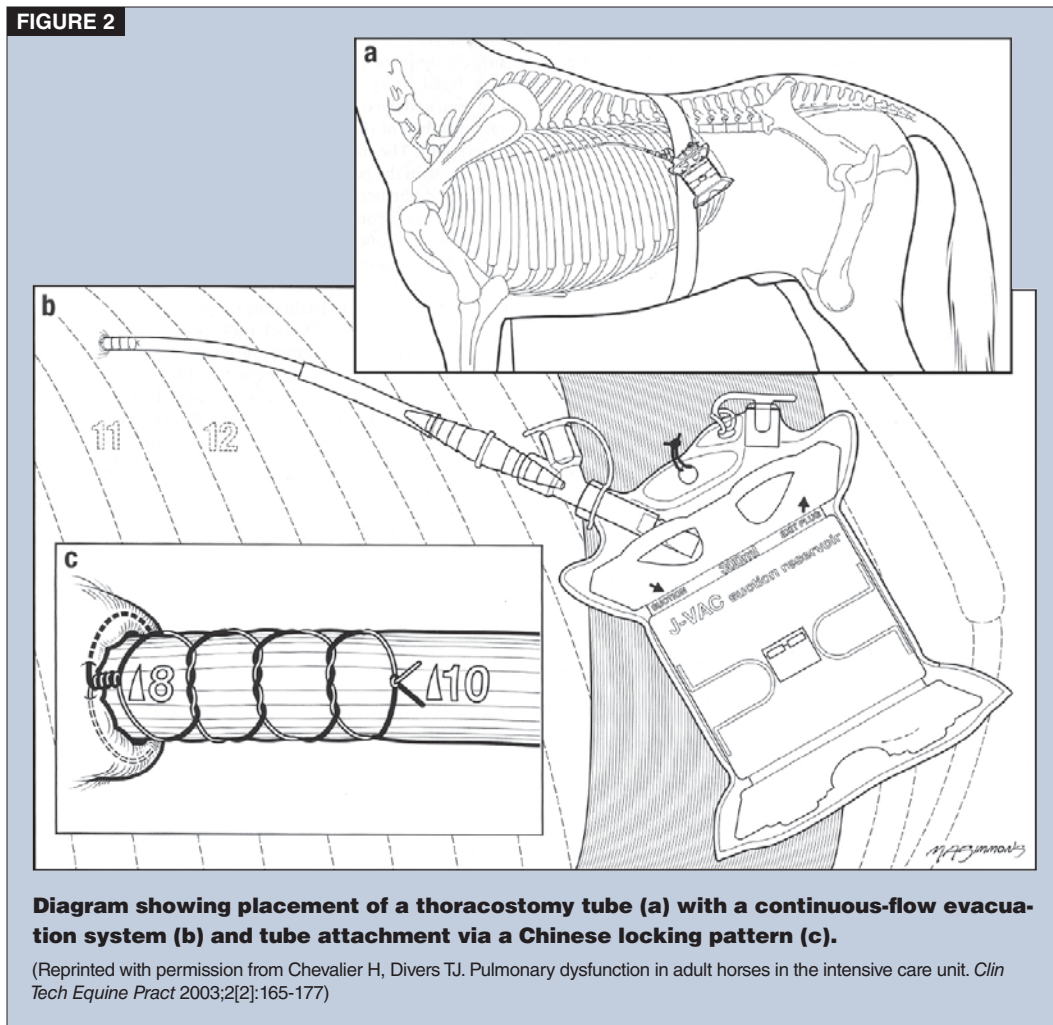
Flail chest results when two or more adjacent ribs are fractured in multiple planes.^{2,3} Blunt trauma is frequently the cause, with fractures occurring on either side of the point of impact. This creates a flail segment of chest wall that exhibits paradoxical respiratory movement. Such abnormal motion prevents development

Critical Point

Determining the location and depth of trauma can guide management decisions regarding thoracic or abdominal involvement; deep wounds and those caudal to the sixth rib are more likely to involve the abdomen.

CriticalPoint

Patient stabilization is the primary goal of initial therapy. Treatment is directed at removal of pleural air, closure or bandaging of thoracic wounds, control of hemorrhage, and treatment of shock.



of the pressure gradient necessary for normal air exchange, leading to severe ventilatory compromise.³ Stabilization of the flail chest segment is required to restore ventilation. Application of an external splint is recommended in small animals with an intact flail segment with little soft tissue damage; this may prove useful in equine patients as well^{2,3} (FIGURE 3). The splint, which is constructed of aluminum rods and a metal or plastic stent, is secured to the ribs with orthopedic wire, providing stability for fracture healing. Septic pleuritis, possibly associated with an orthopedic wire, was a reported complication in one repair.² Flail chest characterized by severe fractures or extensive soft tissue damage usually requires surgical debridement, fracture stabilization, and reconstructive procedures of the chest wall.³ Bandaging of the thorax is contraindicated for patients with flail chest, as inward stabilization of the flail segment results

in decreased ventilation and further pulmonary injury. Attendant pulmonary contusion, which is significant with flail chest patients, causes decreased alveolar volume, decreased compliance, and impeded diffusion at the blood-air interface.

Hemothorax and Hemorrhagic Shock

Hemorrhagic shock results from the pathologic loss of blood from many causes, including trauma, and leads to hypovolemia.⁷ Hemorrhagic shock may occur in horses with thoracic trauma when damage to the heart, great vessels, and intercostal and pulmonary vasculature results in hemothorax and significant blood volume loss. Clinical signs associated with hemorrhagic shock include tachycardia, tachypnea, pale mucous membranes, trembling, sweating, distress, and, possibly, a systolic heart murmur.^{8,9} These signs vary with the severity of blood loss, acute or chronic hemorrhage, and

the underlying lesion.⁹ In equine patients with trauma and acute hemorrhage into the thorax or abdomen, the degree of tachycardia may not correlate with the severity of pain. For example, moderate to severe tachycardia (80 to 140 bpm) in a horse with mild or intermittent pain may indicate severe blood loss.

Immediate treatment of equine patients with thoracic hemorrhage includes fluid therapy, stopping the hemorrhage if possible, and whole blood transfusion when indicated.¹⁰⁻¹² The goal of fluid support in treating acute circulatory failure is rapid restoration of the circulating vascular volume, cardiac output, and tissue perfusion.^{10,13} The administration of balanced, polyionic intravenous crystalloid fluids is indicated at a rate of 20 to 80 mL/kg over several hours, depending on the degree of hypovolemia and blood pressure. Normal to low blood pressure (permissive hypotension) is the goal of therapy if the hemorrhage can be stopped.⁸ Hypertonic (7.2%) sodium chloride solution (4 mL/kg; 1 to 2 L in an adult horse) has also been used successfully in treating hemorrhagic shock in horses and other species,¹³ but its use in uncontrolled hemorrhage may be detrimental because rapid increases in blood pressure could disrupt clot formation. Hypertonic saline exerts its effect via osmotic extracellular plasma expansion, increased plasma volume, and increased vasopressin levels.^{13,14} When hypertonic saline is used in horses for shock management, isotonic

fluid therapy should follow immediately. The use of a large amount of hetastarch is likely contraindicated in patients with acute hemorrhage because of possible coagulopathy or coagulopathic effects.^{8,11} Fresh-frozen plasma is indicated to replace clotting factors when hemorrhage leads to abnormal clotting factor loss or consumption, a problem further exacerbated by additional crystalloid therapy.^{8,11} Aminocaproic acid (10 to 20 mg/kg) may help prevent fatal hemorrhage when surgery is not an option; it should be administered slowly, mixed in intravenous fluids.^{8,15}

Blood transfusions should be considered when signs of hypotension and severe bleeding persist despite initial fluid therapy. Horses can lose approximately 20% of their blood volume (8% to 10% of their body weight; approximately 8 to 10 L in an 1100-lb [500-kg] adult horse) without changes in their blood pressure. In peracute cases, death from hemorrhage may occur without a marked decrease in the packed cell volume (PCV).^{8,12} Therefore, the need for a transfusion in patients with acute hemorrhage should be based on clinical signs (i.e., heart rate, pulse quality, mucous membrane color, temperature of extremities, attitude, degree of weakness) and not on the PCV. Several measurements that may be helpful when determining the need to transfuse include blood lactate, arterial or venous oxygen tension or saturation, and blood pressure.¹² The recommended volume of blood to transfuse is approximately

CriticalPoint

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FIGURE 3

Managing rib fractures that create flail chest. Septic pleuritis is a reported complication of this technique if the wires that stabilize the ribs enter the thoracic cavity and act as a conduit for bacteria.



Application of orthopedic wires.



An external splint.

6 to 8 L in adult horses or 30% to 40% of the estimated or calculated blood loss⁸ (BOX 1). Autotransfusion may be attempted when a large volume of blood is present in the thorax and when bleeding is unassociated with sepsis or bacterial contamination.^{8,16,17} We agree with the cited authors that the blood must be collected from a *sterile* thorax via aseptic technique to avoid bacterial contamination. After insertion of a thoracic teat cannula or chest tube, blood is collected in a container

with small amounts of an anticoagulant (e.g., approximately one part acid citrate dextrose per 15 parts blood).

Abdominal Injury

Thorough evaluation of the abdominal cavity is also important in equine patients with thoracic trauma.^{1,2} The cupula of the diaphragm extends to the sixth rib during expiration, making it essential to evaluate the abdomen of an equine patient with a deep, penetrating thoracic injury caudal to this location.¹ A complete evaluation of the abdomen includes peritoneal paracentesis, ultrasonography, wound exploration, laparoscopy, or exploratory celiotomy.

Diaphragmatic hernias occur infrequently in horses but have been reported secondary to trauma.¹⁸ Thoracic radiography and ultrasonography are indicated for preoperative diagnosis (FIGURE 4). In one study, although two horses with penetrating thoracic injury were euthanized due to abdominal perforation and bowel rupture, only one had a diaphragmatic hernia.² Large defects with secondary colon displacement into the thorax may cause pulmonary compression and dyspnea, whereas small defects are more likely to incarcerate bowel and cause colic.¹⁸ Successful repairs of diaphragmatic hernias in horses have been reported^{18–20}; however, the prognosis is less favorable with large defects and in horses showing clinical signs.²¹

Thoracic Injury Evaluation

Examination of equine patients with thoracic trauma includes thoracic auscultation and percussion, diagnostic thoracocentesis, chest wall palpation, wound evaluation, blood gas analysis, radiography, and ultrasonography.^{1,2} Auscultation and percussion of the chest wall in equine patients may help identify pneumothorax or hemothorax. In patients with pneumothorax, lung sounds are absent, but increased resonance is percussed dorsally. Diminished lung sounds ventrally and percussion of a fluid line are characteristic of hemothorax. Diagnostic thoracocentesis can be used to confirm pneumothorax or hemothorax.²² A needle, catheter, or teat cannula is placed into the thorax as previously described, and a fluid extension line is attached. Pneumothorax is confirmed when fluid bubbles out of the extension; however, if the fluid is aspirated into the chest,

BOX 1.

A Practical Example of Transfusion in an Equine Patient^a

The amount of lost blood can be estimated from the following formula (packed cell volume [PCV] can be used in this formula once blood volume is reestablished with fluid administration or after 8–12 hr of compensation):

$$\text{Liters of blood lost} = \frac{\text{Normal PCV} - \text{Patient PCV}}{\text{Normal PCV}} \times 0.08 \times \text{Patient weight (kg)}$$

As a rule of thumb, if a PCV of 40% is assumed for the donor, 2.2 mL of whole blood per kilogram of patient weight will increase the PCV by approximately 1% in most horses. For example, 1100 mL of whole blood will raise the PCV from 15% to 16% in a 500-kg (1100-lb) horse. The administration rate of blood varies with the patient's clinical status. For horses with severe hypotension and hemorrhage, blood can be administered as a rapid bolus along with (but not in place of) crystalloids and colloids because the benefits outweigh the risks of reactions. More often, crystalloids and colloids are given as boluses first and then followed with blood administration. When possible, it is advisable to initially administer blood slowly (approximately 0.1 mL/kg over 10–15 min) to ensure tolerance. After that period, rates of up to 20–30 mL/kg/hr can be used. To remove fibrin and debris, plasma filtration sets should be used for blood administration.

Case Example:

A 450-kg (990-lb) Thoroughbred racehorse was impaled on a fence, resulting in acute thoracic trauma and a PCV of 10%.

$$\begin{aligned} \text{Blood loss (liters)} &= (40\% - 10\%) \div 40\% \times (0.08 \times 450 \text{ kg}) \\ &= 30\% \div 40\% \times 36 \\ &= 27 \text{ L} \end{aligned}$$

Typically, the goal is to replace 30% to 40% of the calculated blood loss:

$$27 \text{ L} \times 0.30 = 8.1 \text{ L of whole blood administered as a transfusion}$$

^aAdapted from Magdesian KG. Therapeutics in practice: acute blood loss. *Compend Equine Contin Educ Vet* 2008;3(2):80-90.

pneumothorax is unlikely. Chest wall and wound palpation may help identify rib fractures, thoracic wall penetration, foreign bodies, or other injury. Arterial blood gas analysis provides information on lung ventilation, lung perfusion, and acid–base status, while arterial and venous samples together provide information on tissue oxygenation.¹² Serial samples are indicated to help evaluate the response to therapy. Thoracic radiography (**FIGURE 5**) and ultrasonography are becoming more practical in the field. These diagnostics can help detect rib fractures, pneumothorax, pneumomediastinum, hemothorax, diaphragmatic hernias, and foreign bodies.¹ Ultrasonographic evaluation is also useful for determining the amount of blood or air in the thorax, guiding pleurocentesis, and inserting chest tubes.

Specific Thoracic Injury

Pneumothorax

In a review of 40 cases of pneumothorax in horses, the reported causes were pleuropneumonia, open and closed thoracic trauma, and surgery of the upper and lower respiratory tract.²³ In this study, pleuropneumonia was the most common cause of pneumothorax; affected horses had a significantly worse prognosis for survival compared with horses with pneumothorax due to other causes. There are three types of pneumothorax. *Open pneumothorax* occurs with penetrating, open chest wounds when air moves freely during inspiration and expiration.^{1,2} Damage to the lung parenchyma by displaced rib fractures or a ruptured lung bulla permits air to enter the pleural space, creating a *closed pneumothorax*. *Tension pneumothorax* occurs when intrapleural pressure exceeds atmospheric pressure. This life-threatening condition usually follows the formation of a pleurocutaneous fistula, in which air enters the pleural space during inspiration but is blocked from exiting during expiration. Thoracic pressure builds on the affected side, forcing air across the mediastinal cavity and/or decreasing compliance of the opposite lung. Severe hypoxemia with P_{aO_2} levels as low as 22 mm Hg has been reported in humans with tension pneumothorax.¹

Unilateral pneumothorax, except for tension pneumothorax, is well tolerated in horses. However, a thin, fenestrated caudal mediastinum in some horses may predispose them to

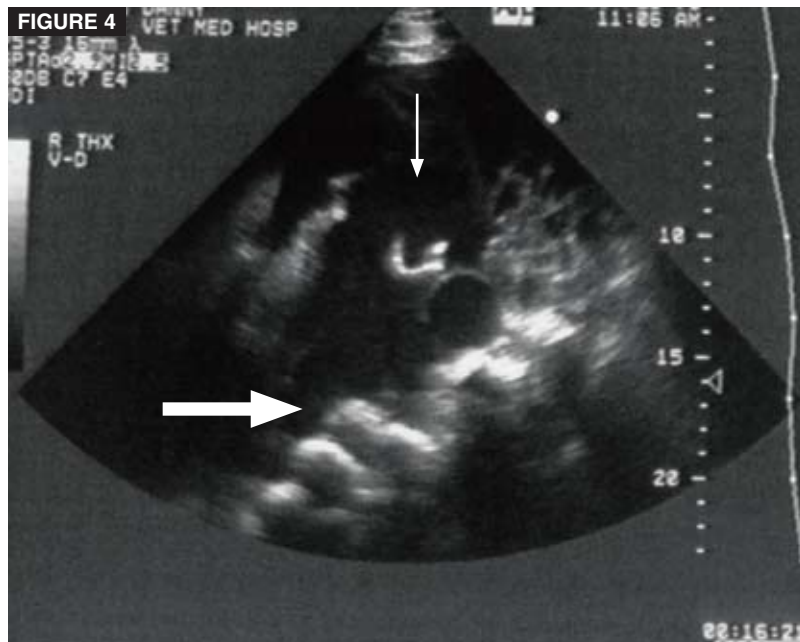


FIGURE 4 Thoracic ultrasonogram of an equine patient with diaphragmatic hernia involving the liver and small intestine. Note the distended loops of small intestine (large arrow) and region of the liver (small arrow) within the thoracic cavity.

bilateral pneumothorax—a potentially fatal complication. Based on radiographic examination, nine of 15 horses with penetrating thoracic injury had pneumothorax, six cases of which were bilateral.²

Hemothorax

Hemothorax, hemorrhagic shock, and death may result from severe thoracic injury involving the heart or great vessels. Most horses with massive hemothorax from thoracic injury do not survive.¹ However, in six of 15 horses with a penetrating thoracic injury, hemothorax (possibly originating from the intercostal artery or pulmonary laceration) was not life threatening.² Removing blood from the thorax improves pulmonary ventilation and avoids the formation of septic pleural effusion, pleural adhesions, and constricting fibrothorax.^{1,2} Patient stabilization through restoration of circulating blood volume is recommended before thoracic drainage.

Rib Fractures

Most rib fractures in equine patients occur in foals during parturition, and their management is described in the literature.^{1,24–27} Rib fractures in foals are reported to be a significant cause of morbidity and mortality but may not be clinically apparent.^{24–27} Ultrasonography was found

CriticalPoint

Progressive subcutaneous emphysema with secondary pneumomediastinum or, less commonly, pneumothorax is a reported complication of axillary wounds in horses.

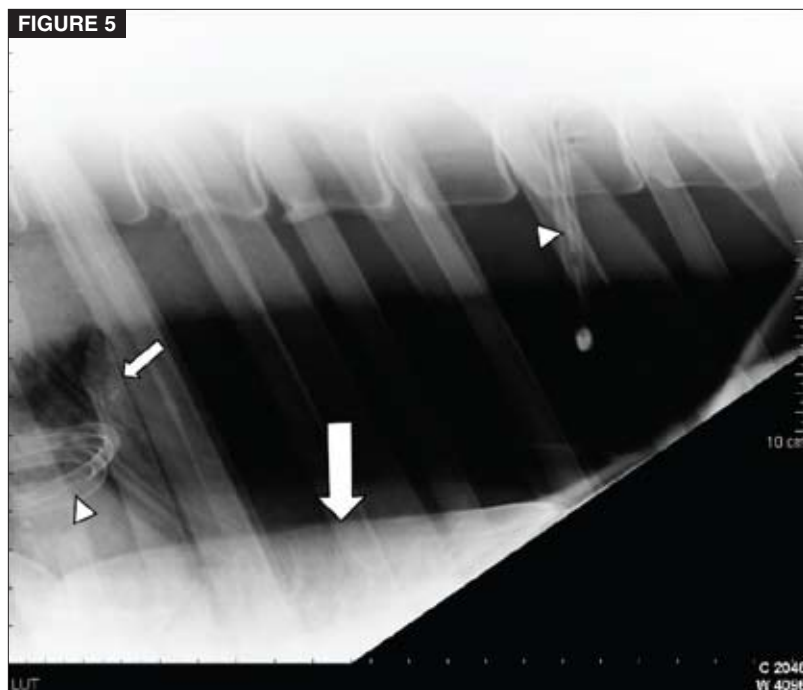


FIGURE 5
Thoracic radiograph depicting bilateral pneumothorax in an equine patient with thoracic trauma. Note the dorsal margin of the collapsed lungs (large arrow), the fractured rib (small arrow), and the chest tubes (arrowheads).

to be superior to radiography for evaluating thoracic trauma in foals, even for identifying nondisplaced fractures.²⁷ Surgical stabilization may be recommended to reduce the reported 25% mortality rate associated with direct complications from rib fractures.^{24,26,27}

Rib fractures are also common in adult horses following blunt or penetrating thoracic injury.¹ Five of 15 horses sustained rib fractures in a review of penetrating thoracic trauma.² Although some fractured ribs can be identified on physical or radiographic examination, many fractures may not be palpable or visible and may be missed. Most rib fractures in adult horses are reported to heal without fixation.¹ Displaced rib fractures may lacerate the lungs, heart, blood vessels, diaphragm, or other deep structures. In such cases, surgical rib fixation is indicated to minimize continued thoracic injury.³ One possible complication is a closed pneumothorax, resulting from closed chest wounds in which rib fractures cause pulmonary parenchymal damage. The reported techniques for stabilizing rib fractures include the use of quill sutures, external splints, pins, wires, and plate application.^{3,28} When severe rib damage prevents realignment, the remaining bone and fragments should be removed.

Lung Lacerations

Lung trauma is a rare manifestation of thoracic injury in horses. Few reports in the large animal literature describe how to manage lacerations involving the lung following thoracic trauma, although one report summarizes intrathoracic surgery in large animals.²⁸ Partial or complete lung lobectomy is recommended for severe lacerations, cysts, bullae, abscesses, or tumors.²⁹ Conventional excision and closure by suture or staple techniques are described in small animals and may be applied to equine patients.^{29,30} Bronchial involvement is identified via application of warm saline to the site of injury and followed by bronchial closure.²⁸ Overlapping horizontal mattress sutures are placed to seal the lung stump after an amputation and to repair lacerations to the lung margin. The edge of the excision line is oversewn with a simple continuous pattern to avoid leakage.³⁰ Injury to the central lung parenchyma may also be closed via a simple continuous suture pattern following identification of bronchial damage and ligation. Monofilament, absorbable suture material with swaged-on, atraumatic needles is currently recommended for lung and bronchial closure.^{28,30} Minor alveolar leakage does not require closure and generally seals quickly.

Axillary Wounds

Axillary wounds often extend deep into the tissues and function as one-way valves, producing marked, progressive subcutaneous emphysema. Most clinicians recommend packing these wounds with gauze and closing the skin or using stent bandages to limit further air penetration into the tissue.²² Packing material should be replaced every 24 to 48 hours until the wound bed has completely granulated. Equine patients should be confined to a stall and cross-tied to minimize limb movement. However, despite various treatments, axillary wounds in horses may lead to severe subcutaneous emphysema that may progress to secondary pneumomediastinum (and, occasionally, pneumothorax), which may become apparent weeks after the initial injury. In affected patients, reports document respiratory distress that occurred as late as 16 days after injury, necessitating patient confinement and observation for an extended period of time.^{2,31} In six of 15 horses in one study, pneumomediastinum was identified; five of the six horses had axillary wounds.²

Conservative Versus Surgical Management

Thoracic injury may be successfully managed with conservative and surgical treatment strategies.^{1,2,22,32} However, patient stabilization is the primary objective before either method of treatment.^{1,22,32} Horses with simple rib fractures, small chest wounds, or modest degrees of pneumothorax or hemothorax and without severe lung lacerations, rib fractures, deep penetration, or contamination are candidates for conservative management. Medical therapy includes antimicrobials and NSAIDs, thoracocentesis or thoracostomy tube placement, second-intention wound healing, bandaging, and the supportive care measures described in this article. Surgical therapy may be indicated for more severe injury.³² Surgery allows improved exploration and lavage of the wound and pleural or abdominal cavities, control of hemorrhage, complete removal of foreign bodies, repair of lung lacerations and rib fractures, and the stabilization of flail chest.

Anesthesia and Surgical Approach

Selecting the appropriate type of anesthesia and surgical approach for treating thoracic injury requires careful consideration of several factors, specifically patient stability; anesthetic concerns; location, type, and extent of the injury; clinician experience; and response to initial treatment.²⁸ General anesthesia should be used with caution in thoracic trauma patients until they have been initially stabilized.^{1,22} Anesthetic risks must be weighed against the benefits of standing versus recumbent procedures. To avoid further respiratory and cardiovascular compromise of patients, clinicians should select standing wound exploration and treatment when possible.^{1,22} Intercostal perineural anesthesia is recommended for standing procedures to facilitate repair and help control postoperative pain. Thorough wound exploration, debridement, and lavage are necessary to remove bacteria, foreign bodies, rib fragments, and other debris.¹ Many of these treatments may be used in standing horses. However, tension or bilateral pneu-

mothorax, which is difficult to manage without the ability to provide mechanical ventilation, may develop during standing surgery, resulting in severe cardiopulmonary deterioration.^{1,2} General anesthesia is indicated in horses with severe chest wall disruption, deep penetrating wounds, foreign bodies, abdominal cavity involvement, complicated rib fractures, extensive lung lacerations, or severe contamination that requires aggressive thoracic lavage.³² The use of controlled positive-pressure ventilation is essential in equine patients with open pneumothorax.² In addition, patients in which hemorrhage, pneumothorax, or hypoxemia persists despite conservative treatment may require wound exploration or wound closure techniques that necessitate mechanical ventilation and general anesthesia.²

Most thoracic approaches in equine patients simply involve enlarging the existing traumatic wound. However, several surgical approaches to the equine thorax have been reported, including lateral thoracotomy via the intercostal technique or rib resection and thoracoscopy.^{28,30,33-35} In small animals, a median sternotomy has also been described for gaining access to both sides of the thorax³⁰; this approach may be useful in calves or foals.²⁸ In general, the thoracotomy incision is centered over the site of the thoracic injury, and in most cases, the wound is simply enlarged to obtain adequate exposure of the ribs, heart, lungs, diaphragm, and pleura.^{1,28} Various retractors, including the Finochietto rib retractor, are also useful for gaining surgical exposure.

Thoracoscopy provides several advantages over thoracotomy for evaluating and treating thoracic injury in equine patients.³³⁻³⁵ Thoracoscopy allows detailed exploration of the thoracic cavity in patients with minimal morbidity, whereas thoracotomy is more invasive and is limited by difficult exposure.³³⁻³⁶ Standing thoracoscopy provides excellent access to the dorsal and lateral aspects of the thorax, while the cranial and ventral portions are best viewed with a lateral, a dorsal, or an oblique recumbency technique.³⁵ The specific identification of the organ injury can help direct treatment and improve planning for thoracotomy or abdominal procedures.³³ With thoracoscopy, foreign bodies within accessible regions of the thorax may be identified and removed.¹ Thoracoscopy can also help effectively evaluate

and treat many postoperative complications of thoracic injury, including pleuritis, pericarditis, abscesses, pleural adhesions, and diaphragmatic hernias.³³⁻³⁵ Currently, thoracoscopy alone does not allow closure of diaphragmatic defects because of nonreducible omental adhesions and the limitations of available instrumentation.³³

Wound Closure

Primary wound closure is recommended, when possible, after thoracic injury in horses.^{1,2,22} For small uncomplicated wounds, the thoracic muscles and soft tissues are apposed over the defect. For large chest wounds, or those otherwise unsuitable for routine closure, two thoracic reconstructive techniques have been described in large animals: primary muscle flap and prosthetic mesh repairs.^{1,3,22} Rotating muscle pedicle flaps of the longissimus dorsi and external abdominal oblique muscles, transposed via a Z-plasty technique, were used to close a caudal lateral thoracic wound in a horse.³⁷ Polypropylene mesh, although useful for closing large defects in animals, should be used with caution to avoid complications related to infection. We recommend closing as much of the wound as possible at the initial surgery. Mesh implants should be reserved for subsequent procedures, when necessary, and only after infection has resolved. Delayed primary closure and second-intention healing may also be selected, especially with large or highly contaminated wounds.^{1,22} Closed suction drains placed into the wound can help prevent seroma formation and secondary incisional infection. Mesh expansion and various tension-relieving suture patterns are most commonly used in horses to reduce tension during closure of extensive thoracic or abdominal wounds.¹ Close postoperative monitoring is essential. When infection persists, aggressive retreatment via debridement, drainage, lavage, and appropriate antimicrobial selection based on culture and sensitivity is recommended to prevent secondary pleuritis.²²

Prognosis

In a review of 15 cases, a satisfactory outcome was reported following penetrating thoracic trauma without extrathoracic injury.² Eleven horses, representing a 73% survival rate, were discharged from the hospital. The other four horses were euthanized due to complications

of extrathoracic injury, including colon perforation, renal trauma, and spinal luxation.² While horses that develop secondary pleuritis often have a guarded prognosis,^{38,39} it is important to note that only one horse developed pleuritis, indicating a low incidence of this complication.² A mortality rate of approximately 50% has been reported in horses that develop pleuritis or acute pleuropneumonia.^{1,2,22,38,39}

Conclusion

The emergency evaluation and treatment of horses with thoracic injury primarily involves cardiovascular and respiratory function assessment and provision of appropriate support. An understanding of emergency first-aid steps; shock therapy; anesthetic concerns; standard surgical approaches to the thorax; methods of wound treatment, reconstruction, and closure; and potential complications can help clinicians manage these difficult cases.

We recommend a thorough evaluation of the abdomen in all cases of thoracic trauma,

especially for injuries caudal to the sixth rib. Frequent, extended monitoring for respiratory distress in equine patients with axillary wounds is advised to detect secondary pneumomediastinum and pneumothorax and to provide appropriate therapy. A low occurrence of thoracic empyema has been reported in cases of penetrating thoracic injury in horses; however, if septic pleuritis develops, it has a poor prognosis and a mortality rate of approximately 50%.^{1,2,22,38,39} Without extrathoracic injury or severe complications, as discussed in this article, the prognosis for equine patients with thoracic injury should be favorable.² 🐾

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3 CE
CREDITS

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1. Which condition does not require immediate emergency treatment in horses with acute thoracic injury?

- airway obstruction
- tension pneumothorax
- nondisplaced rib fracture
- massive hemothorax

2. In a retrospective study²³ in horses, which problem was identified as the most common cause of pneumothorax and was associated with decreased survival?

- open thoracic trauma
- closed thoracic trauma
- pleuropneumonia
- lower respiratory surgery

3. Overlapping _____ sutures are placed to seal the lung stump after amputation or to repair lacerations to the lung margin.

- horizontal mattress
- vertical mattress
- simple interrupted
- cruciate

4. Following wound bandaging or closure in equine patients with pneumothorax secondary to thoracic trauma, which emergency procedure is indicated?

- intravenous fluid therapy
- whole blood transfusion
- removal of a foreign body
- removal of pleural air

5. Of the following sequelae reported with thoracic injury in horses, which one has been associated with axillary wounds?

- hemothorax
- pleuritis
- pneumomediastinum
- rib fracture

6. A horse presents to your clinic with a history of acute thoracic injury and clinical signs of hemorrhagic shock. On what clinical evidence should you base the need for a whole blood transfusion?

- PCV
- total plasma protein level
- platelet count
- clinical signs

7. In patients with acute hemorrhage, a large amount of _____ is contraindicated because of possible coagulopathic effects.

- hetastarch
- hypertonic saline
- whole blood
- plasma

8. A 5-year-old Standardbred gelding suffers blunt trauma during race training. On presentation, you note the following: severe respiratory distress, an open chest wound, flail chest, tachycardia, pale mucous membranes, and colic. You diagnose pneumothorax, hemothorax, diaphragmatic hernia, and multiple rib fractures. Following patient stabilization, which treatment strategy do you recommend?

- standing surgery to stabilize the flail chest with a thoracic bandage
- standing surgery to stabilize the flail chest with an external splint
- standing surgery to explore the wound and stabilize rib fractures
- surgery with the patient under general anesthesia to explore the wound; evaluate the thoracic and abdominal cavities; repair the diaphragmatic hernia; stabilize the rib fractures; remove foreign bodies; place thoracic drains; and debride, lavage, and close the wound

9. Flail chest results from

- the fracture of two or more adjacent ribs in one plane.
- the fracture of two or more adjacent ribs in multiple planes.
- two or more fractures involving a single rib.
- rib fracture with secondary pulmonary laceration.

10. Which statement regarding pneumothorax is true?

- Open pneumothorax involves lung perforation.
- Closed pneumothorax does not involve lung perforation.
- Tension pneumothorax occurs when intrapleural pressure exceeds atmospheric pressure.
- Tension pneumothorax occurs when atmospheric pressure exceeds intrapleural pressure.