Thoracic Trauma: Causes and Triage in Horses

Sam Hurcombe
BSc BVMS MS DACVIM DACVECC
Associate Professor LA Emergency & Critical Care

Overview
- Causes of thoracic trauma:
  - Diaphragmatic hernia
  - Rib Fractures
  - Penetrating injuries
  - Pneumothorax/Pneumomediastinum
  - Re-expansion pulmonary edema
- General emergency management considerations

Initial Evaluation
- Watch – breathing
  - Rate, depth, synchrony, chest wall motion
- Penetrating wounds?
- Signs of other body system involvement
  - Mentation, colic, heart rate/rhythm

Diaphragmatic Hernia
- Clinical signs can vary
  - Colic is common
    - Rectal exam may feel "empty"
  - Dyspnea with paradoxical breathing patterns
    - Small rents may cause more severe colic signs due to strangulating of bowel
  - Imaging can be useful
    - Ultrasound and radiography
  - Exploratory celiotomy

Diaphragmatic Hernia
- Congenital
  - Morgagni (retrosternal) - ventral usually
  - Septum transversum fusion failure
  - Smooth edges, +/- hernial sac
- Acquired
  - Sudden increase in thoracic or abdominal pressure
    - Trauma
    - Parturition
  - Central diaphragm → weakness at musculotendinous junction?
  - Fresh edges, damaged fibers, acute inflammation
Diaphragmatic hernia in horses: 44 cases (1986–2006)


<table>
<thead>
<tr>
<th>Trait</th>
<th>Number</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Sex</td>
<td>Male</td>
<td>23 (52%)</td>
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<tr>
<td>Sex</td>
<td>Female</td>
<td>21 (48%)</td>
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<tr>
<td>Side</td>
<td>Right</td>
<td>24 (54%)</td>
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<tr>
<td>Side</td>
<td>Left</td>
<td>20 (46%)</td>
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Diaphragmatic Hernia

Morgagni (retrosternal) hernia

- X = xiphoid
- LC = large colon

Ventriculo-diaphragmatic herniation

- Direct suture: small rents
- Mesh herniorrhaphy: larger rents

Ultrasound

15yo TB Gelding, Colic

Radiograph

Ultrasound

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Radiograph

Ultrasound

Diaphragmatic Hernia

DH: Treatment

- Medical and surgical
  - Medical to stabilize (pre-op and post-op)
  - Surgical to repair the rent a bowel

- Surgical
  - Ventral midline (most common) or lateral thoracotomy with rib resection
    - Direct suture: small ventral rents
    - Mesh herniorrhaphy: larger rents
  - Laparoscopy – standing
    - Small rents, dorsal location
  - All have a pneumothorax
    - Positive pressure ventilation during surgery
    - Evacuation of air/fluid intra-op and post-op (slow re-expansion)
Surgery 1
Reverse Trendelenburg
Remove air in recovery

Surgery 2: Rib Resection, Mesh Repair

Thoracotomy
Gigli wire for rib resection

DH: Prognosis
- Hart and Brown, J Vet Emerg Crit Care 2009
  - 18/44 euthanized; 26/44 taken to surgery
  - 17/26 surgical euthanized; 9/26 survived surgery; 7/9 were discharged
  - Overall survival 16%; 27% of all taken to surgery
- Romero and Rodgerson, Can Vet J 2010
  - 6/31 euthanized; 25/31 taken to surgery
  - Overall survival 23%; 46% of all taken to surgery

Rib Fractures: Neonates
- Common: ~70% of foals presenting to a NICU
- Related to birthing trauma
  - Intra-partum fracture
- Dystocia is a risk factor
- Usually at/near the costochondral junction of the ribs
- Predilection locations related to adjacent anatomy
- Consequences
  - Hemothorax, lung laceration, cardiac laceration, flail segment, respiratory distress
**Diagnoses**

- Palpation
- Radiography
- Ultrasound
  - Detects 4X the number of fractures vs radiography

### TABLE 2: Sensitivity, specificity, negative and positive predictive values of thoracic palpation and visual dorsal midline midsagittal and radiography vs. ultrasonography. A foal was considered positive when ultrasonography or thoracic radiography identified rib fractures.

<table>
<thead>
<tr>
<th></th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
<th>PPV (%)</th>
<th>NPV (%)</th>
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NPV = negative predictive value, PPV = positive predictive value, LL = Left lateral projection, LLL = Left lateral diagonal, DB = Dorsal oblique plane.

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**Most foals had 2 fractured ribs**

- **Left sided** bias
- Ribs 2 through 7 (4th rib most common) likely to be affected.

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**Flail Segment**

- Three or more ribs fractured at 2 sites on each rib
- "Free floating segment with paradoxical movement"
  - Inward displacement during inspiration
  - Outward displacement during exhalation
- In humans, treatment is largely supportive including mechanical ventilation, analgesia
  - Surgery is rarely performed
- In horses, it occurs rarely in adults, more likely in foals and would likely be amenable and necessary to surgical stabilization.
Rib Fractures: Management

**Conservative**
- Exercise restriction and analgesia

**Significant hemothorax**
- Aminocaproic acid
- Oxygen
- Limited drainage ± autologous transfusion

* * * *

D 1 month old with depression and respiratory distress: hemothorax and multiple fractured ribs

Likely acute on chronic injury given the presence of callus formation

Rib Fractures: Surgical Management

**Unstable, axially displaced and multiple ribs (i.e. flail segment)**
- Reconstruction plate, self-tapping screws and cerclage
  - belleau et al, equine vet j 2004; 36:557-562
- Nylon suture and crimp technique
  - rosa et al, Vet Surg 2005;34:399-404
- Cable ties

Penetrating Injuries

- Penetrating injuries may include
  - Axillary wounds i.e. stake/stick wounds
  - Lateral chest wall wounds
  - Displaced open rib fractures
  - Gun shot

- Pneumothorax can be immediately life threatening
  - Open: IP pressure equilibrates to atmospheric
  - Closed: IP pressure equilibrates to atmospheric
  - Tension: IP pressure goes supra atmospheric
  - Wound that sucks air in but doesn’t allow air out (one-way flow)

Penetrating Wounds: Important structures to consider

Axillary Wounds

- Tend to cause pneumomediastinum → pneumothorax
- Subcutaneous emphysema is also very common

Wound Evaluation

- Careful palpation
  - Take care not to increase the depth of injury, particularly near the pleura, increase dirt, vital structures

- Radiography +/- fistulogram
  -Extent of lung/pleural space injury
  -Foreign bodies i.e. gun shot

- Flexible endoscopy in a large tract i.e. from a stick

- Ultrasound: concurrent hemothorax and pleural fluid accumulation
Subcutaneous emphysema

Chest/axillary wound

- Therapy
  - Clean, lavage with minimal debridement
  - Open: pack with saline soaked gauze/crypt packing and secure with tie-over bandage, temporary sutures
  - Limit horse movement and abduction of the limb
    - Can splint the leg, put on a wire
  - Allow most wounds to granulate
    - Primary healing for very clean, minimally contaminated or macerated tissue
  - +/- topical therapy on tissue i.e. neosporin, furacin
  - If pleura has been breached
    - See chest wall injury

Chest Wall Injury

- Triage
  - Cover/seal open wounds
  - Oxygen insufflation
  - Prepare caudodorsal site for thoracocentesis and drainage of air
    - They all have some degree of pneumothorax
- Treatment
  - Broad spectrum antibiotics
  - Anti-inflammatories/analgesia
    - Pleural and rib/intercostal pain!

Penetrating Injury

- Pleuropneumonia +/- abscesses are common
  - May require drainage, thoracotomy, intercostal myotomy
  - Long-term, broad spectrum antibiotics

Thoracotomy

Pleural evacuation

- Instrument: depends on the cause and likelihood of redevelopment (open vs closed)
  - Teat cannula
  - Catheter
  - Small gauge chest tube
- Location:
  - Caudal and dorsal
- Rate:
  - Slowly. Human Medicine recommendation is ≤ 20 cmH₂O
Long term or continuous drainage

- **Bottle 1** connects to the patient and collects secretions etc.
- **Bottle 2** = water seal
- **Bottle 3** determines the suction pressure applied to the airway based on the fluid height, i.e. X cm H₂O

Pneumothorax

- **Re-expansion pulmonary oedema**
  - Perhaps and ARDS-like phenomenon
  - Capillary endothelial fragility
    - Mechanical trauma (collapse and sudden re-opening)
    - Reperfusion injury?
  - Results in increased interstitial fluid and protein accumulation and hypoxemia (low PaO₃/FiO₂)
- Effects are minimized by slow, gradual air evacuation with low negative pressures

Pneumomediastinum

- No lung
- Thoracic aorta is easily visualized with a pneumomediastinum

Mediastinal air highlights mediastinal structures well (trachea, aorta etc)

Traumatic Hemothorax

- Intercostal vessels, pulmonary vessels, heart
- Presentation: anemia, pallor, respiratory distress (rapid, shallow), hemorrhagic shock
- Diagnosis: ultrasonography
- Confirmation: thoracocentesis

- To drain or not to drain?
  - Yes, if severely dyspneic
  - No, as increased pleural pressure may be providing hemostasis and the pleura is able to autotransfuse up to 75% of erythrocytes by 72 hours.
  - Half-way approach (what I do)
    - Provide some dyspnea relief, but don't remove all the blood.
    - Consider autologous transfusion back to the patient
      - 3.8% citrate in a 9:1 dilution
Post-traumatic ARDS/ALI

- Re-expansion pulmonary edema
- Based on strict ARDS definitions in people
  - PaO₂:FiO₂ decreased (< 200; certainly < 500 (n))
  - No LA dysfunction or increased PCWP
  - Pulmonary infiltrates
  - Acute onset of distress
- Cause of acute distress is likely multifactorial
  - Contusion, hemorrhage, collapse, atelectasis, relative surfactant deficiency, ARDS? etc

Pneumothorax, pneumomediastinum
- Pulmonary contusion
- Acute lung injury \(\rightarrow\) contusion, re-expansion injury?
  - PaO₂:FiO₂ < 300
  - Poorly O₂ responsive
- Responded well to continuous suction, O₂ support and antibiotics/analgesics

Closing

- Good review for further details

**Thoracic Trauma in Horses**

Kim A. Sprayberry, DVM**, Elizabeth J. Barrett, DVM, MS**


Questions?

Team ECC surgery: New Bolton Center