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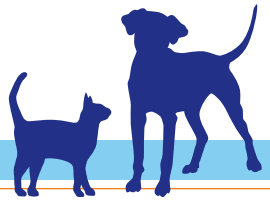

# Pulmonary Contusions

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Pulmonary contusions are a common consequence of blunt thoracic trauma that causes compression–decompression injury to the thoracic wall. Contusions are characterized by damage to the pulmonary vasculature and subsequent leakage of blood and plasma into the interstitium and alveoli followed by massive infiltration with inflammatory cells 24 hours later. The extent of the injury ranges from mild focal bruising in one lung lobe to severe diffuse hemorrhage affecting the entire lung. The severity of the clinical signs depends on the amount of lung affected and ranges from mild respiratory signs to severe respiratory impairment or failure. Because pulmonary impairment from contusions may continue to progress until 24 to 48 hours after the traumatic episode, animals can present with adequate respiratory function and later decompensate. Therefore, close monitoring of these patients is essential to ensure that if signs develop, the patients can be treated appropriately. Diagnosis of pulmonary contusion is based on recent history of thoracic trauma, respiratory compromise, and radiographic findings. Radiographic evidence of pulmonary contusions may not become evident until 4 to 24 hours after trauma; therefore, radiographs obtained before this time may appear normal.

A high index of suspicion for pulmonary contusions should be present in any animal that sustains chest trauma, especially those with concurrent thoracic wall injuries. Pulmonary contusions occur in approximately 40% to 50% of all animals sustaining chest injuries and are most frequently caused by motor vehicle accidents. Concurrent injuries are common and include fractured ribs, flail chest, diaphragmatic hernia, pneumothorax, hemothorax, and head trauma. Care of patients with pulmonary contusions is primarily supportive and includes oxygen therapy, pain management, and management of shock and concurrent injuries. Morbidity is high for patients with pulmonary contusions; however, the mortality rate in dogs has been reported to be approximately 7%. Animals with shock or concurrent injuries and those requiring mechanical ventilation tend to have a poorer prognosis. In animals that survive, clinical signs usually resolve within approximately 1 week.

## DIAGNOSTIC CRITERIA

### Historical Information

#### *Gender Predisposition*

- Males seem to sustain trauma more commonly than females.

### *Editorial Mission*

*To provide busy practitioners with concise, peer-reviewed recommendations on current treatment standards drawn from published veterinary medical literature.*

*This publication acknowledges that standards may vary according to individual experience and practices or regional differences. The publisher is not responsible for author errors.*

*Reviewed 2015 for significant advances in medicine since the date of original publication. No revisions have been made to the original text.*



### *KEY TO COSTS*

**$** *indicates relative costs of any diagnostic and treatment regimens listed.*

## Age Predisposition

- Dogs and cats of any age can be affected.
- Tends to occur in young to middle-aged dogs.

## Breed Predisposition

- Any breed can be affected; however, large- and mixed-breed dogs are documented most commonly.

## Owner Observations

- Respiratory signs range from tachypnea to respiratory distress, orthopnea, and open-mouth breathing.
- Hemoptysis or the presence of blood-tinged fluid in the nose or mouth may also be seen.
- Other signs of trauma, especially thoracic injuries, are often seen concurrently.

## Other Historical Considerations/Predispositions

- The vast majority of animals with pulmonary contusions have sustained some form of blunt thoracic trauma.
- Motor vehicle accidents are the most common cause.
- Animal altercations, falls, human abuse, and crushing injuries are other, less common causes.
- Skull, scapular, cervical, or vertebral fractures are the most common nonthoracic injuries seen in dogs with pulmonary contusions.

## Physical Examination Findings

Clinical signs vary depending on the severity of the injury and range from mild to pronounced respiratory compromise. Despite radiographic signs (see Diagnostic Tests) of pulmonary contusions, clinical signs may be absent.

- — **Mild:** Increased respiratory rate.
- — **Moderate:** Increased respiratory effort, orthopnea.
- — **Severe:** Open-mouth breathing, respiratory distress, cyanosis.

- Fine crackles may be detected on thoracic auscultation.
- Hemoptysis or the presence of blood or blood-tinged fluid coming from the nose or mouth may be seen in severe cases.
- Signs of shock, including thready or weak peripheral pulses, tachycardia, pale mucous membranes, prolonged capillary refill time, and cool extremities, may be evident.
- Concurrent thoracic injuries such as rib fractures, thoracic wall injuries (flail chest, intercostal rents), diaphragmatic hernia, pneumothorax, and hemothorax may also be evident. The presence of pneumothorax or hemothorax may reduce lung sounds dorsally and ventrally, respectively, during thoracic auscultation.
- Arrhythmias may develop because of shock, myocardial contusions, or autonomic imbalance.
- Hypovolemia may make heart sounds less audible.
- Other musculoskeletal injuries such as long bone fractures may also be present.
- Evidence of pain may be elicited upon palpation of the thorax or other injured areas.

### ASSESSING OXYGENATION STATUS

A–a gradient:

- A–a gradient = A – a
  - A = $FIO_2 \times (P_b - 47) - PaCO_2/0.8$
    - $P_b$ = barometric pressure
    - 47 = water vaporization pressure
    - $FIO_2$ = percentage of inspired oxygen (see below)
  - a = $PaO_2$
- $PaO_2$:$FIO_2$
  - $PaO_2/FIO_2$
    - $FIO_2$ (room air) = 0.21
    - $FIO_2$ (nasal oxygen or face mask) = 0.40

- An animal that has sustained head trauma or is in shock may have altered mentation.

## Laboratory Findings

- The most sensitive way to evaluate the respiratory compromise is to perform an arterial blood gas (ABG) analysis:
  - — $PaO_2$ <70 mm Hg indicates hypoxemia. Hypoxemia is most likely caused by ventilation–perfusion mismatch as a result of the hemorrhage and edema in the interstitium and alveoli.
  - — $PaCO_2$ >50 mm Hg indicates hypoventilation, and a normal $PaCO_2$ level in the face of increased respiratory effort indicates significant respiratory insufficiency. Hypoventilation may be caused by a combination of mechanical disruption of the rib cage or diaphragm, respiratory muscle fatigue, and pain.
  - — An elevated A–a (alveolar–arterial) oxygen gradient demonstrates a decreased ability of the lung to oxygenate the blood and may be caused by impaired diffusion or ventilation–perfusion mismatch. An A–a gradient >20 indicates compromised oxygenation.
  - — A ratio of $PaO_2$:$FIO_2$ can also be used to compare the arterial oxygen with the amount of oxygen that the animal is breathing in. This can be used to assess the response to oxygen supplementation in patients with pulmonary contusions. A value <300 suggests acute lung injury, and a value <200 suggests acute respiratory distress syndrome. The box on this page shows how these values are calculated.
- Elevations in alanine transaminase (ALT) level may be caused by blunt hepatic trauma or hypoxia-induced hepatocellular injury.
- Elevations in aspartate transaminase (AST) level may also occur and are likely secondary to muscle injury.
- If significant hemorrhage is occurring, decreases in packed cell volume (PCV) and total solids are likely. In dogs, the PCV may remain normal for several hours after hemorrhage because of splenic contraction.

### Other Diagnostic Findings

- **Radiography** $
  - — Thoracic radiographs should be obtained for all patients that have sustained trauma, especially those demonstrating signs of respiratory compromise.
  - — Radiographs reveal an interstitial or alveolar pulmonary infiltrate. It may be patchy or diffuse and does not typically follow an anatomic pattern (i.e., not limited to certain lung lobes).
  - — Radiographic evidence of contusions may not be seen until 4 to 24 hours after the injury. If changes are seen sooner, they are deemed more severe.
  - — Radiographs may be taken sooner to rule out concurrent thoracic injuries and to serve as a baseline for monitoring the contusions that become radiographically evident later.
  - — The presence of rib fractures or flail chest suggests the likely presence of underlying contusions even when they are not seen radiographically.
- **Bronchoscopy:** Not typically performed unless an airway rent is suspected. Blood or blood-tinged froth or fluid may be seen throughout the affected airways. Airway tears may also be seen. $$
- **Computed tomography (CT) scan:** Able to detect pulmonary contusions immediately after the injury and may also identify lung tears. Used in humans to predict the need for mechanical ventilation after chest trauma. $$
- **Electrocardiography (ECG):** May reveal arrhythmias such as ventricular premature contractions, ventricular tachycardia, sinus tachycardia, or accelerated idioventricular rhythm. $
- **Blood pressure:** Systolic blood pressure <100 mm Hg or mean arterial blood pressure <80 mm Hg indicates hypotension and is likely caused by shock. $

### Summary of Diagnostic Criteria

- Clinicians should have a high index of suspicion for pulmonary contusions in any animal that has sustained blunt trauma to its chest. Signs of respiratory compromise such as tachypnea, respiratory distress, open-mouth breathing, or hemoptysis are strong indications that contusions are present.
- Fine crackles may be heard on thoracic auscultation if contusions are present; however, decreased lung sounds may be detected if fluid or air is present in the pleural space. Thoracic radiographs should be obtained when the animal is stable to establish what injuries are present; contusions appear as a patchy or diffuse interstitial or alveolar pulmonary infiltrate.
- If an animal is in shock after the trauma, additional signs may include tachycardia, pale mucous membranes, prolonged capillary refill time, weak or thready pulses, or hypotension. Arrhythmias may also be detected on auscultation or with an ECG.
- ABG analysis should be performed for animals with significant respiratory signs to determine the severity of respiratory compromise. The procedure must not require restraint in lateral recumbency if the animal has labored breathing or signs of respiratory distress; in these patients, the optimal collection site is the dorsal pedal artery. Hypoxemia, if present, is likely attributable to the lung injury; hypercarbia indicates hypoventilation.

### Diagnostic Differentials

- Pneumonia is a differential diagnosis for the radiographic findings; however, it generally follows a specific pattern (i.e., affecting certain lung lobes) and is less likely than contusions after thoracic trauma. Other radiographic differential diagnoses may include cardiogenic pulmonary edema, noncardiogenic pulmonary edema, and pulmonary hemorrhage from other causes (e.g., anticoagulant rodenticide toxicity).

## TREATMENT RECOMMENDATIONS

### Initial Treatment

- The animal should be rapidly assessed immediately upon arrival to ensure that it has a patent airway and is breathing. Severe contusions may cause copious amounts of blood-tinged froth or fluid to fill the airways. The mouth should be swabbed and suctioned to remove any froth or fluid. If necessary, endotracheal intubation should be performed to facilitate suctioning of the lower airways and enable ventilation if necessary. $
- Flow-by or mask oxygen should be administered at 5 to 10 L/min, or if the animal will tolerate it, a nasopharyngeal catheter should be placed to deliver oxygen at 1 to 2 L/min. $
- If pneumothorax is present and contributing to the respiratory compromise, therapeutic thoracocentesis should be performed immediately. $
- If thoracic wounds are present, the wound should be covered with a gloved hand or a simple occlusive dressing applied to ensure closure of the wound and prevent an open pneumothorax. $
- An IV catheter should be placed so that fluid and drug administration can be performed. $
- Animals in shock require isotonic crystalloids in 5- to 10-ml/kg boluses administered over 10 minutes and repeated until adequate perfusion is achieved. This can be determined by monitoring arterial blood pressure, pulse quality, mucous membrane color, capillary refill time, skin temperature, mentation, urine output, and plasma lactate concentration. Central venous pressure (CVP) should be measured in patients that respond poorly to initial fluid administration. Unfortunately, although helpful, CVP may be challenging to interpret in patients with concurrent pneumothorax or hemothorax. Fluid therapy should continue until perfusion is judged adequate to meet the animal's oxygen delivery needs. Fluids in excess of this should not be administered because this will worsen ongoing hemorrhage and pulmonary edema formation. $

- Colloids such as hetastarch may also be used, especially in patients whose hemodynamic improvements with crystalloids are short lived. Boluses of 5 to 10 ml/kg over 15 to 30 minutes are used. It is not recommended to exceed the maximum daily dose of 20 ml/kg. (The use of colloids is also discussed in the Checkpoints.) $
- Four to 6 ml/kg of hypertonic (7.5%) saline over 10 minutes may be used to restore circulation. Some believe that hypertonic saline may have a lower risk of causing pulmonary edema; others believe that hypertonic saline increases the likelihood of pulmonary edema. $
- Pain must be addressed by administering analgesic agents. If an animal with thoracic injury is in pain, the animal may limit its chest excursions, leading to hypoventilation. Narcotic analgesics are a safe and effective way to treat pain in these patients, and when used alone at appropriate doses, these agents do not cause clinically significant hypoventilation. Continuous-rate infusions (CRIs) may be required to achieve adequate analgesia. Options include: $
  - **Fentanyl:** Dogs and cats: 1–2 µg/kg IV bolus, followed by 2–5 µg/kg/hr IV CRI. A fentanyl patch may be placed as soon as the animal is stable.
  - **Hydromorphone:** Dogs: 0.05–0.1 mg/kg IV or IM q4h; cats: 0.02–0.05 mg/kg IV or IM q4h.
  - **Morphine:** Dogs: 0.5–2.0 mg/kg IM or SC q4h.
  - **Buprenorphine:** Dogs and cats: 0.01–0.015 mg/kg IM or IV q8h.

## Alternative/Optional Treatments/Therapy

- **Mechanical ventilation** may be indicated in patients that are unconscious or unable to maintain a patent airway. An animal may also need to be mechanically ventilated if it has severe respiratory compromise that is unresponsive to oxygen supplementation alone or if it is demonstrating clinical signs of respiratory deterioration or fatigue. If an animal has an ABG with a $PaO_2$ <60 mm Hg despite an oxygen supplementation of ≥50% or a $PaCO_2$ >55–60 mm Hg, mechanical ventilation is recommended. $$$$
- **Emergency ventilation** can be achieved manually using an anesthetic machine reservoir bag or an Ambu bag. $–$$
- Long-term ventilation requires a mechanical ventilator. $$$$
- If IV analgesics are not adequate to maintain pain control, **local or epidural analgesia** may be required. If rib fractures or flail chest are present, local anesthetics can be applied at the caudal border of each rib, above and below each fracture site, and at the caudal borders of the rib cranial to and caudal to the flail segment. $
  - **Lidocaine** (1%–2%): Total dose, 2–4 mg/kg (dogs only).
  - **Bupivacaine** (0.25%–0.5%): Total dose, 1–2 mg/kg (dogs and cats).
  - The volume delivered at each site should be approximately 0.5 ml.

## CHECKPOINTS

— ***Fluid resuscitation in patients with pulmonary contusions is a controversial issue in terms of the fluid of choice and rate of administration.*** *The concern is that fluid administration may cause pulmonary edema and worsen signs of respiratory compromise. It is recommended that fluid therapy be titrated to restore adequate perfusion and cardiac output without administration of excessive quantities that may exacerbate hemorrhage and edema. Careful monitoring ensures that fluid overload does not occur. The fluid of choice varies among clinicians. Although many clinicians prefer colloids to crystalloids based on the assumption of a protective effect of preserving plasma oncotic pressure, no experimental or clinical data are available to suggest that the type of fluid administered has a significant impact on pulmonary edema. Furthermore, excessive dosages of starch-based colloids interfere with platelet function and may aggravate hemorrhage. Regardless of the fluid chosen, it should be used judiciously in animals that are not in shock; giving intermittent boluses and conservative rates to stabilize the patient is recommended. Fluids should never be withheld from a patient that is in hypovolemic shock, particularly after any hemorrhage is controlled.*

— ***Although the use of steroids in patients with pulmonary contusions is widespread, to date, no consistent evidence suggests that steroid therapy improves outcome from traumatic lung injury.*** *Because high-dose steroid therapy poses significant risks, including predisposing patients to secondary infections, the use of steroids in these patients is not recommended.*

## Supportive Treatment

- Cage rest is recommended to ensure that concurrent injuries heal and less strain is placed on the patient's respiratory system. $
- If the patient prefers lateral recumbency, it should be turned every 4 to 6 hours to decrease congestion of the dependent lung. Animals that resist or should not lie on one side should be maintained in sternal recumbency. $
- Decubital ulcers caused by pressure and urine scald should be avoided by providing adequate hygiene and clean, padded bedding. $
- Antiarrhythmic agents may be required to treat ventricular tachycardia. Lidocaine (2%) 2 mg/kg IV slow bolus (repeat up to 8 mg/kg) followed by 25–75 µg/kg/min IV CRI may be used (in dogs only). Sotalol 2–3 mg/kg PO q12h may also be used. $
- Hypotension that is refractory to fluid therapy early in the course of resuscitation indicates the presence of uncontrolled bleeding, cardiac tamponade, or pneumothorax and represents a surgical emergency.
- Packed red blood cell or whole blood transfusions may be required for patients that have sustained blood loss because of

their injuries. Significant blood loss over a short period of time or a PCV <25% is an indication for a blood transfusion. $$
- Antibiotics are indicated in patients with open fractures or wounds. $
  - — **Ampicillin–sulbactam:** 22 mg/kg IV q8h.
  - — **Amoxicillin–clavulanic acid:** 13.75 mg/kg PO q8–12h.
  - — **Cefazolin:** 22 mg/kg IV q8h.
  - — **Cephalexin:** 30 mg/kg PO q8h.

### Patient Monitoring

- Animals with pulmonary contusions should be closely monitored because they have often sustained multiple injuries and are in critical condition. Also, contusions tend to worsen 12 to 24 hours after the injury, so deterioration can occur.
- Routine monitoring should include electrocardiography, blood pressure monitoring, pulse oximetry, and serial ABG measurements. Hypotension, tachycardia, and prolonged capillary refill time are indications for more aggressive cardiovascular support. Persistent hypoxemia or low oxygen saturation during appropriate oxygen supplementation suggests that mechanical ventilation may be warranted.
- PCV and total solids should be rechecked at least once or twice daily to monitor for continued blood loss.
- Chest radiographs may also be repeated to monitor the progression of the contusions but may be less sensitive than serial ABG measurements.

### Home Management

- **Cage rest** must be strictly enforced to allow the injuries to heal and to avoid placing additional strain on the patient's breathing.
- **Analgesic agents** such as NSAIDs should be administered to ensure that the patient is comfortable.
- The owner must watch for any signs of **respiratory compromise.** If these signs are noted, the owner must immediately seek veterinary care for the pet.

### Milestones/Recovery Time Frames

- Respiratory parameters are generally worst at 24 to 48 hours after the trauma and improve by days 3 to 5.
- Pulmonary contusions typically resolve within 7 to 10 days. (Although most animals clinically recover much faster, the pulmonary contusions themselves are not thought to resolve for approximately 7 to 10 days.)

### Treatment Contraindications

- **Prophylactic antibiotics** are not indicated unless concurrent wounds or open fractures are present or secondary pneumonia develops, as documented by a positive bacterial culture.
- **Diuretic therapy** is only indicated if pulmonary edema or fluid overload occurs. Diuretics may cause hypovolemia and worsen the cardiovascular status of an already compromised patient in shock.
- **Steroid administration** has no proven benefit in patients with pulmonary contusions and is not recommended.
- **Bronchoconstriction** to compromised lung lobes is a physiologically appropriate response that should not be counteracted with bronchodilator therapy; bronchodilators are not recommended.

## PROGNOSIS

### Favorable Criteria

- Animals that are not showing signs of respiratory compromise by 48 hours after thoracic injury are less likely to have sustained severe pulmonary contusions.
- The prognosis for dogs with pulmonary contusions is better if they weigh >25 kg. This is likely because they sustain less lung injury and have more pulmonary reserve than smaller dogs.
- Patients that do not present in shock or do not have concurrent injuries typically have a more favorable prognosis.

### Unfavorable Criteria

- Patients with severe pulmonary contusions, as evidenced by signs of respiratory distress, increased respiratory effort, or hemoptysis, have a poorer prognosis.
- Patients requiring mechanical ventilation have a less favorable prognosis.
- Patients with radiographic evidence of contusions within 4 to 6 hours after the trauma likely have more severe contusions.
- Patients that are hemodynamically unstable have a poorer prognosis.
- Patients with concurrent thoracic or abdominal injuries, severe blood loss, or head trauma have a poorer prognosis.

## RECOMMENDED READING

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