RESPIRATORY EMERGENCIES

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OXYGEN

Respiratory support of the critically ill or injured patient can be divided into oxygen support and ventilatory support. The end goal of respiratory support is to ensure adequate oxygen reaches the blood and carbon dioxide is removed from the blood. Oxygen should be provided to any patient that presents with an increased respiratory rate or effort or evidence of cyanosis. Oxygen is delivered to the cells in 2 forms - dissolved in the blood and attached to hemoglobin; the most important factor being hemoglobin. Adequate hemoglobin for the critical patient is believed to be approximately equivalent to a PCV of 30% (or a hemoglobin concentration of approximately 10 g/dl). Therefore the clinician should ensure that there is adequate hemoglobin in any patient in which respiratory support is being considered.

Oxygen can be provided in a variety of forms. An oxygen source, baggie, plastic wrap, Elizabethan collar, and red rubber tubes are all that are necessary to provide oxygen to almost any patient. It is recommended that a direct oxygen source be available; however, if an anesthetic machine is used then a “Y”- shaped adapter should be used to bypass the anesthetic circuit. A “Y” connector is inserted into the tubing before it enters the circle. A piece of tubing connects the “Y” to the circle and the second arm of the “Y” is connected to the tubing that is providing oxygen to the patient. A hemostat or C clamp is used to clamp off the oxygen to the patient or to the circle system depending on what is required. Nasal or tracheal oxygen always should be humidified.

Oxygen should be considered a first line drug and it always should be provided if there is any possibility the patient might benefit. Flow-by oxygen is easily provided by placing a piece of tubing, that is connected directly to the oxygen source, in front of the patient’s nose or mouth. The flow rate generally varies from 3 to 15 L/min. A mask also can be used but is usually less well tolerated especially if the patient is panting. If a mask is used the rubber fitting should be removed. Many animals will tolerate having their heads or even most of their bodies placed inside a plastic bag. The oxygen tubing is placed through a small hole in the front of the bag and the back of the bag is left open to allow gas to escape. This is particularly useful in the obtunded patient because high concentrations of oxygen can be provided (75-95%) while allowing other procedures to be performed (blood drawing, placement of catheters, x-rays etc.) An oxygen hood can be made by covering the ventral 75% of an Elizabethan collar with plastic wrap. The Elizabethan collar should be 1 size larger than would normally be used for that size of patient. The oxygen tubing is placed along the inside of the collar and taped in place ventrally. Oxygen concentrations of up to 80% generally can be achieved. Flow rates of approximately 1 L/10 kg body weight usually provide an adequate inspired oxygen concentration (FiO_2). Flow rates should be adjusted based on patient comfort, clinical status, pulse oximetry, and blood gases. Oxygen hoods generally are not tolerated by the panting dog as the hood rapidly becomes overheated and over-humidified. The temperature of the inside of the hood should be periodically checked.

Nasal oxygen is the most effective way to provide oxygen to the patient. A red rubber or other pediatric feeding tube is used. For small patients 3.5 to 5 Fr tubes are used. For medium-sized dogs 5-8 Fr tubes are used and for larger dogs 8 to 10 Fr tubes are placed. Cats will usually tolerate 5-8 Fr tubes. Several drops of 0.5% proparacaine ophthalmic solution are instilled in the nose. Lidocaine also can be used. If lidocaine is being used in cats the dose should be monitored to ensure a toxic level is not reached. A small amount of sterile water-soluble gel or lidocaine gel placed on the outside of the tube will facilitate passage of the tube. The nasal catheter is typically measured from the tip of the nose to the lateral canthus of the eye so that the tip will be in the nasopharynx (nasopharyngeal catheter). Clinically animals tolerate the oxygen better if the tip is at this location as opposed to being in the nostril. In cats the tube readily passes into the nasal meatus. By pushing the nasal planum of the dog dorsally and directing the tube ventromedially the tube should pass easily into the ventral meatus. The tube is sutured close to the naris (maximum 0.5 cm from the naris). This suture is very important. Tubes frequently are dislodged if the first suture is placed further away from the nose than 0.5 cm. Additional sutures or staples are placed on the lateral aspect of the face or on the bridge of the nose between the eyes to direct the tube to the dorsal or lateral cervical region where it can be connected to an oxygen source.

At flow rates of 100 ml/kg in larger dogs the FiO_2 will be a minimum of 0.4 and may reach as high as 0.65. With bilateral nasal oxygen the FiO_2 can be up to 0.6 and with flow rates of 200 ml/min the FiO_2 may reach 0.8. If higher flow rates are desired a second tube can be placed in the other nostril or nasotracheal oxygen can be provided. For nasotracheal oxygen the tube is measured to the level of the tracheal bifurcation or the fifth

intercostal space. The patient's head should be held in an extended position to facilitate blind passage into the trachea. If coughing is noted lidocaine can be infused via the tube to anesthetize the larynx. Nasotracheal oxygen is a very useful in the patient with laryngeal dysfunction or collapsing cervical trachea. Oxygen delivered into the trachea should be at 50% of the nasal rates and always should be humidified.

Nasal oxygen should be avoided in the patient with severe nasal or pharyngeal disease and in the patient with severe thrombocytopenia. Sneezing will elevate intracranial pressure and nasal tubes should be avoided if this is a concern.

In the patient who has an upper airway obstruction (functional or mechanical) transtracheal oxygen can be provided on an emergent basis. A large bore over-the-needle catheter or commercially available tracheal catheter can be placed between tracheal rings in the mid cervical region. An adaptor is attached to the catheter and connected to oxygen. An adaptor from a 3.5 mm endotracheal tube (or smaller) will fit on the end of most peripheral over-the-needle catheters. This will provide a fitting that will permit AMBU bag ventilation or attachment to an anesthetic circuit.

Oxygen cages can be used to provide oxygen to patients but have several drawbacks and should be used only if other forms of providing supplemental oxygen are contraindicated. The biggest problem is the inability to evaluate the patient except through observation. Each time the door to the cage is opened the oxygen level drops substantially. This can lead to significant patient anxiety and respiratory compromise. The oxygen flow rates required to operate the units effectively makes this a costly alternative.

If the patient does not respond to supplemental oxygen rapid sequence induction, intubation, and ventilation should be considered. Suction should be readily available. Response to therapy usually can be gauged by monitoring respiratory rate and effort, presence of cyanosis, pulse oximetry readings, and blood gases. Pulse oximetry readings can be very unreliable (even for trending) in the awake animal as well as in those with very darkly pigmented skin, when the skin between the clamp is too thick or too thin, and in the patient with poor perfusion. Artificial ventilation is indicated in the patient with ventilatory failure (inability to exhale carbon dioxide as well as inability to oxygenate) until the cause of the ventilatory failure can be resolved. It is important to recognize these patients. Patients who have been working hard to breathe for an extended period of time may die from ventilatory failure secondary to exhaustion. The goal in these patients should be rapid induction. Ketamine and diazepam are effective and have minimal effect on the circulation. Thiobarbiturates and propofol can be used but are significant cardiovascular depressants and should be used with caution in the cardiovascularly unstable patient. Etomidate and neuromuscular blockers (succinylcholine, atracurium) can also be used for rapid induction. In the compromised patients doses should always be titrated as much less drug may be required than is needed to induce the healthy patient.

TRACHEOSTOMY

A tracheostomy is indicated in the patient with an upper airway obstructive disorder that cannot be relieved adequately. If the thought occurs to you that a tracheostomy is indicated then one probably should be placed! Other indications include situations when an endotracheal tube cannot be inserted in a patient with an obstructed or near obstructed airway, when the obstruction is rostral to where the proximal portion of the tracheotomy tube ends, when it is necessary to assess and treat the bronchoalveolar tree such as deliver medications and aspirate exudate, when it is necessary to decrease dead space and airway resistance, and in those patients requiring long term ventilatory support.

There are no absolute contraindications but there are several relative contraindications. If the tracheostomy is the only breathing route for the patient then the patient must be monitored around the clock since coughing a mucus plug into the tube will cause a complete airway obstruction and suffocation. A tracheostomy may not be ideal when the patient has a coagulopathy, when suction equipment does not exist, and in situations when an endotracheal tube may suffice.

A tracheotomy can be performed in the awake patent using small doses of an analgesic
or sedative (hydromorphone with or without diazepam) or midazolam and local anesthetic (lidocaine). In the awake patient the head is extended. In the anesthetized patient, the patient is placed in dorsal recumbency and a towel or IV fluid bag is placed under the neck which pushes the trachea ventrally. An incision (approximately 5-8 cm or 2-3 inches long) is made on the ventral cervical midline about midway between the cricoid cartilage and the thoracic inlet. The "strap" muscles (sternohyoideus) are separated using blunt or sharp dissection and the trachea is exposed. The trachea is elevated into the incision using thumb and fingers. An incision is made between 2 tracheal rings at the level of rings 3 to 6 extending about 40% of the circumference of the trachea

and a tube is placed in the incision. Traction sutures are then placed around 1 ring cranial and 1 ring caudal to the tracheotomy and tied with the knot approximately 8-10 cm or 3-4 inches from the trachea. These sutures are used for opening the trachea when the tube needs to be exchanged. A tube approximately 1-1.5 mm smaller than what would be used for orotracheal intubation is placed.

Commercial tracheostomy tubes can be used or a clear endotracheal tube can be modified. To modify an endotracheal tube the plastic connector is removed from the end of the tube. Two cuts are then made in the tube 180 degrees apart. The cuts are made long enough so that the tube that remains intact is the right length for the patient (i.e., reaches from the tracheotomy to the thoracic inlet region). Do not cut the cuff inflating mechanism. The 2 wings that are created can be cut short if needed. The tube connector is placed back into the tube. Two holes are created at the end of each wing and umbilical tape or IV tubing is placed through the holes and tied around the back of the neck of the patient. The tube is not secured in any other form to the patient. Two or 3 sterile 4x4 squares are placed between the tube and the tracheotomy incision. Sterile saline (2-10 ml depending on the size of the patient) should be instilled or the patient should be nebulized (preferred) q2-4 hours to help lubricate respiratory secretions. The tube should be suctioned q6-8 hours after instilling saline and hyperoxygenating, and should be aseptically changed q6-12 hours or as needed. When suctioning larger patients the operator should inhale a normal breath and hold the breath. When the operator comfortably feels the need to breathe suction should be discontinued. For small patients the breath should be exhaled then held. When the operator comfortably feels the need to breathe the suction should be discontinued. Oxygen can be provided via the tracheostomy by placing a sterile narrow bore feeding tube down the tracheostomy tube. Care should be taken to ensure the oxygen tube is not so large as to obstruct exhalation. When the tube is no longer needed the tracheotomy incision is left to heal by second intention. The wound should not be bandaged until the tracheotomy incision is healed to prevent subcutaneous emphysema from developing.

Complications of a Tracheostomy
The number one complication is obstruction of the tube and with nobody watching death will result in minutes. Other complications include dislodgment, hyperthermia (generally rare), dehydration, pneumonia with nosocomial bacterial infection, wound site infection (may be nosocomial), oxygen desaturation due to retained secretions, vagal maneuver with resulting bradycardia, hypotension, and rarely cardiac arrest, tracheal mucosal necrosis and stricture, and perforation or tearing of the trachea or tracheal membrane.

Prevention of Complications
1. Use proper equipment
2. Do not over inflate tube cuffs
3. Use gentle technique with insertion of the tube and suction catheters
4. Use as clean a technique as possible
5. Be vigilant
6. Follow a tube care protocol

INTRATHORACIC DISEASE
Pleural space disease (pneumothorax, hemothorax, pyothorax, chylothorax) often can be diagnosed based on the presence of a rapid shallow respiratory pattern, loss of airway sounds, hollow sounds on percussion of the thorax, or the presence of open wounds into the thorax. Any patient who is suspected of having pleural space disease should have a thoracentesis performed prior to taking radiographs. The stress of the radiographic procedure in a patient with severe pleural space disease may lead to respiratory arrest. Thoracentesis is performed between the 7^{th} and 9^{th} intercostal spaces in whatever position the patient is the most comfortable (sternal, sitting, lateral recumbency). Thoracentesis should always be performed bilaterally unless the patient is known to have unilateral disease. The area is clipped and prepped and if the patient is painful local anesthesia should be instilled in the skin and down to the level of the pleura. The needle is introduced into the skin and a drop of sterile saline is placed in the hub of the needle. The needle is slowly advanced and once the fluid is sucked into the pleural space the needle is advanced another few mm to ensure the entire bevel is in the pleural space and then the needle is directed so that it is lying against the chest wall bevel outwards. This technique will help avoid overpenetration of the thorax and injury to underlying lung. In the case of a tension pneumothorax the saline drop will be forced out of the hub when the pleural space is penetrated.

If negative pressure is never achieved during thoracentesis or if thoracentesis is required more than twice a chest tube should be placed. Chest tubes should be placed prophylactically in any surgical patient with a pneumothorax since positive pressure ventilation under anesthesia may worsen a pneumothorax. Chest tubes are always indicated in patients with pyothorax and those that rapidly accumulate chylous effusion may also require chest tubes.

Chest tubes can be placed under sedation and local anesthesia or under general anesthetic. In most dogs chest tubes can be placed under sedation and local anesthetic. General anesthesia is required in most cats. If general anesthesia is required the patient should be intubated and ventilated. The size of the chest tube should be the approximate diameter of the mainstem bronchus in a patient with a pneumothorax since this is conceivably the largest hole that could exist. It also helps prevent having the tube clog with viscous fluids or blood clots. Smaller diameter tubes may be chosen for patients with a chylothorax or pyothorax (if the fluid is not very viscous). The patient's lateral thorax is surgically prepped. An assistant grabs the skin over the thorax just caudal to the scapula and pulls the skin cranially. Local anesthetic is instilled at a location between the 7^{th} and 9^{th} intercostal space from the skin down to the level of the pleura. A small stab incision is made in the skin of sufficient size to allow passage of the chest tube. Using curved hemostats the tissue is bluntly dissected until the pleural space is penetrated. The tube then is passed through the incision and directed cranioventral (ensuring that all the holes in the chest tube are within the pleural space). A blunt-ended stylet is used to stiffen the tube to allow it to pass in a straight line to the desired location. Once the tube is placed the stylet is removed and the assistant lets go of the skin. This creates a subcutaneous tunnel for the tube. A new local block is performed and the tube is anchored to the periosteum of the rib dorsal and ventral to the exit site. A hinge on the suture prevents the skin from pinching when the animal breathes and will improve patient comfort. Antibiotic ointment is placed over the wound, followed by a sterile dressing and the chest is bandaged. The patient should always be x-rayed to confirm the position of the tube.

In the case of a pneumothorax a 3-way stopcock can be placed in the tube and the tube can be aspirated on an intermittent basis; however, this is only advised if it is anticipated that the patient will only accumulate small volumes of air. To allow the lung to seal most rapidly the lung should be kept fully inflated as possible (i.e. least amount of air in the chest as possible). Otherwise each time the air is aspirated the lung will reinflate and break apart any seal that is trying to form over wounds. Heimlich valves are useful only for dogs over 15 kg body weight and should be used only as a temporary measure. They should not be used in any patient that has fluid coming through the tube since the fluid will cause the valve to seal and prevent air from escaping. Ideally continuous underwater suction should be used on chest tubes until it is established that the air leak is resolving. Usually 10-20 cm water pressure is required to keep the chest evacuated. Tubes can be removed when volumes of less than approximately 1-2 ml/kg/24 hrs are being produced.

Analgesia must be provided to every patient with a chest tube. This can be effectively provided using a mixture of lidocaine and bupivicaine. Intercostal nerve blocks for 1-2 rib spaces either side of the tube can be performed or intrapleural analgesia can be provided by administering the local anesthetics via the chest tube into the pleural space. Care should be taken with cats to ensure the toxic dose of the local anesthetic is not exceeded; the local anesthetic can be diluted by 50% if additional volume is required. Local anesthetics should always be either warmed to body temperature or mixed (1:9) with sodium bicarbonate to decrease the sting. Parenteral narcotics should be provided if local anesthetics are not providing sufficient analgesia.

NEBULIZATION

Nebulization therapy should be used for treating patients with pneumonia and bronchoconstrictive disease (i.e., feline allergic bronchitis). Nebulization is provided using a commercial unit or oxygen delivered at high flow rates through a nebulizer (available through most respiratory equipment suppliers). The nebulized fluid can be delivered via face mask, into a baggie placed over the patient's head, or into an enclosed chamber if the patient will not tolerate the flow directed at the face. Saline (0.9%) is an excellent mucolytic. Bronchodilators such as albuterol and terbutaline, as well as corticosteroids can be given by nebulization. These drugs are very effective in feline asthmatics.

References available on request.