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Emergency Patients - An Organ Approach Mini Series

Session One: Nursing Care of the Respiratory Emergency Patient

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Nursing Strategies for Respiratory Emergencies

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Introduction

Patients with respiratory distress are commonly seen as emergency patients, either following trauma or due to a longer standing pathology. Regardless of the actual cause of the respiratory distress, all patients show similar outwardly evident signs of laboured respiratory effort which demonstrates inability to ventilate (physically move air in and out of the pulmonary system) or to respire (the ability to exchange oxygen and carbon dioxide in the lungs) efficiently. General signs include increased respiratory rate, adapting different postures, open mouth breathing and alterations in respiratory patterns.

These cases need urgent attention to avoid the risk of respiratory failure, cardiac arrest or hypoxic damage to tissues. The key to a successful outcome is rapid localisation of the problem and stabilisation; to achieve this the most useful tools are the history and a thorough physical examination. If a working diagnosis can be obtained with this information alone, without resorting to any stressful procedures that may cause decompensation, then specific therapy can be targeted much earlier in the treatment period.

Initial presentation

Initial stabilisation of the dyspnoeic animal requires that the inspired oxygen concentration is increased. This can be done before and during a rapid thorough physical exam, then allow the animal to rest with further oxygen therapy prior to further work-up or treatment. The rise in blood oxygen levels will also result in a calmer and less panicky animal, as dyspnoea (the physical sensation is difficulty in breathing) will be reduced. The extremely dyspnoeic animal that cannot adequately ventilate and oxygenate even with oxygen supplementation may require anaesthesia to intubate and gain control of the airway, and to instigate positive pressure ventilation.

Gaining intravenous access allows administration of drugs, fluids and, if necessary, allows intravenous anaesthesia to be rapidly administered; this may be necessary if the patient decompensates and endotracheal intubation to gain control of the airway is required. But if the animal is too stressed by restraint to allow a catheter to be placed, then supplement oxygen and try again later.

Observation

Initially observing the patient prior to a physical examination is invaluable in recognising dyspnoea.

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Changes in posture

The patient will adopt positions to minimize any restriction to air ow, restraining the patient pre- vents these adaptations and can lead to decompensation. Postural changes include the following:

- Flared nostrils, open mouth breathing
- Extension of the neck, and lifting the head
- Abduction of elbows to minimize chest wall compression
- Sitting or lying in sternal recumbancy, and shifting positions.

Changes in breathing pattern

Normal respiration is at 15–30 breaths per minute; little chest movement is seen as the diaphragm does most of the work. Inspiration is usually equal in length to expiration. Abnormalities include the following:

- Abdominal effort – contraction of abdominal muscles to help with expiration.
- Paradoxical breathing – severe dyspnoea, inter- costals contraction draws the diaphragm for- ward and the abdomen is sucked in.
- Inspiratory phase longer than expiratory phase, or vice versa.

Physical examination

Mucous membrane colour and capillary refill time provide useful information about the respiratory system. Cyanosis gives a blue coloration to the mucous membranes; this is typically what students are told to look out for as an indication of low blood oxygen levels. Cyanosis will only be present in severe hypoxaemia (<80% arterial blood saturation), so while it is definitely a sign supplementary oxygenation is required, the absence of cyanosis does not mean all is well. The moderately hypoxic animal will still have pink mucous membranes. Pulse oximetry can be useful in conforming the presence of hypoxaemia.

Auscultation of the respiratory system as part of a rapid physical examination provides vital information to help localise the cause of respiratory dis- tress. The cervical trachea, lung fields and heart should be auscultated. Abnormal sounds, or asymmetry in sounds from one lung compared with the other are relevant. Abnormalities may include the following:

- *Wheezes:* narrowing on the airways likely (e.g. inflammation, masses). If on inspiration, upper airway pathology is suspected. If wheeze occurs 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 develop myocardial disease rather than valvular disease.
- History, observation and physical examination should help to localise the cause of dyspnoea to one of four areas: upper airway, lower airway, lung parenchyma or the pleural space. Having localised the source of the problem, specific stabilisation techniques can be applied where suitable.

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Upper airway

The upper airway consists of the nose, mouth, pharynx, larynx and trachea. Causes of respiratory distress at this level are related to partial or complete obstruction. This may be due to a number of factors:

- Brachycephalic obstructive airway syndrome (BOAS)
- Foreign body
- Space occupying lesions (abscess, neoplasia)
- Laryngeal paralysis
- Laryngeal or pharyngeal oedema
- Trauma.

Patients with upper respiratory tract obstruction tend to present with audible inspiratory noise (stridor) with a long drawn out inspiratory phase. In cases with an acute onset, such as a foreign body, the patient is often very stressed and panicked.

Stabilisation relies on oxygen supplementation, which helps to calm the patient; gentle technique is required as patients often resent handling of the face or neck. Cases of laryngeal paralysis will often respond to cooling, anti-inflammatories to combat oedema and low doses of sedative as an anxiolytic.

In cases where there is no response to medical management, or where a foreign body is suspected, then urgent control over the airway needs to be gained. Following pre-oxygenation, general anaesthesia is induced and the patient intubated with an endotracheal tube. If intubation is not possible, the clinical team should be ready to immediately place a tracheostomy tube.

Lower airway disease

Disease of the lower airway usually refers to problems with the small bronchi, and coughing is common (non-productive). Dyspnoea, with expiratory effort, and wheezes audible on auscultation are common findings. Common disorders include the following:

- Feline asthma
- Bronchial irritation
- Bronchitis
- Foreign body
- Smoke inhalation.

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

If lower airway disease is suspected, radiography is helpful, and should show a ‘bronchial pattern’ with minimal signs of alveolar disease. As well as oxygen supplementation, treatment may include bronchodilators, corticosteroids and antibiotics.

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Lung parenchymal disease

The alveoli are concerned with gas exchange. Interference with the ability to expel carbon dioxide and absorb oxygen in the alveoli will give rise to dyspnoea. Interference in the process may be caused by filling or collapse of alveoli, or an increase in the thickness of the diffusion barrier due to in infiltration. Common disorders include the following:

- Pulmonary oedema
- Neurogenic pulmonary oedema (choking, strangulation, seizures)
- Pneumonia
- Pulmonary contusions
- Pulmonary haemorrhage
- Pulmonary inflammatory diseases.

Patients often present with hypoxaemia, hash lung sounds and crackles, and a productive cough and nasal discharge may be present. Careful auscultation of the heart should be carried out to try to ensure congestive heart disease is not present (mitral valve murmur in dogs, gallop rhythm in cats).

Thoracic radiographs are useful; the distribution of pathology can be an aid to identifying the underlying cause. If radiographs cannot be obtained due to severe respiratory distress, then treatment should be initiated based on the likely diagnosis given both history and physical findings. Pneumonia may be due to respiratory tract pathogens, or secondary to aspiration of foreign material or gastric contents. Broad spectrum anti- biotics with nebulisation and coupage are indicated where bacterial pneumonia is suspected; diuretics are indicated in suspected cases of pulmonary oedema.

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. Accumulation of air, fluid or soft tissue within the pleural space leads to reduced ventilation and so poor respiratory function. The most important physical finding with these patients is the presence of dull or diminished lung and heart sounds.

Common Cause of Pleural Space Disease:

- Pneumothorax (open or closed)
- Pleural effusion:
    - Transudate (e.g. congestive heart failure)
    - Pyothorax
    - Haemothorax
    - Feline infectious peritonitis
    - Neoplasia
- Diaphragmatic hernia

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Common presenting signs in pleural space disease are as follow:

- Increased respiratory rate and effort
- Dyspnoea
- Cough
- Dull or muffled lung and heart sounds.

Stabilisation relies on oxygen supplementation, minimal stress and vascular access followed by thoracocentesis. It is important that in all cases of suspected pleural space disease thoracocentesis is performed before any attempts at radiography. Thoracocentesis is both diagnostic and therapeutic, and will rapidly improve the condition of patients with pleural effusion or pneumothorax. Thoracic radiographs can then follow thoracocentesis; removal of effusion will also now make underlying pathology easier to visualise. The results of thoracocentesis coupled 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.

Patients with diaphragmatic rupture usually bene t from a period of stabilisation prior to corrective surgery. Indications for immediate surgery include entrapment of the stomach with gaseous bloat, or suspicion of ruptured gastrointestinal tract.

Thoracic radiography

Radiography is a useful diagnostic tool in the dyspnoeic animal, but is no substitute for a thorough physical examination. In suspected cases of pleural space disease, thoracocentesis should always be performed first. Obtaining radiographs is stressful for the animal and potentially life-threatening, so may not be indicated for the animal with severe problems. Where there is a clinical benefit, and the animal is stable enough, radiography should be performed with as little stress as possible. Continue oxygen supplementation throughout the procedure.

Nursing Techniques for Respiratory Patients

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 assessed 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.

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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-cilary 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.

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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 coupage / percussion.

In both veterinary and human patients, coupage / 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 coupage / 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. Coupage / 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.

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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 ventro-medially 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.

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- 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.

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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 rate 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.

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

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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.

Thoracocentesis

Thoracocentesis is the procedure used to remove air or fluid from the pleural space. The preparation of all necessary equipment for the procedure is vital, before it is commenced.

A wide clip should be performed on the lateral thorax from the sixth to ninth intercostal spaces, and then the area aseptically prepared. Gentle restraint should be used so that patient is in a position that minimizes stress while maximizing its ability to breathe. For most patients tolerate sternal recumbency is a tolerable, and comfortable position, and this positioning has the benefits of allowing access to both sides of the chest if required. However, the patient may be allowed to stand, sit or be placed in lateral recumbency if these positions are preferable.

The chosen needle or catheter should be long enough to penetrate the patient's pleural space. Butterfly needles have a short length of tubing attached, which is useful if the patient moves slightly during the procedure. When using either hypodermic needles or over-the-needle catheters, connecting a short IV infusion extension set will have the same effect. A three-way tap or needle-free valve allows a syringe of suitable size to be attached without the risk of entraining further air. Some veterinary surgeons believe over-the-needle catheters to be a safer option, however, they are likely to cause iatrogenic pneumothorax and have a tendency to kink.

The needle should be slightly inserted into the seventh, eighth or ninth intercostal space, positioning the needle along the cranial border of the rib to avoid the intercostal vessels and nerves that run immediately caudal to the rib. The needle is inserted to the mid thoracic level, if fluid and air are expected, or in the dorsal third when only air is anticipated. The syringe may be gently aspirated as the needle is advanced through the soft tissues of the chest wall to allow confirmation of placement of the needle within the pleural space.

Once the needle is within the pleural space, it is stabilized to allow drainage of air. Some clinicians reposition the needle to flatten it against the rib cage to reduce the risk of trauma to the lungs; however, this procedure can lacerate lung tissue if the needle has been inadvertently placed into the lung during placement.

The pleural space should be completely evacuated of gas and air, volumes of which should be measured and recorded in the clinical record. During thoracocentesis an improvement in the patients respiratory pattern and rate should be detected. Once negative pressure is achieved, the needle is withdrawn from the chest.

Chest-drain placement

Depending on the rate of air accumulation, thoracocentesis may not be sufficient for drainage and therefore the placement of a chest-drain (tube thoracostomy) may be necessary. The placement of a chest drains should be considered where:

- Air or gas accumulates rapidly, necessitating thoracocentesis more than twice within a 24 hour period
- Negative pressure cannot be achieved during thoracocentesis
- If tension pneumothorax is present.

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There are a wide variety of chest drains available, including trocar drains, non-trochar drains and drains that be inserted using the Seldinger (over-the-wire) technique. The latter are particularly useful in cases of pneumothorax and will be discussed in more detail.

As with thoracocentesis, preparation of all equipment needed for the procedure it vital before the procedure commences.

Complications

Iatrogenic pneumothorax, laceration of a lung lobe or vessel and drain migration are all potential complications of wire-guided chest-drain placement. In patients where a shorter length of catheter is introduced, drainage of unexpectedly large volumes of air immediately following placement of the drain should alert the veterinary surgeon and nurse to the possibility that one of the drain fenestrations may be located in the subcutaneous space or even outside the thoracic wall. This may also be observed if there is any slippage of the drain (backing out) at any time post placement.

Drainage and equipment monitoring

Drainage

Placement of a chest drain allows the ongoing drainage of air accumulation within the thorax. This can be achieved using either manual, intermittent systems, e.g. the Heimlich valve, or continuous-drainage grenade and low-pressure suction systems.

When using a syringe for manual, intermittent drainage, it is important that excessive negative pressure is not applied. This can cause the chest drain to be sucked against the pleura and is not only uncomfortable for the patients, but can result in lung injury. In most cases of pneumothorax, initially only air will be withdrawn. However, as the volume of air in the pleural space reduces, small amounts of pleural fluid or blood may be noted in the drain and syringe. This should alert the clinician that the chest drain procedure is almost complete and they should then be more vigilant to avoid applying excessive negative pressure.

Using a syringe appropriate to the patient's size can help to reduce the risk of applying excessive negative pressure, for example, using a 5-10ml syringe in patients <15kg, applying no greater than 1-2ml of negative pressure and a 20-60ml syringe for patients >15kg, applying no more than 3-5ml of negative pressure.

A continuous suction unit should be used if air continues to accumulate rapidly within the pleural space. Two-bottle and three-bottle systems are available. Approximately 15-20 cm of negative pressure is applied to the pleural space to remove air. These units should be kept below the level of the patient if possible. This facilitates drainage of any fluid that may be present and helps to limit the possibility of reflux of fluid into the thorax.

Equipment monitoring

Fluid levels in the water-seal and suction-control chambers of such units need to be monitored. Fluid in either chamber can evaporate, so may need to be topped up periodically. The water seal chamber prevents back flow of air or fluid into the pleural space and fluctuations in this chamber during breathing are normal. If this is not observed, the chest drain or associated tubing may be kinked or clamped shut. Intermittent bubbling in the water-seal chamber during breathing indicates an ongoing leak into the pleural space. This should diminish and then stop as the air leak seals. If the bubbling in the water-seal chamber is continuous, this indicates an unresolved pneumothorax or alternatively that there is a leak in the chest drain or associated tubing. The system must be constantly assessed for leaks, as failure of the system can result in acute respiratory distress.

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Tracheostomy tubes

Twenty-four hour care is essential in patients with tracheostomy tubes in place as potentially fatal occlusion of the tube by exudate, mucus, bed- ding or skin folds may occur, as well as tube dislodgement. If present, the inner cannula of the tube should be removed for cleaning whenever an increased noise or effort in respiration is detected, or initially every 2 hours post-placement. The cannula should be cleaned thoroughly using warm water, allowed to air dry and then replaced. For tracheostomy tubes without an inner cannula, the entire tube should be removed for cleaning. Ideally, a spare sterile tracheostomy tube should be available for immediate replacement into the trachea following the removal of the dirty tube. The stay sutures above and below the tracheal incision should be used to gently bring the trachea to the level of the skin and to open the trachea.

Humidification: If the inner cannula or lumen of the tracheostomy tube is repeatedly full of exudate or mucous, then either nebulised air should be used for periods for the animal to inhale, or 0.1 mg/kg sterile saline should be instilled into the tube every 2 hours (the instillation of the tube may initiate transient coughing).

Suction: Suction of the tracheostomy tube should be performed only as required. It is required more frequently in smaller dogs and cats. The patient should be pre-oxygenated for 30–60 seconds before suction is performed. A sterile suction catheter should be introduced aseptically into the tracheostomy tube and suction applied for no more than 10 seconds, whilst gently rotating the suction tube. The suction catheter should remain within the tube during suctioning and only inserted into the delicate trachea if absolutely necessary to clear an obstruction distal to the tracheostomy tube.

The tracheostomy stoma should be inspected at least once, preferably twice, daily. The area should be gently cleaned using sterile saline-soaked swabs. If the above measures do not relieve breathing difficulties, then the entire tube should be changed. It is important that a veterinary surgeon is on-hand and the ability to perform endotracheal intubation and oxygen administration are readily available. The patient should be pre-oxygenated and the trachea stabilised using the stay sutures around the tracheal rings, above and below the tracheostomy site. The existing tube should be removed and a new tube rapidly inserted.

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