Chest and Airway Trauma
Martin Downes MVB PhD

Initial Survey
In the initial consult it is prudent to determine the history of the INCIDENT, vs. the patient as time is often limited to make an initial assessment. ABC status should be determine, A-airway, B-breathing, C-cardiovascular status and neurologic status of the patient and any life-threatening problems treated immediately, with the patient stabilizing before moving on to the next system. Vital signs should be recorded and blood samples taken for minimal database and include packed cell volume, total solids (protein), blood glucose, ACT, and urine specific gravity.

Things to take specific note of:
- a.) Arterial bleeding: often seen with open long bone fractures, hemothorax, or splenic and liver fractures;
- b.) Respiratory system: consider both oxygenation and ventilation;
- c.) Cardiovascular system: consider both pump and volume;
- d.) Neurologic system: consider both central and peripheral neurologic injury;
- e.) Tertiary systems (liver, kidney, spleen, bladder);
- f.) Musculoskeletal systems

Thoracic Survey
This starts with detailed evaluation of potential life-threatening injuries in the thorax. Pattern of respiration is especially important to note when examining a chest trauma case:
- Rapid, shallow pattern
  - pneumothorax, effusions, and diaphragmatic hernia
- Slower, more laboured (abdominal)
  - respiration pulmonary injury generally results
  - pain may limit chest movements and cause a shallower pattern.
- Slow, shallow breathing and paradoxical respiration
  - head or cervical spinal trauma.
- Areas of dullness
  - haemothorax or diaphragmatic hernias
- Harsh adventitious lung sounds
  - pulmonary contusions
- Decreased lung sounds/simultaneous auscultation and percussion
  - pneumothorax

Thoracic radiographs are not indicated for initial assessment of thoracic injury due to the stress and possible complications of sedation/anaesthesia of an already compromised patient. However performing needle thoracocentesis to detect the presence of air or fluid is a very quick and relatively stress free diagnostic tool. Then when initial stabilization is obtained, radiographs can be performed.

Often signs of thoracic injury may not be evident on initial assessment, especially on radiographs or even electrocardiographs as some conditions can develop much later, therefore periodic reassessment is mandatory to prevent respiratory or cardiovascular problems being overlooked going forward.
Arterial blood gas analysis and pulse oximetry are important tools to utilize when determining the functional capacity of compromised cardiopulmonary system.

Generally speaking, physical exam, arterial blood gas analysis, and pulse oximetry are the tools used to evaluate thoracic injury in the emergency room followed by thoracocentesis, radiology, electrocardiography and ultra-sonography.

**Thoracocentesis**
This is a very useful tool and very easy to perform. Thoracocentesis can be carried out in a standing patient, or in sternal or lateral recumbancy. The location is the seventh or eighth intercostals space with the dorsoventral location of the puncture being influenced by whether fluid or air is expected to be aspirated.

Tools:
- An 18-20 gauge needle, or IV catheter
- A 3-way stopcock and a
- 20-60 ml syringe
- IV extension tubing (if necessary).

The skin is pulled cranially first and the needle is inserted into the intercostal space, but not the peritoneum, at a 90-degree angle to the skin surface. The skin is let go, and the thoracic peritoneum is penetrated at a 45-degree angle with the needle pointing cranially.

Sedation or local infiltration is necessary if the patient is extremely anxious or painful. Sedation is usually with valium and butorphanol IM or IV. Clipping and prep are done IF time allows though it may be overlooked if this is a life saving and immediately required procedure.

**Pulse oximetry**
Pulse oximetry measures oxygen saturation and allows the instantaneous estimation of arterial oxyhemoglobin. It is measured via transmission of light through the skin, and reading the absorption of light by hemoglobin. The arterial oxyhemoglobin saturation (SaO2/SpO2) is not linearly related to the PaO2, but it provides continuous information on oxygen delivery to the periphery and is most useful as a real-time monitor. Instruments are relatively inexpensive, safe, easy to use, and well tolerated by patients. It is a good method of measuring oxygen delivery however changes in hemoglobin concentration and peripheral vasoconstricted will make readings difficult to interpret.

Interpretation:
- Expect saturation levels to be 95% or greater
- Exercise caution if levels fall below 95% and investigate cause
- Act quickly if levels fall below 90%

SaO2 <90%:
- Check the probe positioning.
- Check oxygen
- Check breathing of the patient.
- Consider respiratory stimulants.
Arterial blood sampling
Arterial blood gas is much more accurate than pulse oximetry and sampling is an easy art to master with practice, however certain equipment is required if this procedure is to be carried out and blood gas analyzers like an iSTAT, STATpal, NOVA or standard bench-top laboratory blood gas analyzers are required (more on this in preparing for an emergency).

The goal of arterial blood sampling is to determine the animal’s efficiency of oxygenation and ability to ventilate. As a general rule; patients with PaO2 levels below 80 mmHg require oxygen supplementation and a PaO2 of less than 60 mmHg with an inhaled oxygen > 50% indicates a need for mechanical ventilation. It is also important to bear in mind that PaCO2 is important and is a measure of the patients’ ability to ventilate. Hypoventilation is indicated by increases PaCO2 and hypoventilation in an animal without significant head trauma is indicative of severe contusion, patients with PaCO2 values exceeding 50 mmHg require mechanical ventilation.

If a tension pneumothorax or severe parenchymal damage is suspected percutaneous placement of an arterial catheter can be a very useful tool for repeated blood gas analysis.

Site for arterial sampling:
- Femoral artery (individual sample only, not suitable for catheterization or repeated measures)
- Dorsal metatarsal artery. (the proximal metatarsus, medial to the extensor tendons, between the second and third metatarsal bones)
- Dorsal pedal artery (medial to the long digital extensor tendon at the level of the proximal tarsus).

In the patients with severe hypoperfusion, hypercapnia and acidemia at the tissue level it may be better to measure PO2 (normal range = 40-50mmHg) and PCO2 (=PaCO2/0.87) central venous blood vs. arterial blood; however these are not a direct representation and should be used as a guideline to treatment.

Oxygenation or ventilation impairment
If oxygenation or ventilation is impaired, a number of conditions should be initially considered in the chest trauma patient. We will focus on a few of these in this lecture, in all of the following cases supportive care is necessary and should be tailored to the individual patient. All forms of chest trauma are extremely painful and optimum pain relief is required, we generally using an opiate, sedative or a combination of drugs to provide the optimum pain management for our patients.

Pulmonary Contusions
Pulmonary contusions are probably the most common injuries following chest trauma. Damage to the lung causes hemorrhage and oedema into the interstitium, alveoli, and small airways. Contusions may not appear for up to 12 hours and careful monitoring is required as they may lead to hypoxemia - pain induced hypoventilation may be contributory and decreased cardiac output.

Hemoptysis, or blood in the oropharynx and trachea indicates severe chest contusions. Thoracic auscultation - moist rales/ bronchial sounds may be used for diagnosis and contusions can sometimes be confirmed using x-rays appearing as alveolar or interstitial infiltrates. Arterial blood gas/pulse oximetry monitoring and clinical signs are the most sensitive means of detecting respiratory compromise and should be carried out for prolonged period of time.
Treatment is by supportive care and maintaining adequate tissue oxygenation. Hypertonic saline solutions and/or colloids are useful fluid choices as they rapidly restore circulatory function without causing deleterious pulmonary effects. Fluid therapy restores adequate cardiac output but careful monitoring is required to avoid fluid overload. Dyspneic and hypoxmic patients require oxygen therapy. Pain associated with thoracic trauma inhibits ventilation, reduces cough, promotes atelectasis, and predisposes to pulmonary infection so analgesia via opioids or sedatives is required. Cage rest and physical therapy may be warranted.

**Airway Obstruction**

When assessing a chest, head or neck trauma patient the pattern of respiration and listen carefully to breath sounds, while palpating and visually inspecting the oral cavity, larynx, and trachea is essential as airway patency is of utmost importance as severe or complete obstruction of the airway will result in exaggerated inspiratory efforts or apnea and death, these obstructions can be a result of severe head (palatal, mandibular, or pharyngeal) or neck injury or food regurgitation, care should be taken as cervical fractures could be present, however locating the obstruction is a priority, the use of head and backboards could be necessary. Breath sounds may indicate location of the obstruction. Oropharyngeal = "gurgly;"
Laryngeal or upper tracheal obstructions = "raspy" or stridorous.
In partial obstruction, nasal oxygen may help stabilize the patient while the location is been ascertained, oxygen flow rates of 100-200 ml/kg/min.
For complete obstruction: transtracheal oxygen cannula, or tracheostomy may be required if the obstruction can’t be removed immediately.

**Pneumothorax**

There are 2 main types of pneumothorax; closed pneumothorax and open pneumothorax. Closed pneumothorax may result from perforation of the lungs, airways, or esophagus, these usually begin unilaterally but progress bilaterally as the pleural space is interconnected. A tension pneumothorax is a commonly seen form of closed pneumothorax and occurs when air enters the pleural space during inspiration, but cannot to exit during expiration, this is extreme as the resulting pressure build up compromises ventilation and venous return, quickly leading to death. Patients with pneumothorax have Clinical signs: Rapid, shallow, respirations; decreased lung sounds, increased resonance (pings) on percussion and jugular distension with tension pneumothorax. Thoracocentesis is diagnostic and a necessary treatment; a chest tube should be placed if continuous or repeated air removal is required.

**Pleural effusion/Hemothorax**

Pleural effusion and hemothorax can be caused by many factors post chest trauma; rupture of the internal thoracic, intercostals or internal mammary vessels, cardiac or great vessel damage can lead to heamothorax, esophageal rupture can lead to pleural effusion. Signs of hemodynamic compromise and hypovolemic shock generally precede respiratory distress in hemothorax cases. In both effusion and hemothorax: Thoracic auscultation reveals dullness ventrally in standing or sterna patients. Positive thoracocentesis is diagnostic, but be aware should not exclude based on negative result. X-rays will show fluid in the thorax. If it reveals an acidic exudate, high in amylase it is suggestive of esophageal rupture and pneumothorax is often present. Contrrast media in the mediastinum or pleural space.
Treatment of hemothorax depends on volume, if small amount and bleeding stopped a single thoracocentesis may be enough, if large amounts, chest drain placement is required. Hemodynamics should be stabilised and autotransfusion can be considered in a massive hemothorax until an alternative source of blood is available, this clot can clot so use of anticoagulants is warranted. Exactly how much blood to remove from a hemothorax is a very controversial issue as the accumulation of blood may increase intrapleural pressure enough to provide tamponade for cessation of bleeding, however leaving blood behind can lead to clotting and fibrotic fibers in the pleural cavity and substantial hemorrhagic effusion may cause a significant decline in pulmonary function. My opinion is to remove as much as you can and if repeated drainage is needed consider surgery. Treatment of pleural effusion; immediate surgical repair and drainage are indicated if due to esophageal rupture as a constricting mediastinitis can prove fatal. Broad-spectrum antibiotics.

Flail Chest and Rib Fractures
By definition a flail chest is 2 or more ribs broken in 2 or more places. With rib fractures paradoxical movement reduces the volume of air inhaled, ie pain leads to splinting and pulmonary contusions are also often present as well as other lung pathologies. Diagnosis is generally by clinical signs, x-rays. Treatment and management depends on severity and other pathologies. If no pulmonary compromise pain management alone may be sufficient. Sternal recumbency aids respiration, wrapping the chest is seldom necessary and may increase respiratory compromise and reduce fracture healing. It is important to identify the underlying pathologies if any exist. Contusions, pneumothorax, heamothorax open chest wounds are some possible, but also caudal fractures may indicate abdominal trauma and cranial rib fractures may lead to cardiac trauma.

Open Chest Wounds
Generally caused by penetrating trauma or dog bites, leading to pneumothorax and often contamination of the pleural space, pleural effusion and heamothorax may be present also. Wounds should be occluded immediately with Vaseline-impregnated gauze and a chest wrap on and they are often occluded naturally by the animals’ skin, a blanket, etc which enables them to survive till hospitalisation. Treatment; temporarily close the wound, chest drain placement and surgery once stabilized. Antibiotics will be nesecary in these cases as infection is almost always infiltrated into the pleural cavity.

Tracheobronchial Injury
Tracheobronchial Injury can be caused be overpressure or direct injury to the airways. It generally leads to large continuous air leaks often in multiple spaces. Diagnosis can be made by clinical signs and bronchoscopy. Surgery is often required in these patients ie; distal bronchi may need resection and proximal tracheal tears need repair using stents.

Embolism
Embolisms occurring secondary to trauma may be of three types: Air; largely goes unrecognized and often leads to death. 2 types: Venous air embolism is usually not clinically significant because relatively large amounts of air are tolerated by this route. Arterial air embolism is often fatal ; ventricular fibrillation, loss of consciousness, seizures, bradyarrhythmias, and cardiac arrest. IPPV treatment in lung may predispose. Fat; again largely goes unrecognized and may precipitate diffuse coagulopathies or adult respiratory distress syndrome.
Thromboembolic or Pulmonary thromboembolism (PTE); hypoxia, hypocapnia, and dyspnea with relatively normal radiographs and a traumatized lung field, it is more common with chronic disease states such as AIHA, Cushings, protein losing glomerulonephropathy, or pancreatitis.

**Traumatic Myocarditis**
Possibly from blunt trauma of the heart, myocardial ischemia, and autonomic imbalance as a consequence of CNS injury leading to post-shock arrhythmias and seems to be more common in dogs than in cats. Metabolic disturbances such as hypoxemia, anemia, hypokalemia, hypomagnesemia, acidemia, abnormal body temperature, pain, and hypotension can lead to these arrhythmias:

- VPCs,
- idioventricular rhythm,
- ventricular tachycardia

Treatment; Identify and treat underlying cause, oxygen and anti-arrhythmia drugs as necessary; Tachycardia, fibrillation and flutter; lidocaine (2-5 mg/kg/hour), or Procainamide (1-2 mg/kg/hour).

**Diaphragmatic Hernia**
Diaphragmatic hernias in trauma cases are more common in cats and the resulting respiratory compromise depends on the severity of the hernia and the volume of organs trapped in the thoracic cavity. Generally diminished heart and lung sound and borborygmus may be heard in the thorax if the intestines or stomach are herniated. Diagnosis is easy if there is displacement of viscera into the thorax however this may not occur immediately and it could be weeks following injury. Radiograph ultrasound and contrast studies can be used to aid diagnosis. Surgical correction is usually necessary however timing is important. Immediate surgical correction is only warranted if gas filled viscus that is rapidly expanding (usually the stomach) is present in the thorax, normally hemodynamic stabilization is achieved before surgical correction is carried out.

**Lung Lobe Torsion**
Uncommon, occurs when (usually the right middle lobe) rotates on its hilar axis. Lobe torsion can lead to or in some cases be caused by; pleural effusion, pneumothorax or hemothorax or a combination of these. Most cases occur in large deep chested dogs. X-rays display a "ground glass" opacification of the affected hemothorax due to vascular congestion, edema and atelectasis in the affected lobe. Surgical removal is the treatment of choice and the lobe should be removed even if it appears normal during surgery.