Nursing the Respiratory Patient

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The Respiratory Patient

Each cell within the body requires energy (adenosine triphosphate – ATP) for cellular processes. From the respiratory system each cell is provided with oxygen for the process of aerobic respiration to produce the energy required for all cellular processes. Through the respiratory tract the body acquires oxygen and disposes of the waste carbon dioxide.

The respiratory system can be divided into upper and lower respiratory tracts.

Upper airway is made of nose, mouth, pharynx, larynx and trachea

The upper airway is a channel for the passage of air into the lower airway and is classed as anatomical ‘dead space’ as no gas exchanges (respiration) occurs. However it does provide one of the main forms of defence from dust, infection and other inhaled irritants by producing mucous. The mucous is swept towards the larynx by cilia which line the respiratory tract so mucous carrying irritants can be swallowed or expelled through the nose and mouth. As air passes the nasal turbinates it is humidified and warmed. Without this process damage can occur to the respiratory tract and mucous production can also increase. Mucous relies on water for movement so it is vital respiratory patients are kept hydrated to utilise this natural defence mechanism.

Lower airway is made up of bronchi, bronchioles, alveoli, lung tissue

The primary function of the lower airway is gas exchange (respiration). Gases are exchanged by diffusion across the surface of the alveoli. Oxygen dissolves in water and moves across into the blood and binds to haemoglobin where it is circulated to each cell in the body via the cardiovascular system. Carbon dioxide the waste product of respiration dissolves in water and moves from the blood into the alveoli and is exhaled out through the upper airway.

The thorax is made up of left and right lungs, pleural cavity, chest wall, ribs and diaphragm

Airway protection

The airway is protected by:

- Sneezing
- Coughing – cough receptors are present in the pharynx, larynx and bronchial tree
- Mucociliary cells – mucous production

Respiratory process

Main aim of respiration is to produce ATP (energy) for all the body’s cells

ATP – adenosine triphosphate

- Chemical energy is released by the process of respiration
- Most chemical reactions in the cells of the body are driven by ATP
- ATP is a form of chemical energy that cells can use
- Oxygen ‘burns’ glucose (primary source of food energy) to release ATP
Gas exchange

Occurs in the alveoli by diffusion – movement from a higher to a lower concentration. Initially:

- There is a higher concentration of carbon dioxide in the blood than the alveolus so carbon dioxide moves into the alveolus
- There is a higher concentration of oxygen in the alveolus than in the blood so oxygen moves into the blood

So oxygen and carbon dioxide is exchanged; blood picks up oxygen and carbon dioxide is expelled out the lungs via the respiratory tract.

Circulation

- Oxygen binds to haemoglobin
- The cardiovascular system transports the haemoglobin around the body delivering oxygen to cells

Breathing

Inspiration

- During inspiration the diaphragm contracts and flattens, the external intercostal muscles contract pulling the ribs upward and outward which increases the volume in the thoracic cavity and decreases the thoracic pressure so air moves into the respiratory tract

Expiration

- During expiration the diaphragm relaxes and returns to a resting dome like shape, the external intercostal muscles relax, the ribs move down and inward, decreasing the volume in the thoracic cavity and increasing thoracic pressure expelling air out of the respiratory tract.

It is important for the whole respiratory system to be intact for ventilation to occur.

Initial Assessment

Definition- ‘The sensation of difficulty in breathing that is experienced by patients with compromised respiratory function’.

This sensation is caused by the effect of low oxygen partial pressure, or high carbon dioxide partial pressure in arterial blood acting on the ventilator motor centres in the brainstem. This leads to an increase in ventilator drive, and it is that that produces clinical signs of respiratory distress.

Diagnosis

It is essential that patients in respiratory distress are spotted immediately. Be aware of the fragile state these patients are in, even a small amount of stress or struggling may tip them over the edge. Observation and a detailed physical examination are the most important tools for diagnosing and locating a cause of dyspnoea, this can give enough information to allow an initial treatment plan to be started, before more stressful diagnostic tests and handling. Even though this examination is
important, patients may often benefit from a period of oxygen stabilisation before attempting a thorough exam.

**Observation**

**POSTURE**

- Extension of the neck, and open mouth breathing.
- Abduction of elbows of elbows in dogs
- Sitting in sternal recumbency in cats, and shifting positions
- Lateral recumbency in dog serious sign, extremely serious in cats

**BREATHING PATTERN**

- Normal pattern is 15-30 breaths per minute, with little chest movement seen, as most movement is from the diaphragm
- Abdominal effort- contraction to help with expiration.
- Paradoxical breathing- severe dyspnoea, intercostal contraction draws the diaphragm forward and the abdomen is sucked in.

**Physical examination**

**MUCOUS MEMBRANE**

- Colour, - pink, blue, cherry red, brown.
- Capillary refill time
- Pulse oximetry very useful to confirm presence or absence of hypoxia

**AUSCULTATION**

- Auscultate the cervical trachea, lung fields and heart.
- Wheezes?- narrowing on the airways likely (inflammation, masses etc.). If on inspiration, upper airway pathology suspected. If occur on expiration, suspect lower airway disease, e.g. feline asthma
- Crackles? - air bubbling through fluid, or opening and closing of small airways. Often indicate pulmonary oedema, haemorrhage or exudates in the alveoli.
- Muffled sounds? - suspect pleural space disease, liquid, air, or diaphragm rupture.
- Heart sounds- In dogs the absence of a murmur or dysrhythmia means heart failure as a cause of dyspnoea is unlikely. This is more difficult in cats, as they usually suffer myocardial disease rather than valvular disease.

The examination should aim to localise the problem to airway (upper or lower), lungs, or pleural space. Any patient presenting in respiratory distress should have flow-by or mask administration of oxygen during their physical examination. Mask administration is superior but often not tolerated,
particularly by cats. Stress should be kept to a minimum as any struggling will lead to increased oxygen demand, so therefore if a mask isn’t tolerated then do not persist with it. Initial physical examination may need to be very brief but a quick effective auscultation of the thorax is vital in almost all circumstances as there is pleural fluid of air then stabilisation will not be achieved by oxygen therapy alone.

Initially observing the patient and listening to them from a distance is very useful. Increased inspiratory effort suggests upper respiratory tract, pulmonary parenchymal or pleural space disease. Increased expiratory effort suggests lower airway disease which is uncommon in the trauma patient. Patients with pleural space disease can also have very rapid shallow breathing pattern. Noise audible without a stethoscope suggests upper respiratory tract pathology which could include partial obstruction due to blood or other material in the mouth, nares and/or pharynx. Finally the patient’s abdominal movement should be observed. The abdominal and thoracic walls should move in the same direction. The abdomen will move markedly in patients with increased respiratory effort as the diaphragm is pushing the abdominal contents more rapidly and more caudally than usual. This is often described as ‘increased abdominal effort’ but actually the movement is passive as abdominal contraction can only aid expiration. If the abdominal wall moves inwards as the thoracic wall moves outwards this is known as paradoxical abdominal movement. There are several possible causes for this but in the trauma patient it is important to know that this can be seen with diaphragmatic rupture. Cyanotic mucous membranes indicate extremely poor oxygen delivery to the peripheral tissues.

After assessing the patient in this way thoracic auscultation should be performed. Auscultation of the lung fields can reveal crackles or harsh lung sounds (commonly heard with parenchymal (alveolar) disease such as pulmonary contusions although these patients may initially show no physical examination abnormalities – see later). Auscultating the thorax of patients with upper respiratory tract noise (as described above) can be difficult as this noise is ‘referred’. To determine if the noise being heard is originating in the upper respiratory tract or the thorax the clinician should auscultate over both the laryngeal region and the thorax; the origin of the noise is likely to be where it is heard loudest. Dull or quiet lung sounds with increased respiratory effort suggest pleural space disease. If the dullness is more pronounced dorsally this suggests pneumothorax whereas ventral dullness suggests pleural fluid such as haemothorax. Diaphragmatic rupture patients can be confusing to auscultate as there can be areas of dullness and some areas of increased respiratory sounds, also the heart sounds may be most audible in an unusual position. It is important to note this as, unlike pneumothorax and pleural fluid patients, thoracocentesis is generally not indicated (as even if pleural fluid is present it is generally not a significant amount).

The cardiovascular and neurological systems also need to be carefully and quickly assessed. Auscultation of the patent’s heart rate and rhythm should be performed while concurrently listening carefully for any murmurs or gallop rhythms. The pulse should be palpated at the same time to note any pulse deficits. Pulse quality should be assessed and also whether central or peripheral pulses are palpable. Pulse quality can be affected by shock but also by anaemia with bounding pulses common in patients with a low PCV. Mucous membrane colour and capillary refill time give further information about peripheral perfusion. Canine patients in hypovolaemic shock will have changes in their cardiovascular parameters as shown below.
<table>
<thead>
<tr>
<th>Heart rate (bpm)</th>
<th>Pulse quality</th>
<th>Mucous membranes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild shock</td>
<td>130-150</td>
<td>Bounding</td>
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<tr>
<td></td>
<td></td>
<td>Pink, CRT&lt;1 sec</td>
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<tr>
<td>Moderate shock</td>
<td>150-170</td>
<td>Decreased</td>
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<tr>
<td></td>
<td></td>
<td>Pale pink, CRT &lt; 2sec</td>
</tr>
<tr>
<td>Severe shock</td>
<td>170-220</td>
<td>Markedly decreased</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Very pale, &gt;2 sec/absent</td>
</tr>
</tbody>
</table>

Neurological assessment does not need to be detailed. An assessment of whether mentation is appropriate is required and if possible it is useful to know if the patient is ambulatory. In trauma cases, information about the basic cranial nerve reflexes like PLRs and pupil size as well as presence of deep pain can be recorded but decisions about euthanasia should not be made on the basis of these initial tests if the patient has suffered head trauma (as time can lead to impressive improvement) or if the patient is collapsed and has impaired perfusion as reflexes may be disguised.

The length of time taken to perform the initial triage examination should be much less than that taken to read this description, with an assessment of urgency made within a couple of minutes at the most. If the patient is stable a more thorough physical examination can now be performed. Trauma to the thorax may be extremely obvious, but with some penetrating injuries this is not necessarily the case. With both dog bites and gun injuries, wounds can be very small and easily missed, particularly for small animals with thick fur. Therefore, the patient should be carefully palpated and clipping can be invaluable in identification of penetration.

**Upper Airway Disease**

Upper airway disease commonly affects the larynx, so loud stridor is common, audible without a stethoscope.

Clinical signs include;

- Dyspnoea
- Increased inspiratory effort, increased inspiratory time
- Change in vocalisation
- Excessive panting
- Hyperthermia (insufficient air passing over tongue to cool)

Differential Diagnoses include;

- Brachycephalic syndrome
- Laryngeal paralysis
- Tracheal collapse
- Foreign bodies
- Neoplasia, abscess, polyps.

**Approach to Upper airway disease;**

These patients are most likely to present with increased effort and prolonged inspiratory breath as they try and force air through the narrowed airway. Often patients will have audible inspiratory noises (stridor) and present in a state of panic due to the acute onset to their disease. Patients with more complete obstructive disease can be tachypnoeic and cyanotic.
Diagnosis is made primarily and initially through observations of the patient’s breathing pattern and checking the airway for obstruction, e.g. vomit, foreign material in the mouth and throat. Radiography can assist however these patients will require stabilisation in the initial stages of treatment. Many acute upper respiratory cases will require almost immediate sedation to calm the patient and relax the airway. Sedation can also be helpful, and may be required, to remove the obstruction and/or obtain an emergency airway for the administration of oxygen via intubation of the trachea or in some cases tracheotomy.

The main priority is to encourage the animal to rest in an oxygen rich environment. They often resent handling of the head or neck- so nasal catheters or oxygen cages are best.

- Some cases may benefit from sedation. (Low doses of ACP –as long as not hypovolaemic-, combined with opioid)
- Anti-inflammatory doses corticosteroids
- Cooling- fans, ice, alcohol
- Fluid therapy if hypovolaemic

If no response to medical treatment, emergency intubation or tracheostomy. If an animal is anaesthetised, all equipment ready for a surgical tracheostomy should be available, in case intubation is not possible.

**Lower Airway Disease** – interference with the ability to exchange gases

- Asthma
- Pulmonary oedema
- Pneumonia
- Pulmonary contusions
- Smoke inhalation/near drowning
- Pulmonary thromboembolism

Disease of the lower airway usually refers to problems with the small bronchi, and coughing is common (non-productive). Patients present with dyspnoea, prolonged expiratory effort, coughing and wheezes audible on auscultation are common findings. On auscultation of the thorax, moist, harsh, wheezing sounds can sometimes be heard. Often the signs and breathing patterns associated with lower airway disease relate to damaged or fluid filled alveoli. These patients have pale mucous membranes due to hypoxia; occasionally cyanosis can be seen but more likely with upper respiratory disease. Diagnosis can be confirmed with radiography. To assess the degree of respiratory compromise an arterial blood gas analysis and pulse oximetry can be useful as well as assisting with clinical assessment of oxygen therapy.

These animals usually present due to crises or flare ups of existing problems, or when the disease becomes end stage.

If lower airway disease is suspected, radiography is helpful, and should show minimal signs of alveolar disease

**Pulmonary Parenchymal Disease**

Disease processes affecting the alveoli. Rapid shallow breathing is common, with crackles and increases lung sounds. A productive cough (often productive) and a nasal discharge may be present.
Examples include pneumonia, pulmonary oedema, neurogenic pulmonary oedema, pulmonary haemorrhage and pulmonary thromboembolism.

**Thoracic (Pleural) Space Disease**

The pleural space is the potential space that exists between the pleura of the lungs, and the pleura of the chest wall. The pleural space disease can be due to air, pleural effusion, or abdominal contents within the pleural space.

Common presenting signs:
- Increased respiratory rate and effort
- Dyspnoea
- Cough
- Dull or muffled lung and heart sounds

Restrictive disorders:
- Pleural effusions
- Trauma to the chest wall, rib cage or diaphragm

Disorders affecting the mechanics of negative pressure ventilation
- Rib fractures
- Penetrating chest wounds
- Flail chest

Diaphragmatic hernia can be both restrictive (abdominal contents herniating) and the mechanics of ventilation by a diaphragmatic tear.

Patients can present with a shallow, rapid breathing pattern. The patient may find it difficult to adequately inflate its lungs and as result show dramatic abdominal effort. Particularly in the acute patient mucous membranes tend to be pale or cyanotic. When pleural effusions and/or pneumothorax are present heart and lung sounds will be dull on auscultation. Patients with chronic respiratory conditions may show little to no obvious signs of acute respiratory distress as they may have adapted to reduced respiration over time.

Radiographs will diagnose a thoracic disorder however some patients will require emergent thoracocentesis as part of their stabilisation to remove the pleural effusion/air before radiography (+/- ultrasound). The patient may need an indwelling chest drain(s) to continually remove recurrent effusions. Any thoracostomy patient will have a chest drain(s) placed for post-operative drainage and pain management. It is important to collect a sample of effusion when initially performing thoracocentesis in case it is required for examination at a later stage.

**Admitting the Respiratory Patient**

Try to keep calm and keep you patient calm as respiratory patients can be extremely fragile.
- Give appropriate oxygen therapy
- Reduce stress (handling)
- Brief clinical exam – check for cyanosis: cyanosis is a late stage and is quickly followed by death if left untreated
- IV catheter if possible
- Brief clinical examination
- Observe and stabilize
- More thorough clinical examination when indicated
- Exception – suspect pneumothorax or pleural fluid (radiography? ultrasound?)
- Diagnostic – blood gases, blood work, radiography, CT

Oxygen supplementation, minimal stress, vascular access followed by thoracocentesis are standard for initial stabilisation. Thoracic radiographs can then follow. The results of thoracocentesis couple with radiography should allow a diagnosis to be made.

If repeated thoracocentesis is required due to fluid or air building up again in the pleural space, a chest drain is indicated.

**Stabilisation of the respiratory system**

Normal cellular function is dependent on a constant supply of oxygen sufficient to meet energy needs. Hypoxia (lack of sufficient oxygen available to tissues) results in cellular dysfunction. Diseases of the pulmonary system such as pneumonia, v/q mismatch and shunting may result in hypoxia. Hypoxemia results from disorders affecting oxygen transport such as haemoglobin dysfunction, anaemia and diminished cardiac output.

Patients with hypoxemia (PaO2 < 80% or SpO2 < 85%) may benefit from the addition of supplemental oxygen alone. Severe cases that are nonresponsive to oxygen supplementation may require mechanical interventions such as positive end expiratory pressure (PEEP) to maximize gas exchange at the alveolar level. Also, patients with hypoxia secondary to severe anaemia may not benefit from O2 therapy alone and may require transfusion of red blood cells to increase haemoglobin carrying capacity. It should also be remembered that patients who are anaemic (PCV <15%) will not appear cyanotic. In any case the benefit of oxygen therapy must be weighed against the potential complications associated with prolonged exposure to excessive amounts of oxygen (>60% for >12 hrs), i.e. oxygen toxicity. Oxygen toxicity is a serious complication of prolonged O2 supplementation because excess oxygen free radicals can cause severe cellular damage particularly in the lungs. For this reason it is generally recommended that O2 supplementation not exceed 50% whenever possible and that O2 therapy is decreased/discontinued promptly.

**Oxygen Supplementation**

Respiratory distress occurs as a result of hypoxia, hypercapnia or a marker increase in the work of breathing. Hypoxia is the most common cause of respiratory distress and those patients suffering with hypercapnia or increased respiratory effort will be suffering from concurrent hypoxia. In these cases the supplementation of oxygen is of vital importance in terms of managing any patients with respiratory distress. If there is ever any uncertainty as to whether a patient is in respiratory distress then supplemental oxygen should be administered whilst the patient is assess and its condition evaluated.

**Oxygen supplementation techniques**

Room air is composed of approximately 21% oxygen. A variety of methods are available which aim to increase this percentage, with each individual technique having its advantages and disadvantages.
For both short and long term administration, the percentage of inspired oxygen achieved will be affected by the size of the patient, their respiratory rate and the oxygen flow rate used. General guidelines to the approximate flow rates of oxygen can be used as a starting point but adjustments should be made depending upon the individual patient’s requirements.

**Oxygen source**

A variety of oxygen sources can be used, and their selection will vary between individual practices, dependent on the facilities available. Most commonly practice will select from:

- Direct from an oxygen cylinder using oxygen tubing
- Using a breathing system attached to an anaesthetic machine
- Piped oxygen source:
  - Using oxygen tubing
  - Using a breathing system

**Other therapeutic considerations for the respiratory patient**

The most important aspects of respiratory therapy for the ICU patient are directed treatment of the underlying disease process while providing adjunctive / supportive strategies that will maximize the likelihood of a positive outcome. Some of those adjunctive / supportive strategies are described below.

**Humidification:** The importance of humidification of inhaled gas can be overlooked in veterinary medicine. If oxygen is to be administered for more than one hour, it is recommended that it should be humidified. This is especially important in patients with nasal or tracheal catheters in place, or those patients undergoing mechanical ventilation, as the oxygen being administered to the patient bypasses the upper airway, where humidification would naturally occur in the animal. When inhaled gas is not humidified, ciliary activity and mucus movement can be impaired (increased viscosity of respiratory secretion, impaired muco-ciliary clearance), inflammatory changes and necrosis of ciliated pulmonary epithelium can occur, mucosal desiccation, viscid, tenacious secretions can be retained, bacteria can infiltrate and atelectasis and pneumonia can result. Most commercial oxygen cages have humidification systems integrated into them. When a patient is being supported with positive pressure ventilation, use of a heated humidifier in the inspiratory limb of the ventilator circuit will fulfil the need for humidified inspired gas. Humidification is simply achieved by allowing the oxygen to bubble through sterile water. Bubble humidifiers are cheap and will connect to flow meters designed for piped oxygen. If a humidifier is not available, then regular nebulization can be carried out, but this requires much more intensive nursing and more expensive equipment.

**Prevent Atelectasis:** Many of our patients are immobile either on a transient or on a long-term basis. Patients that are immobile are prone to develop atelectasis of the dependent lung lobe(s). Atelectasis in turn is a cause of pulmonary dysfunction. When combined with underlying pulmonary disease, the magnitude of the pulmonary dysfunction can worsen dramatically. Chest physiotherapy is a complex of therapeutic techniques designed to combat atelectasis, promote the elimination of secretions, and the resolution of underlying pulmonary conditions. Frequent variation in body position (right lateral, sternal, left lateral) every 2-4 hours is one simple and practical technique for achieving this goal.

Nebulization / aerosolization of isotonic saline to patients with thick / tenacious secretions is often utilized in veterinary medicine as a technique to help loosen the secretions and make them easier to expectorate. This type of aerosol is called bland aerosol. The mucus layer is composed of a "gel" layer that is hydrophobic and faces the lumen as well and a "sol" or hydrophilic layer that faces the
mucosa. The hydrophobic nature of the gel layer significantly inhibits the usefulness of bland aerosol. At the present time, there is minimal evidence to support this practice in people and none to support it in our animal patients. When patients are treated with bland aerosolization, treatment is often followed by cuppage / percussion.

In both veterinary and human patients, cuppage / percussion has not proven to prevent atelectasis, but as part of a complete chest physiotherapy protocol, it has been shown in humans, to help reverse atelectasis in patients with mucus plugs. Percussion can be achieved by mechanical devices specifically designed for this purpose, disposable soft plastic cupped wands, or simply cupped hands. When performing manual cuppage / percussion, the hands should be cupped and rapidly and gently struck against the chest wall in an alternating pattern. All areas and both sides of the chest wall should be addressed. The procedure should be carried out for 5-10min every 4-6 hours. Cuppage / percussion is contraindicated in patients with injuries to the chest wall or sternum.

Probably the most effective and simple method for the prevention of atelectasis is to encourage patients to stand and walk as soon as they are able. Benefits result from a combination of a change in position and the likelihood of greater inspired tidal volumes. Frequently with respiratory patients, the author will simply stand patients outside their cages for a few minutes every four hours. Oxygen dependent patients that are able to walk (if even for a few steps) are taken for very short walks through the ward with the aid of a mobile oxygen source. Postoperative patients are strongly encouraged to stand and / or walk soon after they are awake. It is important to recognize that adequate pain control will facilitate all of these procedures. Finally, nutritional support for the critical respiratory patient should not be overlooked.

**Short term methods of oxygen supplementation**

When a patient in respiratory distress presents at the practice, a brief targeted examination should be carried out (focusing on the respiratory, cardiovascular and neurological systems) and initial stabilization of the patient should be carried out. During this period oxygen should generally be supplemented using non-invasive techniques, commonly via mask or flow-by techniques (see later). These techniques however do require a member of staff to administer them to the patient continuously in order for them to be effective, hence these are generally viewed as short term measures and, if required, the facilities to administer oxygen for a longer period may need to be organized.

1) **Mask supplementation**

Using a mask to administer oxygen to a patient is a simple and relatively effective technique. The required oxygen flow ranges from 1L/min (for cats and small dogs) through to 10L/min (for giant breeds). Whilst a high percentage of inspired oxygen (80-90%) can be achieved in anaesthetized dogs using a tightly fitting mask, the majority of conscious dyspnoeic patients are unlikely to tolerate a tightly fitting mask and therefore the it may not be possible to achieve a tight fitting seal using the mask, and therefore the actual percentage of inspired oxygen may actually be as low as 35-55%. In calmer patients it may actually be possible to gently hold the mask over the muzzle whilst allowing free movement of the patient, but many patients, cats in particular and severely dyspnoeic patients, will not allow the mask near their muzzle. Attempts to struggle to administer oxygen via a facemask should not be made as this may be counterproductive as the patient’s oxygen demand will be increased by the stress and increased muscular activity. This method of oxygen supplementation is best used on collapsed or weak patients who are unable to move. Caution should be taken as a
tightly fitting mask may result in re-breathing of expired carbon monoxide if an insufficient flow rate is used and the patient can also become hyperthermic.

2) Flow-by

Flow-by-supplementation is not an efficient means of administering oxygen to an animal. This method is generally used for administering oxygen to animals during examination. This one advantage of this technique of oxygen administration is that it is readily available in an emergency and it is also a less stressful method of administering oxygen than mask supplementation. When administering oxygen to a conscious patient via this technique at best the patient is likely to receive an inspired oxygen percentage of 40%. Flow rates of 2-10 litres/minute should be used and during administration the oxygen outlet should be held as close to the patient’s mouth or nose as possible without causing distress to the patient.

3) Tracheal oxygen supplementation

In patients demonstrating severe respiratory distress, secondary to upper airway obstruction, a useful technique is to place a catheter percutaneously into the patient’s trachea. Preparation of the patient needs to be carried out as quickly and stress free as possible and should consist of a brief clip of the proposed site overlying the trachea and preparation using chlorhexidine gluconate solution. A large bore 14 or 16 gauge catheter is inserted between the tracheal rings of 4 and 5 or 5 and 6. Once the stylet is within the trachea the catheter is advanced into the tracheal lumen in the direction of the carina and the stylet removed. Oxygen is then administered in a flow by fashion directed at the catheter. This technique is only useful in dogs weighing over 10kg who have a sufficiently large tracheal lumen to allow catheter placement. Invasive tracheal oxygen can be difficult to maintain and therefore it is only a useful technique as a short term option.

Longer term oxygen supplementation

Following an initial physical examination and emergency stabilization (e.g. furosemide administration or thoracocentesis) it is often beneficial to allow the patient to spend a period in a kennel to calm down before further examination and/or treatment is carried out. During this period it is likely that continued oxygen supplementation will be required and so longer terms techniques may be utilized, with the patient remaining on mask or flow-by oxygen whilst all equipment and consumables are prepared.

1) Nasal catheters

It is possible to supply oxygen directly into the respiratory tract via nasal catheters in both dogs and cats. Feeding tubes are most commonly used as nasal catheters with a 5 French catheter being suitable for a cat or small dog and 8 or 10 French being used for most dogs.

Technique for nasal catheter placement

- Prior to placement pre-measure the catheter against the animal by measuring from the nostril to the medial canthus of the eye
Instill a few drops of 0.5% proxymetacaine or 2% lidocaine into the nostril 10 minutes before placement as a local anaesthetic to desensitize the nostril.

The patient should be gently restrained with their nose pointing dorsally and the catheter should be gently advanced into the ventral meatus.

The nasal planum should be pushed dorsally whilst aiming the catheter ventromedially to help aid correct placement.

The catheter should be quickly but gently advanced as patients frequently move and sneeze during this part of placement.

If the catheter is not correctly placed in the ventral meatus then it will not advance to the pre-measured distance as the dorsal and middle meatuses end at the ethmoid turbinates rather than in the nasopharynx.

Once the catheter is in situ it should be fixed in place using sutures or tissue glue attached to ‘butterfly wings’ of tape around the catheter.

The catheter should loop around the alar cartilage with fixation close to the nasal orifice to prevent dislodgement.

The catheter is then looped dorsally between the eyes (which hopefully will reduce the chance of the patient removing it!) or onto the lateral aspect of the head to be secured just below the ear.

Once in place a buster collar should be placed to prevent displacement of the catheter by the patient.

If the patient becomes distressed during any part of the procedure the procedure should be abandoned as this may result in worsening of the hypoxia. This procedure is contraindicated in animals with coagulopathies and patients with increased intracranial pressure.

Nasal catheters can provide an inspired oxygen percentage of 40-50% when using an oxygen flow rate of 50-100 ml/kg/minute. Flow rates above this should not be used as they can result in gastric dilatation.

A second catheter can be placed in the opposite nostril and this will further increase the inspired oxygen concentration to 60-70%.

It should be remembered that this technique will be relatively useless in a panting or mouth breathing patient as this will result in mixing of the air within the pharynx and drastically will reduced the actual inspired oxygen concentration.

Additional fenestrations can be made to the distal end of the tube which helps to avoid excessive irritation of the nasal mucosa.

2) Nasal prongs

The nasal prongs currently used for veterinary patients are designed for human use. They are available in two sizes: adult and paediatric. The prongs advance approximately 1cm into the patient’s nostril and will provide an inspired oxygen percentage approximately 40%. They are minimally invasive but as a result of this are easily displaced by an intolerant patient. The concurrent administration of proxymetacaine into each nostril approximately 10 minutes before placement can be useful; another technique to maintain the prongs in situ is to tape the prong tubing together over the dorsal aspect of the muzzle. As with nasal catheters this technique is less efficacious in panting patients.
3) **Tracheal catheter**

It is possible to use trans-tracheal catheters for the longer term administration of oxygen, particularly for patients with facial or upper airway injury, a standard intravenous catheter may be used or long stay catheters are available, specifically for this purpose, which have an increased length. These catheters can be very difficult to secure and prevent kinking unless the patient is recumbent.

**Procedure**

- The skin around the cricothyroid ligament or the last two tracheal rings should be aseptically prepared. Lidocaine 2% can be infiltrated as a local anaesthetic to the region.
- A needle or trocar is introduced, through which a long flexible catheter is passed into the trachea.
- The needle is then removed, leaving the distal extremity of the catheter in front of the carina tracheae (approximately at the height of the fifth intercostal space).
- The oxygen flow should be set at 10-50ml/kg/min, in order to obtain a FiO2 of 40-60%, the oxygen should always be humidified.

4) **Buster collar oxygen hood - ‘Crowe collar’**

Oxygen may be administered into an enclosed Elizabethan collar. Practice made collars should have a small gap left at the top of the collar to allow the venting of humid air and carbon dioxide. Despite this vent hole, many dogs and some cats become hyperthermic, especially in hot environments. Placement of the collar may be poorly tolerated by some patients, although many will settle once in a kennel. A high flow rate needs to be used with this technique to initially fill the collar with oxygen, and then a rate of approximately 1 litre/minute is generally adequate for a medium sized dog and should result in percentage inspired oxygen of approximately 40%.

5) **Oxygen cage/incubator**

Collapsible or lightweight oxygen cages are commercially available in various sizes, and ex-hospital incubators are relatively easily available second hand via auctions or websites. These devices have the adaptors for breathing systems or piped oxygen and are simple to use. Models vary widely in terms of thermoregulatory or humidity control. Fixed oxygen cages are also available (including interchangeable oxygen doors) – but these are rarely oxygen or humidity controlled (even if they do give an oxygen or humidity reading it is often not possible to control the levels). If the cages are completely sealed it is possible for hyperthermia to develop, particularly in the panting dog. It is of note that once the cage or incubator is opened that the level of oxygen within rapidly drops to room level. This can mean that if a patient is frequently handled their inspired oxygen is barely increased.

An oxygen cage can be made quite easily within the practice environment as required by placing cling film over the front of the cage, although there are gaps present and the cages are generally of large volume (when considering the volume of oxygen required to fill it), relative to the patient within it, means that despite high flow rates the percentage of oxygen is often barely increased.
6) **Endotracheal intubation and ventilation**

It is very rare that an animal that is in respiratory distress requires anaesthetizing and intubation to allow the provision of 100% oxygen. This most commonly occurs in patients with upper airway tract obstruction when intubation allows the by-passing of an obstruction, e.g. laryngeal paralysis, collapsed trachea. It can be difficult to judge when intubation is required and blood gas analysis may aid in this decision (see chapter 4). Less invasive techniques should be attempted first and then the patient’s response assessed. If a patient still has marked respiratory distress despite treatment then intubation and ventilation may be required if the cause of respiratory distress is not upper airway tract in origin. In general the prognosis for patients requiring intubation and ventilation is very poor.

<table>
<thead>
<tr>
<th>Technique</th>
<th>O2 flow rate</th>
<th>FiO2 %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cage</td>
<td>10-12 l/min</td>
<td>40-50</td>
</tr>
<tr>
<td>Mask</td>
<td>2-5 l/min</td>
<td>40-50</td>
</tr>
<tr>
<td>Bag or hood</td>
<td>2-5 l/min</td>
<td>30-40</td>
</tr>
<tr>
<td>Flow by</td>
<td>2-10 l/min</td>
<td>30-40</td>
</tr>
<tr>
<td>Nasal tube</td>
<td>50-100 ml/kg/min</td>
<td>30-50</td>
</tr>
<tr>
<td>Transtracheal</td>
<td>10-50 ml/kg/min</td>
<td>40-60</td>
</tr>
<tr>
<td>Endotracheal tube</td>
<td>10 ml/kg/min</td>
<td>100</td>
</tr>
</tbody>
</table>

**Oxygen toxicity**

Exposure of the lungs to an inspired oxygen fraction greater than 60% for longer than 24-72 hours can lead to oxygen toxicity. This causes damage to the alveoli potentially worsening any lung disease present. Ideally therefore oxygen ventilation should be kept below 60% for longer term supplementation. As most practice situations do not achieve an inspired percentage below 60% this is generally a theoretical concern.

**Tracheostomy tube**

Placement of tracheostomy tubes usually takes place in the emergency situation, such as following laryngeal paralysis, tracheal trauma/avulsion, tracheal obstruction, tracheal foreign body, but may sometimes be placed prior to an elective surgical procedure. Their purpose is to allow patient to breathe through a tube placed into the trachea

The correct post-operative care of the patient and their tracheostomy tube is vitally important in order to ensure patient survival and prevent post-operative complications.

- Endotracheal tube or tracheostomy tube
- Lidocaine
- Surgical blade (no 10)
- Monofilament suture (2/0)
- Dressing and antibiotic cream

**Procedure**

- Clip the ventral region of the neck
- Inject lidocaine into the incision site
- make a skin incision from the larynx to
- blunt dissect the tissue planes and separate the sternohyoid muscles
- place Gelpi retractors to expose the trachea
- make an incision between the 4th and 6th tracheal rings (no more than 40% of the circumference)
- place sutures around the proximal and distal rings
- introduce the tracheostomy tube
- close the proximal and distal parts of the skin wound
- apply antibiotic cream to the area surrounding the wound and apply a sterile dressing.

**Main points for the management of the tracheostomy tube:**

1. Maintaining a patent airway
2. Asepsis
3. Patient comfort
4. There are a wide variety of tracheostomy tubes on the market today however, as the majority are designed for human use they tend to be difficult to secure and remain in place in canine or feline patients and do not conform well to the shape of the trachea. When selecting the most appropriate tube size for the patient is important to take possible tracheostomy complications into consideration and try and prevent them.

Tracheostomy tubes should ideally be constructed of a non-irritating, autoclavable material, which is comfortable for the patient and easy to maintain. Such materials include silicone and polyvinyl chloride (PVC). Stainless steel tubes are very rarely used today.

The length of the tube should extend to six or seven tracheal rings from the placement site, with a tube size which is approximately 50-70% of the diameter of the trachea. This will allow breathing around the tube should it become occluded at any time and will also prevent pressure necrosis of the trachea, which may result if an overlarge tube is placed. The tracheostomy tube is normally placed at the level of the 3rd/4th tracheal cartilages. The incision should not extend greater than 50% of the tracheal circumference, in order to minimise post-operative stenosis.

It may be useful to use a pulse oximeter/capnograph to monitor the patient’s oxygen saturation once the patient has been removed from the oxygen source to ensure correct placement and adequate ventilation.

**Suction and cleaning**

Continuous nursing of patients which have had tracheostomy tubes placed is vital in order to prevent the risk of airway obstruction as a result of dislodgement or occlusion of the tube.
Occlusion is the most life threatening occurrence. The main cause of occlusion is the build-up of secretions; this situation is often worsened by the body’s natural defence system as the body reacts to the presence of the tracheostomy as if it were a foreign body, resulting in the excessive production and build-up of secretions within the airway.

Suction and cleaning of the tube is vital in preventing such occlusion. Scheduling for suction is dependent upon the individual patient; length of time the tube has been in situ and upon how quickly the tube becomes blocked with blood, mucus or exudate. Observation is the best way to gauge the need for increased tube care combined with accurate recording of the type and volume of secretions removed on the patient’s hospitalisation records. Generally the tube will require suctioning every half hour initially, with the frequency then being reduced to four or six hourly as less exudate is produced. Cats often require more frequent maintenance than dogs as they seem to produce much thicker mucus.

Many people use dog urinary catheters to suction the secretions, however these catheters are fairly rigid and care must be taken not to traumatis the trachea. Tracheal suction catheters or silicone nasogastric feeding tubes (6-8 French, Global products) may be more suitable. Suction catheters specifically designed for the purpose are available; these catheters have an opening at the proximal end which allows the vacuum to be bypassed without turning off the suction apparatus.

The longer the tracheostomy tube is in place, then the fewer secretions will be produced. This means in the early stages the tube should be suctioned every 20 minutes, but over time this can be reduced. Sometimes the tracheostomy tube may need to be changed if the secretions are building up on the inner surface and cannot be suctioned. Pre-placement of stay sutures around the tracheal rings above and below the tracheostomy tube when it is inserted initially makes this an easier task. Double lumen tracheostomy tubes make cleaning the tube much easier. The inner cannula is simply removed, cleaned and replaced. Cleaning the inner cannula clears the airway of accumulated secretions; it also rids the tracheostomy tube of bacteria that can be harmful to the patient. Cleaning the tracheostoma also removes accumulated secretions from the stoma as well as decreases the risk of infection of the stoma by removing bacteria using a sterile technique.

Rotating the suction catheter on removal further minimises mucosal damage and aids the removal of secretions. These catheters also improve the safety of the suctioning technique, as negative pressure is applied to the trachea, the bronchi and alveoli (atelectasis) may collapse resulting in hypoxaemia. Therefore a short suctioning time (10 seconds) should be used. The length of the catheter also needs to be considered, the risk of atelectasis is also reduced is the suction catheter is no larger than half the inside diameter of the tracheostomy tube.

The following procedure should be followed for the suctioning of tracheostomy tubes

1. The patient should be pre-oxygenated for several minutes by applying a source of oxygen close to the opening of the tube
2. Aseptic technique should be followed throughout the following procedure, which includes the use of sterile surgical gloves
3. A suitable suction catheter is selected, see below, which should be soft, pliable and sterile
4. Sterile saline should be instilled, dependent upon the patient’s size, usually between one and five millilitres, not more frequently than hourly
5. The inner cannula of the tracheostomy tube, if used, is removed and cleaned
6. The suction catheter is inserted to the level of the carina without a vacuum
7. Intermittent light suction is applied while the catheter is withdrawn in a circular motion. Suction can be applied either via a suction unit or by using a sterile 20-50ml syringe
8. The entire suction time should not exceed 10 seconds – if repeated suction is required then the patient should be allowed to relax and pre-oxygenate again before repeating the process
9. Re-insert a sterile inner cannula while the removed cannula is cleaned and sterilised. If no inner cannula is being used, then it may be necessary to carefully clean the opening of the tube using cotton buds and saline, to remove any build-up of secretions. Scrub solutions should be kept away from the tube and the incision as irritation may occur.
10. The skin around the tube should be cleaned using a chlorhexidine solution
11. The stay sutures should be examined along with the cleanliness of the ties. If the ties are contaminated, if they are contaminated then new ties should be placed before the removal of the contaminated ties
12. Ensure that the patient’s airway is patent and the tube is secure. Make sure the patient is comfortable. Sterile swabs may be placed beneath the phalanges of the tube to improve comfort; a sterile dressing should also be applied to cover the skin surrounding the tracheostomy site, e.g. primapore, Smith & Nephew.
13. Clinical signs that the tube requires suction/cleaning:
   - dyspnoea
   - distress
   - coughing
   - harsh sounds from the tracheostomy tube
   - discharge from the tube
   - patient discomfort

**Humidification/Nebulisation**

Tracheostomy tubes bypass the humidification process in the upper airway which results in the desiccation of the respiratory mucosa, also the secretions become more viscous, inflammation, small airway closure and the increased risk of infection can occur. Cool air fans may also aid in creating a dry atmosphere. These patients usually require intravenous fluid therapy in the post-operative period as they lose a lot of fluid through excess secretions and evaporation.

Normal saline may be introduced into the bronchial tree via the tracheostomy tube, to aid the removal of thick secretions. It was previously thought that the introduction of the saline would liquefy these secretions prior to suctioning them out; however, recent research into human patients indicates that the instillation of saline into the lungs is not effective in liquefying secretions. Mucous is 99% bound by disulphide bonds and the addition of saline does not break this bond to make it less tenacious. However, the instillation of saline is beneficial in causing the patient to cough strongly and subsequently loosens secretions

Sterile saline (2-5ml) dependent upon the size of the patient, is instilled into the tracheostomy tube following pre-oxygenation of the patient. Pre-oxygenation is required to avoid hypoxia during suctioning.

The skin around the tube must be kept clean and dry. The application of petroleum jelly or barrier spray, e.g. Cavilon, around the tube will help prevent excoriation of the surrounding tissue.
Aseptic techniques should be adhered to at all times when dealing with tracheostomy tubes to minimise infection rates. Tracheostomy tubes are a major risk for any infection. Sterile gloves should be worn whenever dealing with the tube and suction tubing should always be replaced and sterile whenever used. Antibiotics should not be used as a substitute for sterile techniques as it increases the infection risk by antibiotic resistant bacteria.

**Patient comfort**

Bedding material, fur loss and litter trays can also be hazardous so the kennel should be cleaned on a regular basis, bedding material should be minimal and cat litter should be changed to shredded paper to prevent the inhalation of dust/litter particles. Furthermore, bedding materials that do not shed lint that may be inhaled through the tube or stoma should be provided. In addition, excessive amounts of bedding should be avoided as this may cover the tube or stoma, and can quickly lead to suffocation.

Time spent with the patient can include a regular period of coupage. This will aid in loosening secretions and induce coughing, especially after using suction and installation of saline. Coupage should be used with caution in patients with trauma to the thoracic cavity to avoid further trauma.

Great care must be taken to ensure that the tracheostomy tube does not become dislodged during coupage, especially as productive coughing can result. The tube should be checked when the coughing has subsided.

The nursing involved in caring for a patient with a tracheostomy tube is highly rewarding, nursing a patient from its initial respiratory emergency through surgery and into its recovery gives an immense sense of achievement as much of the care and the outcome of these patients is dependent on intensive and dedicated nursing as much as the veterinary skills involved in the placement of such tubes.

**Thoracocentesis**

This can be lifesaving and diagnostic, diagnostic imaging is not necessary to confirm pleural space disease prior to performing thoracocentesis. Confidence can be gained by a brief examination with a portable ultrasound machine looking for free pleural fluid or pneumothorax, but this is not essential. Thoracic radiography should not be performed if a patient is in respiratory distress as positioning or restraint could lead to marked distress and can on occasion be fatal. Thoracocentesis performed on a patient without pleural fluid or pneumothorax does not lead to complications in the vast majority of patients. Therefore, trust your physical examination and perform thoracocentesis if you think it is necessary.

In small to medium dogs (<20-25kg) and cats a butterfly catheter, three way tap and syringe can be used. In larger breed dogs, butterfly catheters often do not penetrate the pleural space. A large gauge catheter such as a 16 gauge can be used in these dogs. It can be attached via the stylet (slightly awkwardly as there is no luer lock fitting) to a three way tap attached to the syringe. The stylet can be removed once the catheter has been inserted into the pleural space making attachment to a three way tap catheter easier and decreasing the risk of trauma to the lung, but often this results in kinking of the catheter and therefore ineffective drainage as well as having a period of time when there is a port from the pleural space externally leading to iatrogenic pneumothorax. Often, therefore, keeping the stylet in situ is more effective.
To perform thoracocentesis, the patient needs to be effectively but sympathetically restrained and flow-by or mask oxygen provided. Most dogs and cats prefer to lie in a sternal position but they may prefer to stand. The patient should be clipped and the skin aseptically prepared over the caudal thorax dorsally if air is suspected and ventrally if fluid is suspected. This differentiation is much less important in small dogs than cats. The needle should be introduced at a 90° angle perpendicular to the skin between the 8th and 9th rib, in the ventral third of the chest if fluid is suspected and in the dorsal third if air is suspected. Aiming in the middle of the intercostal space is the simplest approach. The caudal aspect of the rib should be avoided to avoid the intercostal vessels and nerves.

Lidocaine can be infused in the area prior to thoracocentesis, but generally is not necessary and causes as much pain if not more than the procedure itself. The pain part appears to be going through the skin, so this can be done in one movement. If you have an assistant (making the procedure much simpler), they can then put negative pressure on the syringe at this point. The needle is then slowly advanced and once in the pleural space fluid will appear in the syringe or there will be a loss of negative pressure with a pneumothorax. The needle should then be flattened against the thoracic wall with the bevel facing inwards. As much fluid or air as possible should be removed. If a sanguineous fluid is obtained, then it should be checked to see if it clots and if it does, then thoracocentesis should be immediately stopped. If the patient struggles, the procedure will be difficult. Sedation with 0.1-0.3mg/kg butorphanol can be useful.

**Thoracic drain**

Thoracic drains are placed for the evacuation of air or an effusion (pyothorax, haemothorax etc.) from the chest cavity to re-establish normal negative pressure, which is essential to ventilation.

**Equipment required**

- sterile surgical gloves
- surgical kit
- surgical blade
- suture material (monofilament)
- lidocaine 2%
- sedation or induction agents
- thoracic drainage tube
- three way tap
- method of aspiration
- 50 ml syringe
- Dressing materials

There are two main thoracic drain placement techniques; one method uses haemostatic forceps, the other using a trocar or guide wire.

**Procedure**

- Sedate and administer local or general anaesthesia (the procedure may be carried out in the conscious patient in an emergency situation although adequate analgesia should always be provided)
- Clip the side of the chest where the drain is to be placed
- Measure and mark the tube (from the point of introduction to the point of the sternum).
- The skin can be pulled forward towards the patient’s head.
• An incision can be made at the seventh or eighth intercostal space (upper third)
• The drain should be introduced into the thoracic wall until tissue resistance decreases slightly.

**Seldinger tube placement**

To place these drains sedation or good restraint is required. Bouncy or less compliant dogs can be given butorphanol or methadone, cats generally require more marked sedation such as midazolam and ketamine. If sedation is required, then the removal of as much fluid or air via thoracocentesis as possible prior to sedation is recommended to stabilise the patient. Local anaesthetic is generally not required although can be used if desired. Drains can be placed in dogs in sternal recumbency but in cats lateral recumbency is recommended. The thorax should be clipped and prepped aseptically centred over the 8-9th intercostal space. A drape and sterile gloves should be used. A small incision should be made over the 8-9th intercostal space with a number 11 blade. The incision should be in the dorsal third of the chest for a pneumothorax and in the ventral third for fluid. The catheter is directed perpendicularly into the chest and once the pleural space is entered the catheter is directed cranially and the catheter advanced off the stylet. At this point there is now an opening into the pleural space and so the end of the catheter should be occluded whilst the J wire is picked up. This is then fed into the pleural space via the catheter. It should run smoothly and if it doesn’t suggest the catheter is not in the pleural space and the catheter should be withdrawn and the procedure started again. The wire is advanced until the second mark on the wire is visualised or until resistance is noted. At this point the rest of the wire should be carefully removed from the packaging. It is very easy for the wire to ‘spring out’ and become contaminated so take care! The wire should be held and the catheter withdrawn from the pleural space. The chest drain is introduced into the pleural space by running it over the wire. Once the drain is in situ then the wire is removed and the drain sutured in place. A light dressing such as a Primapore should cover the insertion site. The drain should be used to allow immediate pleural space evacuation as a pneumothorax can be induced by placement. Generally only one drain needs to be placed for patients with a pneumothorax. Radiography can be used to check placement of the drain, but if it is functioning well this is far more important than appearing on radiography.

**Trocar type chest drain**

Trocar chest drains are generally more difficult to place than others such as over-the-wire types, due to the size and relatively blunt tip. They are most easily placed when the chest is open at surgery, when their passage through an intercostal space can be more carefully controlled and directly observed. It is possible, however, to place them closed and they do offer a few advantages compared to the other types: the main one is that the chest can be evacuated more quickly due to their larger diameter, although in trauma cases (where air is the most likely substance to be removed) this is not usually significant. They are also likely to be better at aspirating particles of infected material – this may be inspissated pus, or perhaps pieces of foreign material. Disadvantages include a likely higher incidence of complication compared to an over the wire type, and also that animals subjectively seem more comfortable on recovery. This may be due to their large size affecting adjacent ribs and intercostal nerves during normal respiration, as the trocar chest drain is often close in diameter to the size of the intercostal space.

It is worth planning the types and fittings for any chest drain well in advance of seeing a case, as they often arrive in an emergency. This is particularly true of the trocar-type drain, as the connections to attach to a syringe often do not come supplied with the drain. Typically the chest drain end is plastic tubing which doesn’t seem to fit any regular connectors. This can be cut off and a Christmas tree adaptor inserted or short pieces of pre-sterilised suction tubing can be placed over the end of the drain and again into a standard Christmas tree adaptor. A normal bung or side tipped syringe can then be attached. All attachments need to be carefully placed to prevent accidental detachment,
and two means of occluding the chest drain should always be employed when not in use, such as bungs, Christmas tree adaptors and syringes, and in direct communication with the thoracic cavity and so should be handled carefully to avoid contamination.

**Intravenous access**

Intravenous access is very useful in patients allowing effective drug and fluid administration as well as blood sampling at the time of catheter placement. However, it is generally not essential in the patient in respiratory distress and can cause undesirable stress. The use of calm restraint, alternative veins such as the lateral saphenous, and EMLA cream will aid placement, but the procedure should be abandoned if causing excessive stress. Trauma patients may have hypovolaemia in conjunction with respiratory distress, requiring fluid therapy via an intravenous catheter. Patients with both hypovolaemia and respiratory distress are often easier to handle than those with respiratory distress alone.

**Cardiovascular stabilisation**

Shock occurs when there is inadequate perfusion relative to tissue demands resulting in decreased oxygen and nutrient delivery and waste removal. In thoracic trauma patients, the most common reason for shock is hypovolaemia. Physical examination allows recognition of the hypoperfused patient through:

- Tachycardia
- Abnormal pulse quality
- Abnormal mucous membrane colour
- Mentation changes

These changes outline the classic physical examination findings in dogs with hypovolaemic shock. Treatment of hypoperfusion is a priority. Intravascular fluid deficits should be replaced rapidly and prior to surgery if required as this will decrease morbidity and mortality under general anaesthesia. The volume of fluid administered will be dependent on the severity of the patient’s clinical signs. Patients with mild signs obviously require less fluid than those with more severe signs. Hypoperfused patients are treated to effect and therefore a standard dose of fluids cannot be applied to all animals.

There is no ideal fluid for resuscitation and the argument over which fluid is best is on-going. Isotonic crystalloids are the first choice in the majority of situations as they are familiar, cheap and associated with few side effects. The ‘shock dose’ for isotonic fluids is 60-90ml/kg for dogs and 40-60ml/kg for cats. Patients presenting with hypoperfusion should be treated with a proportion of the ‘shock dose’ administered over a short period depending on the severity of their signs. The derivation of this dose is based upon a single blood volume and this dose has been shown experimentally to be very safe when administered rapidly. Fluid resuscitation should target an end point which should be as close to normal cardiovascular parameters for that animal as possible. After the patient has received their initial dose they should be reassessed. If their cardiovascular parameters are still deranged a further dose should be administered. Generally in dogs, boluses of 10-40ml/kg of isotonic crystalloid over 10-30 minutes are appropriate with the volume of fluid and the length of time of the infusion varying with the severity of the clinical signs. Hypertonic saline is a
useful fluid for extremely large dogs where rapid administration of large volumes of isotonic crystalloids can be challenging. A dose of 2-4ml/kg given over 5-20 minutes will give similar results to a full shock dose of isotonic crystalloids.

Artificial colloids have also been recommended as resuscitation fluids. They have more potent and longer lasting effects than crystalloids due to their persistence in the intravascular space. There is no evidence to suggest that they are more effective or associated with a better outcome than isotonic crystalloid fluids. The maximum shock dose of most artificial colloids is 20ml/kg/24 hours and for resuscitation an initial dose of 5ml/kg given over 10-20 minutes is generally used.

Once hypoperfusion has been recognised and measures to stabilise the patient have been initiated, attempts should be made to identify the disease process that has led to hypoperfusion. If cardiac rhythm abnormalities are present then hypoperfusion, hypoxia and any acid-base and electrolyte abnormalities should be corrected. Further discussion is below.

**Neurological stabilisation**

If a patient presents with acute spinal disease only and paresis or paralysis then a full neurological examination should be performed and analgesia given as required. If a fracture is suspected, great care should be taken when manipulating the patient and it will not be possible to perform a complete neurological examination.

Patients displaying signs of inappropriate mentation may require treatment of raised intracranial pressure. Remember that severe depression can also be due to poor perfusion in these cases and assess perfusion parameters as effective cardiovascular resuscitation may lead to improvements in mentation. In all cases, if mentation is severely depressed then the patient’s head should be elevated to approximately 30° with care not to compress the jugular veins, perfusion should be maintained and treatment with Mannitol may be required.

**Investigation**

**Calculating blood oxygen content**

The amount of oxygen in the blood can be calculated using the following equation:

\[ CaO_2 = (SpO_2 \times 1.34 \times Hb) + (0.003 \times PaO_2) \]

\( CaO_2 \) = Oxygen content in the blood

\( SpO_2 \) = The percentage of haemoglobin saturated with oxygen

\( Hb \) = Haemoglobin (which can be easily estimated by dividing the PCV by 3)

\( PaO_2 \) = The arterial oxygen partial pressure

This is a useful equation to know as it shows how vast majority of oxygen in the blood is carried by haemoglobin. It also nicely demonstrates what a pulse oximeter and arterial blood gas analysis tells us about. The equation also shows that oxygen delivery to tissues will not be adequate in patients which are markedly anaemic even if their SpO2 and PaO2 are good.
Pulse oximetry

Most small animal practices have a pulse oximeter and it can be used outside of the operating theatre to aid assessment of patients in respiratory distress. That said, it can be difficult to get a reliable reading in many conscious animals. The tongue is generally the best place to place the probe in an anaesthetised patient but this is not an option in a dyspnoeic animal. Success is most likely with patients with non-pigmented skin and a thin coat. Various locations can be used including the ear, lip fold, skin between the Achilles tendon and tibia, tail, skin on the flank and toe web.

Pulse oximeters give a reading of the percentage of haemoglobin in the patient’s arteries that is bound to oxygen (SpO2). In a healthy animal breathing room air this should be between 95 and 99%. A drop in a few percentage points can lead to a large decrease in oxygen carriage and so pulse oximetry is a fairly good tool. This leads to difficulty though as the readings can vary slightly between probe attachment points. A value below 90% is very concerning suggesting severe hypoxaemia. Consistent levels below this despite oxygen supplementation may suggest the need for mechanical ventilation. Pulse oximetry us much less useful in assessing severity of underlying pathology if a patient is receiving substantial oxygen as their readings should be greater than 99% the haemoglobin oxygen saturation curve demonstrates that this reading does not demonstrate adequate lung function and therefore the test is very insensitive.

If it works, pulse oximetry can be used to assess the severity of a patient’s hypoxaemia on room air therefore and also be used to monitor progression of the disease and response to therapy. However, as well as being difficult to obtain a reading, often pulse oximeters give an unreliable reading. If the pulse oximeter shows a plethysomography trace then the adequacy of the trace gives an idea of the reliability of the SpO2 reading produced. If a pulse rate is generated this should match the patient’s heart rate and if it does not then again the SpO2 given should not be trusted. In general therefore, pulse oximetry is a useful tool, but it should be used in conjunction with observation of the patient and physical examination to aid assessment of the severity of hypoxaemia due to its potential unreliability.