VEHICULAR TRAUMA

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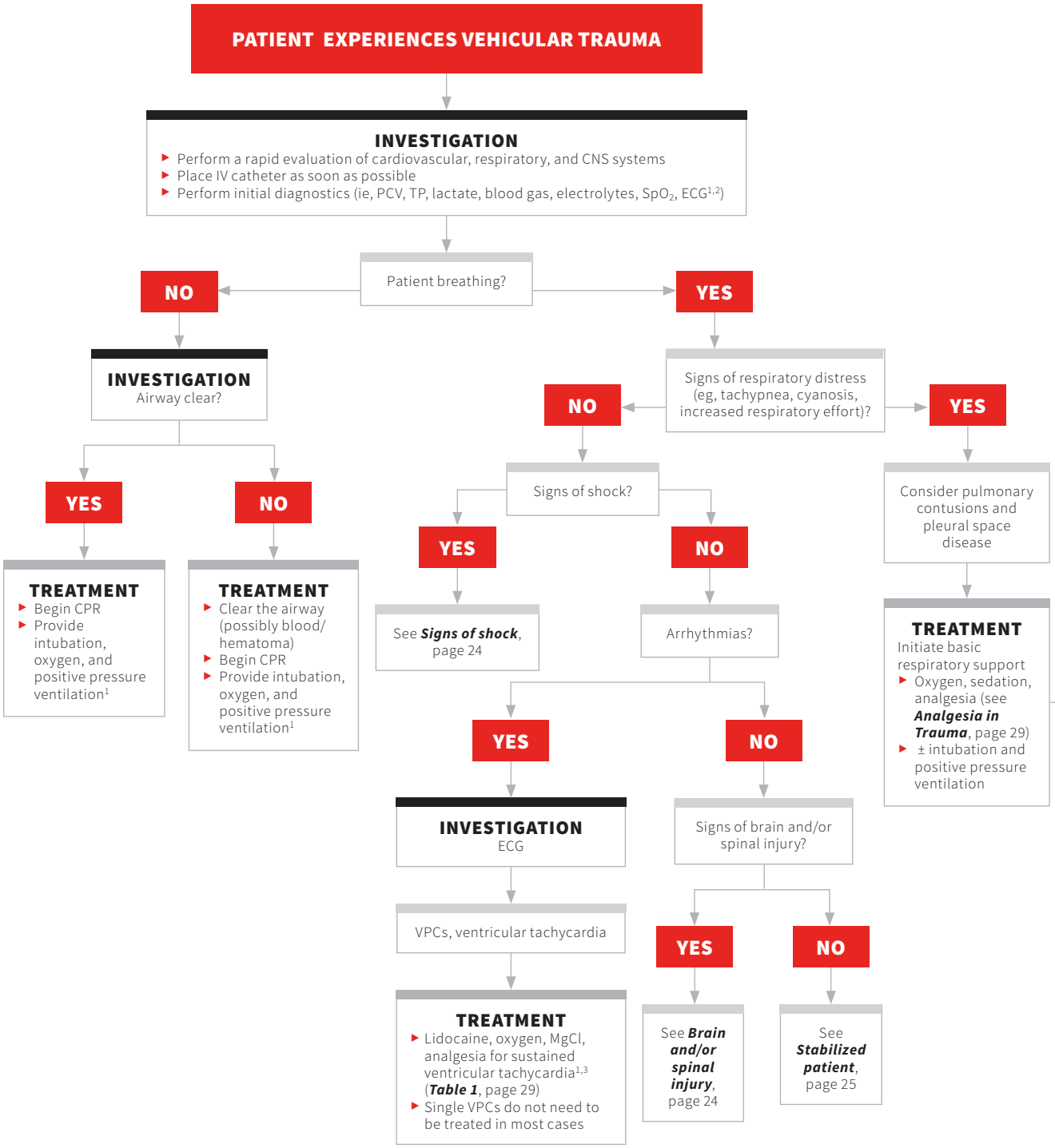

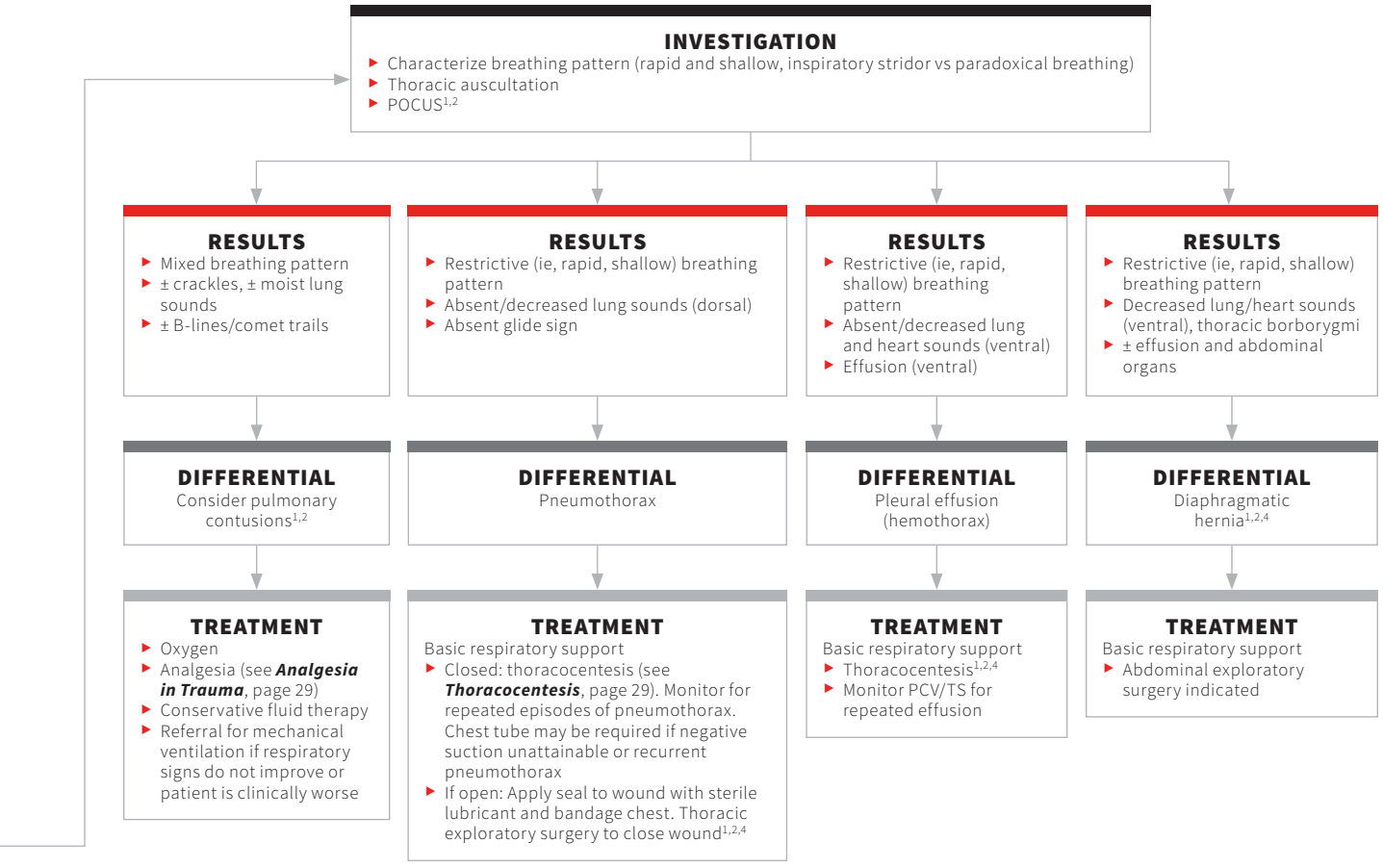

CPR = cardiopulmonary resuscitation
MgCl = magnesium chloride
PCV = packed cell volume
POCUS = point-of-care ultrasound
SpO_2 = oxygen saturation
TS = total solids
VPC = ventricular premature contraction

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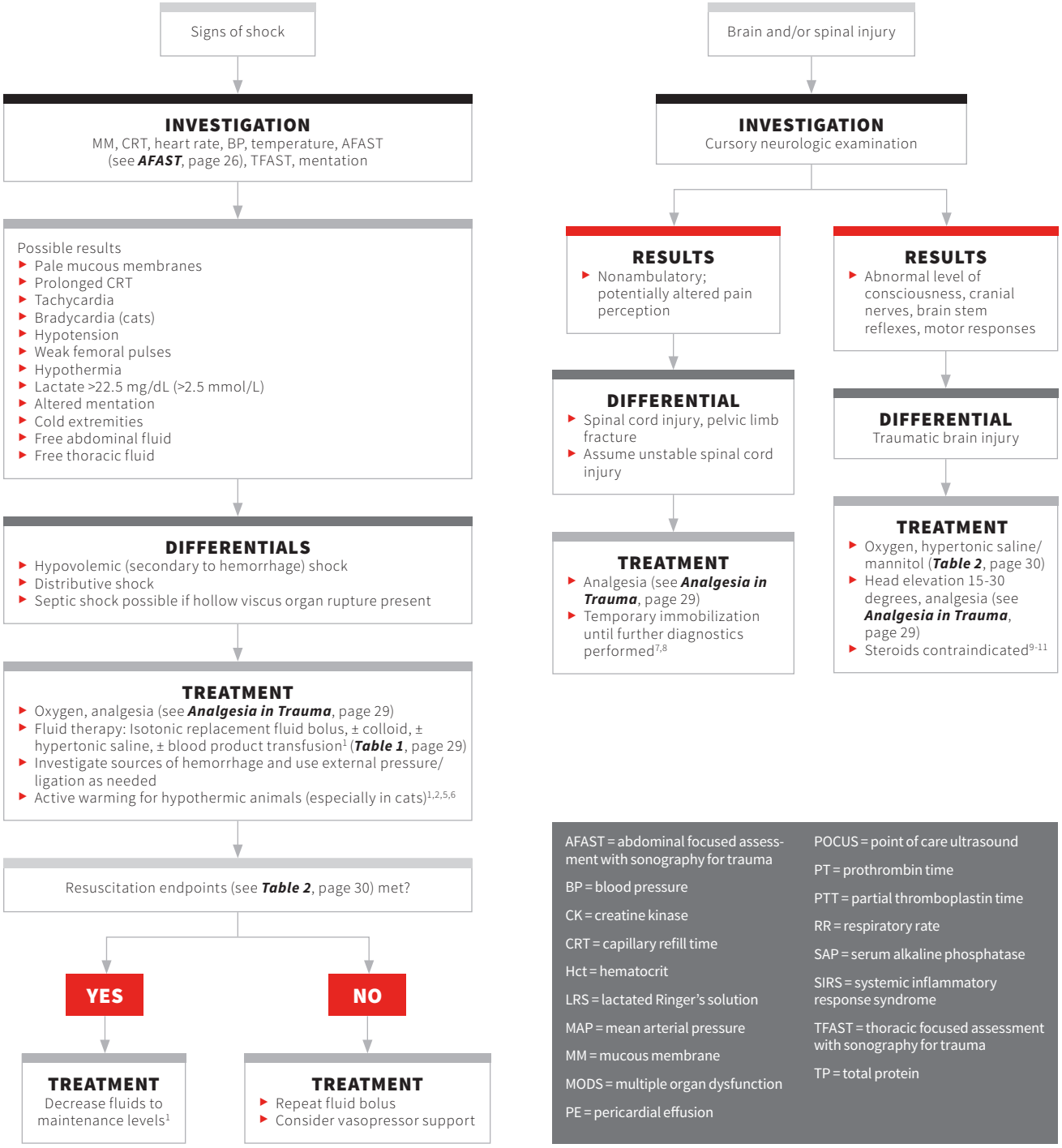

AFAST = abdominal focused assessment with sonography for trauma

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)[7]
- 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 (eg, 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

INVESTIGATION
Thoracic radiography

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

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

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

RESULTS

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

DIFFERENTIAL
Diaphragmatic hernia

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

RESULTS

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

DIFFERENTIAL
Pleural effusion (hemothorax)

TREATMENT

- 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[1,4,12]

RESULTS

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

DIFFERENTIAL
Pneumothorax

TREATMENT

- Thoracocentesis
- If thoracocentesis is needed twice within a very short period (ie, patient with recurrent pneumothorax) or negative suction cannot be obtained, consider thoracostomy tubes[1,4]

RESULTS

- Interstitial to alveolar pulmonary infiltrates

DIFFERENTIAL
Pulmonary contusions

TREATMENT

- Supportive care
- Rest, monitor for 24 hours
- May not be appreciable on radiographs for 24 hours[1,4]

RESULTS

- ***Fractures(s)*** (see ***Fracture[s]*** under ***Orthopedic radiography*** page 26)

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INVESTIGATION
Orthopedic radiography
RESULTS
Fracture(s)
RESULTS
Pelvic, appendicular, rib fractures
TREATMENT
Pain management
External coaptation when possible
± internal fixation
Cage rest
Flail chest: place affected side down[1,7,8]
RESULTS
Spinal fracture(s)
Minimally displaced
Minimal neurologic deficits
Cervical trauma
See Three Compartment Model, page 30
TREATMENT
Pain management
External coaptation
Cage rest
Refer for CT ± MRI
± surgery[7,8]
RESULTS
Spinal fracture(s)
Significant neurologic deficits
Penetrating injury
2 of 3 spinal compartments affected indicates patient is unstable (see Three Compartment Model, page 30)
TREATMENT
Pain management
Immobilize
Refer for CT ± MRI
± surgery as soon as possible[7,8]
INVESTIGATION
Abdominal radiography
RESULTS
Free gas
DIFFERENTIAL
Pneumoperitoneum
TREATMENT
Stabilization and emergency abdominal exploratory surgery
RESULTS
Peripheral blood to abdominal fluid glucose difference ≥20 mg/dL
Effusion lactate ≥22.5 mg/dL (≥2.5 mmol/L) (dogs)
Cytology: Neutrophils (often degenerate), presence of intracellular bacteria
DIFFERENTIAL
Septic abdomen
TREATMENT
Stabilize, initiate broad spectrum antibiotics and emergency abdominal exploratory surgery to evaluate and repair possible damage
INVESTIGATION
POCUS (AFAST)
RESULTS
Free abdominal fluid
INVESTIGATION
Abdominocentesis
Compare PCV/TS, creatinine/potassium, bilirubin, glucose, and lactate of effusion to peripheral blood and cytology
RESULTS
Effusion:serum bilirubin ratio >2
Cytology: bile pigments
DIFFERENTIAL
Biliary rupture
TREATMENT
Emergency abdominal exploratory surgery to evaluate and repair possible damage as soon as patient is stable[1]
RESULTS
PCV/TS of effusion ≈ PCV/TS of peripheral blood
DIFFERENTIAL
Traumatic hemoabdomen
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 stablized[1]
RESULTS
Effusion:serum creatinine ratio >2
Effusion: serum potassium ratio >1.9 (cats) >1.4 (dogs
DIFFERENTIAL
Uroabdomen
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 (eg, 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[1]

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ANCILLARY MATERIAL TO VEHICULAR TRAUMA

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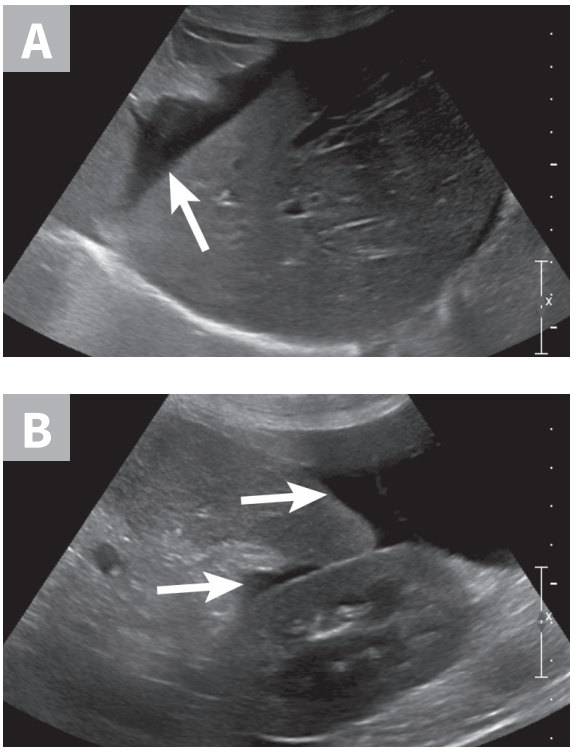
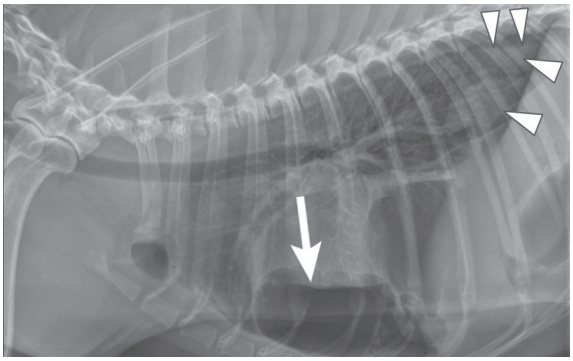
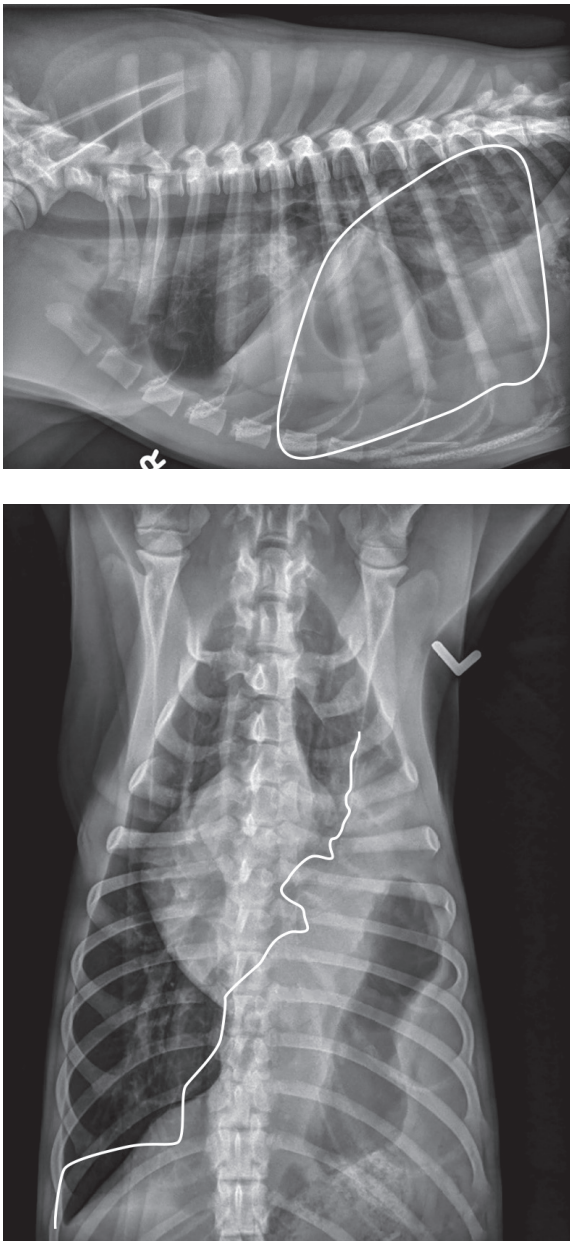


▲ **FIGURE 1** AFAST: Anechoic free abdominal fluid (***arrows***) at the diaphragmatico-hepatic view (***A***) and splenorenal site (***B***). *Images courtesy of Silke Hecht, DACVR, DECVDI*



▲ **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*

TABLE 1

GENERAL GUIDELINES FOR FLUID RESUSCITATION & BLOOD TRANSFUSION IN PATIENTS WITH TRAUMA

Perfusion Parameters	Normal Endpoints
Whole blood[5]	Dogs: 20-30 mL/kg given over 30 minutes to 4 hours, depending on how critical the patient is Cats: 50-60 mL/cat (NOT mL/kg) given over same time period as for dogs
Packed RBCs[5]	Dogs: 15 mL/kg given over same time frame as whole blood Cats: 30-40 mL/cat (NOT mL/kg) given over same time frame as for dogs
Synthetic colloid (controversial)[5]	1-5 mL/kg given over 15 minutes
Fresh frozen plasma[5]	15-30 mL/kg for patients with coagulopathy and active hemorrhage
Isotonic fluid shock bolus (LRS, Norm-R, 0.9% sodium chloride, Plasma-Lyte)[5,9]	10-25 mL/kg given over 15 minutes. End goals should be reassessed; may be repeated until entire shock dose administered. Dog shock dose: 90 mL/kg/hour; cat shock dose: 50-60 mL/kg/hour
Hypertonic saline[5,9]	4-6 mL/kg given over 15 minutes; may be repeated 2-3 times in 24 hours
Mannitol[9]	0.5-1.5 g/kg IV given over 15 minutes, may be repeated 2-3 times in 24 hours
Lidocaine[3]	2 mg/kg IV bolus, followed by 50-80 µg/kg/minute if rhythm converts

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)

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ANCILLARY MATERIAL TO VEHICULAR TRAUMA CONTINUED

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

RESUSCITATION ENDPOINTS

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

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

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