VEHICULAR TRAUMA

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PATIENT EXPERIENCES VEHICULAR TRAUMA

INVESTIGATION
- Perform a rapid evaluation of cardiovascular, respiratory, and CNS systems
- Place IV catheter as soon as possible
- Perform initial diagnostics (ie, PCV, TP, lactate, blood gas, electrolytes, SpO2, ECG)

Patient breathing?

Airway clear?

YES

TREATMENT
- Begin CPR
- Provide intubation, oxygen, and positive pressure ventilation

NO

TREATMENT
- Clear the airway (possibly blood/hematoma)
- Begin CPR
- Provide intubation, oxygen, and positive pressure ventilation

Signs of respiratory distress (eg, tachypnea, cyanosis, increased respiratory effort)?

YES

INVESTIGATION
- ECG

YES

VPCs, ventricular tachycardia

NO

TREATMENT
- Lidocaine, oxygen, MgCl, analgesia for sustained ventricular tachycardia
  [Table 1, page 29]
- Single VPCs do not need to be treated in most cases

NO

Signs of brain and/or spinal injury?

YES

See Brain and/or spinal injury, page 24

NO

See Stabilized patient, page 25

INVESTIGATION
- Signs of shock?

YES

NO

Arrhythmias?

YES

Lidocaine, oxygen, MgCl, analgesia for sustained ventricular tachycardia
  [Table 1, page 29]

See Signs of shock, page 24

Consider pulmonary contusions and pleural space disease

TREATMENT
- Initiate basic respiratory support
  - Oxygen, sedation, analgesia (see Analgesia in Trauma, page 29)
  - Intubation and positive pressure ventilation

NO

NO

YES
**DIFFERENTIAL**

**Pneumothorax**
- **RESULTS**
  - Restrictive (ie, rapid, shallow) breathing pattern
  - Absent/decreased lung sounds (dorsal)
  - Absent glide sign

**TREATMENT**
- Basic respiratory support
- Closed: thoracocentesis (see Thoracocentesis, page 29). Monitor for repeated episodes of pneumothorax. Chest tube may be required if negative suction unattainable or recurrent pneumothorax
- If open: Apply seal to wound with sterile lubricant and bandage chest. Thoracic exploratory surgery to close wound

**DIFFERENTIAL**

**Pleural effusion (hemothorax)**
- **RESULTS**
  - Restrictive (ie, rapid, shallow) breathing pattern
  - Absent/decreased lung and heart sounds (ventral)
  - Effusion (ventral)

**TREATMENT**
- Basic respiratory support
- Thoracocentesis
- Monitor PCV/TS for repeated effusion

**DIFFERENTIAL**

**Diaphragmatic hernia**
- **RESULTS**
  - Restrictive (ie, rapid, shallow) breathing pattern
  - Decreased lung/heart sounds (ventral), thoracic borborygmi
  - ± effusion and abdominal organs

**TREATMENT**
- Basic respiratory support
- Abdominal exploratory surgery indicated

**INVESTIGATION**
- Characterize breathing pattern (rapid and shallow, inspiratory stridor vs paradoxical breathing)
- Thoracic auscultation
- POCUS

**RESULTS**
- Mixed breathing pattern
- ± crackles, ± moist lung sounds
- ± B-lines/comet trails

**DIFFERENTIAL**

**Consider pulmonary contusions**
- **RESULTS**
  - Mixed breathing pattern
  - ± crackles, ± moist lung sounds
  - ± B-lines/comet trails

**TREATMENT**
- Oxygen
- Analgesia (see Analgesia in Trauma, page 29)
- Conservative fluid therapy
- Referral for mechanical ventilation if respiratory signs do not improve or patient is clinically worse

**INVESTIGATION**
- Characterize breathing pattern (rapid and shallow, inspiratory stridor vs paradoxical breathing)
- Thoracic auscultation
- POCUS

CPR = cardiopulmonary resuscitation
MgCl = magnesium chloride
PCV = packed cell volume
POCUS = point-of-care ultrasound
SpO2 = oxygen saturation
TS = total solids
VPC = ventricular premature contraction
INVESTIGATION
MM, CRT, heart rate, BP, temperature, AFAST (see AFAST, page 26), TFAST, mentation

Possible results
- Pale mucous membranes
- Prolonged CRT
- Tachycardia
- Bradycardia (cats)
- Hypotension
- Weak femoral pulses
- Hypothermia
- Lactate >2.25 mg/dL (>2.5 mmol/L)
- Altered mentation
- Cold extremities
- Free abdominal fluid
- Free thoracic fluid

DIFFERENTIALS
- Hypovolemic (secondary to hemorrhage) shock
- Distributive shock
- Septic shock possible if hollow viscus organ rupture present

RESULTS
- Nonambulatory, potentially altered pain perception

DIFFERENTIAL
- Spinal cord injury, pelvic limb fracture
- Assume unstable spinal cord injury

TREATMENT
- Analgesia (see Analgesia in Trauma, page 29)
- Temporary immobilization until further diagnostics performed

TREATMENT
- Oxygen, analgesia (see Analgesia in Trauma, page 29)
- Temporary immobilization until further diagnostics performed

DIFFERENTIAL
- Traumatic brain injury

RESULTS
- Abnormal level of consciousness, cranial nerves, brain stem reflexes, motor responses

TREATMENT
- Oxygen, hypertonic saline/mannitol (Table 2, page 30)
- Head elevation 15-30 degrees, analgesia (see Analgesia in Trauma, page 29)
- Steroids contraindicated

AFAST = abdominal focused assessment with sonography for trauma
BP = blood pressure
CK = creatine kinase
CRT = capillary refill time
Hct = hematocrit
LRS = lactated Ringer’s solution
MAP = mean arterial pressure
MM = mucous membrane
MODS = multiple organ dysfunction
PE = pericardial effusion
POCUS = point of care ultrasound
PT = prothrombin time
PTT = partial thromboplastin time
RR = respiratory rate
SAP = serum alkaline phosphatase
SIRS = systemic inflammatory response syndrome
TFAST = thoracic focused assessment with sonography for trauma
TP = total protein
STABILIZED PATIENT

**INVESTIGATION**
Admit to hospital for at least 24 hours
- Closely monitor RR, respiratory effort, demeanor, and level of pain
- Perform serial PE, AFAST, TFAST (every 15 minutes to 12 hours as needed)
- CBC, serum chemistry profile, ± PT/PTT (repeat as necessary)
- Monitor urine output (at least 1-2 mL/kg/hour)
- See *Systemic Consequences of Trauma*, page 30

Therapeutic plan
- Fluid therapy with isotonic crystalloids (40-90 mL/kg/day)
- Continue analgesia with opioids.
- Consider NSAIDs (e.g., robenacoxib, 2 mg/kg PO every 24 hours) if normotensive and ideally eating on own
- Provide oxygen if oxygen dependent
- Address any cutaneous wounds
- Antibiotic therapy as indicated for wounds, open fractures, or septic peritonitis
- Monitor Hct, BP, oxygenation, level of pain, mentation, and cranial nerve signs
- Recumbency care if not moving on own

Discharge criteria
- Eating and drinking well
- No longer oxygen dependent (based on primary clinical signs, respiratory rate, effort)
- Pain well-managed with oral analgesics
- Adequate plan for follow-up care depending on injuries sustained

Perform diagnostic evaluations

**DIFFERENTIAL**
Diaphragmatic hernia

**RESULTS**
- Incomplete diaphragmatic silhouette
- Obscured cardiac silhouette
- ± gas filled loops/stomach in thorax

**DIFFERENTIAL**
Pleural effusion (hemothorax)

**TREATMENT**
Surgery
- Ideally delayed 3-5 days to allow improvement of pulmonary contusions if present. Indications for emergency surgery:
  - Herniated stomach
  - Strangulated bowel/organ
  - Inability to oxygenate properly despite appropriate treatment
  - Ruptured viscera

Typically resolves with supportive care.
- Thoracocentesis may be required if large volume of effusion. Oxygen support and blood transfusion may also be required.
- Assess coagulation times. Rarely requires surgical intervention, but emergent surgery may be required if large-volume bleed present

**DIFFERENTIAL**
Pneumothorax

**RESULTS**
- Silhouette effect
- Retraction of lung lobes
- Fissure lines
- Atelectasis

**TREATMENT**
Thoracocentesis
- If thoracocentesis is needed twice within a very short period (i.e., patient with recurrent pneumothorax) or negative suction cannot be obtained, consider thoracostomy tubes

**DIFFERENTIAL**
Pulmonary contusions

**RESULTS**
- Interstitial to alveolar pulmonary infiltrates

**RESULTS**
- Widened radiolucent pleural space
- Atelectasis
- Elevation of heart from the sternum

**INVESTIGATION**
See *Thoracic radiography*, page 26

**INVESTIGATION**
See *Orthopedic radiography*, page 26

**INVESTIGATION**
See *Abdominal radiography*, page 26

**INVESTIGATION**
See *POCUS (AFAST)*, page 26

Continues ➤
RESULTS
- Fracture(s)

DIFFERENTIAL
- Pelvic, appendicular, rib fractures

TREATMENT
- Pain management
- External coaptation when possible
- Internal fixation
- Cage rest
- Flail chest; place affected side down

RESULTS
- Pelvic, appendicular, rib fractures
- Minimal displacement
- Minimal neurologic deficits
- Cervical trauma
- See Three Compartment Model, page 30

TREATMENT
- Pain management
- External coaptation
- Cage rest
- Refer for CT ± MRI
- Surgical intervention

RESULTS
- Spinal fracture(s)
- Minimal displacement
- Minimal neurologic deficits
- Cervical trauma
- See Three Compartment Model, page 30

TREATMENT
- Pain management
- External coaptation
- Cage rest
- Refer for CT ± MRI
- Surgical intervention

RESULTS
- Free gas
- Pelvic, appendicular, rib fractures

TREATMENT
- Stabilization and emergency abdominal exploratory surgery

RESULTS
- Free abdominal fluid
- Pelvic, appendicular, rib fractures

TREATMENT
- Stabilization and emergency abdominal exploratory surgery

DIFFERENTIAL
- Pneumoperitoneum

TREATMENT
- Stabilize, initiate broad spectrum antibiotics and emergency abdominal exploratory surgery to evaluate and repair possible damage

RESULTS
- Effusion: serum bilirubin ratio >2
- Cytology: bile pigments

DIFFERENTIAL
- Biliary rupture

TREATMENT
- Most respond to supportive care, fluid therapy, blood transfusion, and restricted activity. May consider abdominal compression wrap, but it must be done correctly to be valuable. Surgical intervention is rarely required
- Abdominal exploratory and surgical intervention required when hemorrhage is profound and ongoing and patient cannot be stabilized

DIFFERENTIAL
- Septic abdomen

TREATMENT
- Place urinary catheter. An abdominal drain may be needed if urinary catheter is not fully draining the abdomen.
- Consider contrast study to identify source of leakage (e.g., urethra, urinary bladder, ureter).
- Surgery can be delayed for 6-24 hours if the abdominal cavity is properly drained and there is no evidence of septic peritonitis.
- Urethral tears usually heal on their own without surgical intervention

DIAGNOSTIC/MANAGEMENT TREE
- EMERGENCY MEDICINE & CRITICAL CARE
- PEER REVIEWED

Continues ➤
FIGURE 1  AFAST: Anechoic free abdominal fluid (arrows) at the diaphragmatico-hepatic view (A) and splenorenal site (B). Images courtesy of Silke Hecht, DACVR, DECVDI.

FIGURE 2  Lateral thoracic radiograph of the pneumothorax in a dog. Increased gas opacity in the pleural space, retraction of the lung lobes from the thoracic wall and diaphragm (arrowheads), separation of the cardiac silhouette from the sternum (arrow), and diffusely increased opacity of the lungs due to atelectasis can be seen. Image courtesy of Silke Hecht, DACVR, DECVDI.

FIGURE 3  Thoracic radiographs of diaphragmatic hernia in a dog. Cranial displacement of abdominal viscera (circle), loss of normal diaphragm outline (line), and displacement of thoracic structures can be seen. Images courtesy of Silke Hecht, DACVR, DECVDI.
**THORACOCENTESIS**

Thoracocentesis is often a life-saving treatment that should be performed during initial stabilization, ideally prior to radiographic confirmation of pneumothorax or pleural effusion to prevent patient decompensation in radiology.1,2,4

**ANALGESIA IN TRAUMA**

Quick and effective analgesia is essential for patients with vehicular trauma. Opioids are the drug of choice because of their efficacy and limited adverse effects. NSAIDs should be avoided until the patient is hemodynamically stable. In addition, butorphanol has minimal analgesic effects and should not be used. IM or SC administration of pure µ-receptor agonists may cause vomiting; IV administration is strongly preferred.1,13

- Morphine (0.1-0.5 mg/kg IV every 4 hours)
- Hydromorphone (0.05-0.2 mg/kg IV every 4-6 hours)
- Methadone (0.1-0.5 mg/kg IV every 4-6 hours)
- Fentanyl (2-5 µg/kg bolus, then 2-6 µg/kg/hour IV CRI)
- Buprenorphine (0.01-0.03 mg/kg IV or IM every 6-8 hours)
THREE COMPARTMENT MODEL

- Dorsal column: laminae, spinous processes and their ligaments
- Middle column: dorsal longitudinal ligament, dorsal annulus, dorsal cortex of the vertebral bodies
- Ventral column: ventral longitudinal ligament, ventral annulus, ventral cortex of the vertebral bodies

SYSTEMIC CONSEQUENCES OF TRAUMA

- Common metabolic consequences\(^6,12\):
  - Activation of the coagulation cascade
  - Hypothermia
  - GI disturbance (eg, vomiting, diarrhea)
  - Systemic inflammation (eg, SIRS, MODS)
- Common clinical pathologic abnormalities\(^2,6,12\):
  - Hyperglycemia
  - Hyperlactatemia
  - Metabolic acidosis
  - Hypoalbuminemia
  - Anemia
  - Thrombocytopenia
  - Increased ALT
  - Increased CK
  - Prolonged PT/PTT

### TABLE 2

<table>
<thead>
<tr>
<th>Perfusion Parameters</th>
<th>Normal Endpoints</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart rate</td>
<td>Dogs: 60-120 bpm</td>
</tr>
<tr>
<td></td>
<td>Cats: 160-220 bpm</td>
</tr>
<tr>
<td>MM color</td>
<td>Pink</td>
</tr>
<tr>
<td>CRT</td>
<td>1-2 seconds</td>
</tr>
<tr>
<td>Temperature</td>
<td>99°F-102.5°F (37.2°C-39.2°C)</td>
</tr>
<tr>
<td>Mentation</td>
<td>Alert</td>
</tr>
<tr>
<td>SAP (systolic BP)</td>
<td>&gt;90 mm Hg</td>
</tr>
<tr>
<td>MAP (mean BP)</td>
<td>&gt;70 mm Hg</td>
</tr>
<tr>
<td>Urine output</td>
<td>1-2 mL/kg/hour</td>
</tr>
<tr>
<td>Lactate</td>
<td>&lt;22.5 mg/dL (2.5 mmoL)</td>
</tr>
</tbody>
</table>

**BP** = blood pressure  
**CRT** = capillary refill time  
**MAP** = mean arterial pressure  
**PT** = prothrombin time  
**PTT** = partial thromboplastin time  
**SIRS** = systemic inflammatory response syndrome

References