Inhalational and Respiratory Therapy for the Veterinary Team

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The goal of the approach to the respiratory patient, as with any patient, should be to obtain as specific a diagnosis as possible. Respiratory therapy is much more effective when a specific treatment is directed at a specific diagnosis. However, it is often the case in companion animal medicine that non-specific, symptomatic, or empirical therapy must be employed due to limited diagnostic information. There also exist some therapeutic options that have broad applicability across multiple conditions. In these cases, knowledge of the availability and indications of non-specific respiratory therapeutics can aid in the management of patients afflicted with respiratory disease. The well-trained, well-educated veterinary team is essential in both providing this respiratory therapy in the hospital setting and training pet owners to administer therapy at home.

OVERVIEW OF NON-SPECIFIC RESPIRATORY THERAPY

Oxygen Supplementation.

For respiratory patients, supplemental oxygen is most commonly used to increase inspired oxygen concentration (FiO_2) as a treatment for hypoxemia and pulmonary hypertension, and ultimately, to ensure adequate delivery of oxygen to peripheral tissues. Most of the causes of hypoxemia in small animal patients are responsive to supplemental oxygen therapy.

Clinical and biochemical monitoring of patients receiving oxygen therapy is indicated to ensure adequate response to therapy, as well as monitoring for signs of airway injury secondary to oxygen toxicity. In hypoxemic patients, effective oxygen therapy should result in decreased respiratory and heart rates, decreased respiratory effort, and improvement in mucous membrane color. Biochemical monitoring of hypoxemia and oxygen therapy includes estimation of O_2 saturation (SpO_2) and partial pressure of arterial O_2 (PaO_2). Of the two, PaO_2 is more sensitive assessment of pulmonary gas exchange function, while the SpO_2 is the better indicator of peripheral oxygen delivery, and of the patient's need for oxygen therapy. The goal of oxygen therapy should be to maintain adequate hemoglobin saturation with the lowest FiO_2 possible.

There are several methods for oxygen administration in small animal patients. For rapid access or short-term oxygen therapy (e.g. during physical exam), "flow-by" (i.e., oxygen tubing) or a face mask can be used to efficiently deliver oxygen to the breathing zone of hypoxemic patients. An oxygen cage or oxygen hood (modified E-Collar) can be used for long-term oxygen therapy in small patients, while nasal cannulas are well-tolerated in larger patients. For all methods used, the oxygen supply must be humidified prior to delivery in order to minimize epithelial injury and facilitate mucociliary clearance.

NEBULIZATION THERAPY

Indications

The goal of nebulization therapy is to generate and deliver fluid particles to the lower airways and alveoli. This method is typically used to dispense mucolytics (saline, n-acetylcysteine), antimicrobials (gentamicin, tobramycin), or bronchodilators. Nebulizers generate fluid particles in the range of 0.5 – 3.0 μM in size, which makes them readily respirable to the lower airways and alveoli. Sterile saline (5-10 ml per treatment) nebulized into the airways up to four times daily in hospitalized patients can be an effective mucolytic in bronchopneumonia or chronic airway disease. Nebulization of saline combined with coupage is also a simple technique for generating effective, productive cough in dogs and cats with alveolar disease. In the past, mucolytic agents like N-acetylcysteine have been used via nebulization, but are no longer recommended due to airway irritation and the potential for these agents to trigger bronchoconstriction [1] .

Nebulized antibiotic therapy can be administered in conjunction with systemic antibiotic therapy for complicated bronchopneumonia cases [2]. In these cases, the total parenteral dose of an aminoglycoside (e.g., 6.6 mg/kg gentamicin) is diluted with saline up to the total volume of the nebulizer reservoir and delivered until empty once or twice daily.

Beta-receptor agonists (β-agonists) are effective bronchodilators that also possess some beneficial immune-modulatory effects [3]. Short-acting β_2-selective agonists (albuterol, levalbuterol) are available in both nebulized and metered dose inhaler forms. Their onset of action is very rapid, which makes them useful in the acute management of respiratory distress due to bronchoconstriction and small airway obstruction. However, their duration of action is short (2-4 hours), and chronic use can lead to worsening of airway obstruction due to receptor downregulation and increased airway inflammation [4]. These factors limit the utility of short-acting inhaled β_2-agonists in chronic management of small airway disease. Bronchodilators that are formulated for nebulization delivery include albuterol (0.5%) and levalbuterol (0.31mg/3ml). While doses specific for veterinary medicine have not been firmly established, estimated doses for cats can be extrapolated from pediatric doses [2].

Types of Nebulizers

The three types of nebulizers utilized in companion animal medicine include jet nebulizers, ultrasonic nebulizers, and mesh nebulizers. All versions are available in larger, tabletop devices and smaller, portable devices.

Jet nebulizers use compressed air to blast liquid through capillary tubing into a baffle, which generates an aerosol of varying particle sizes. Larger tabletop versions can be used to deliver aerosol to a tank or an oxygen tent, while smaller versions can efficiently deliver nebulized liquids to the breathing zone of an individual patient. Advantages of jet nebulizers include ease of use, low cost, and the ability to deliver both saline as well as a variety of drugs, including many that cannot be effectively delivered via metered dose inhaler or other nebulizer types. The major disadvantage of jet nebulizers is the requirement for a compressor some compressed gas source. Because they require capillary tubing to draw fluid through the device, they can also be difficult to clean and disinfect [5].

Ultrasonic nebulizers use an electronic oscillator to cause high velocity mechanical vibration of a crystal that is in contact with a liquid within a reservoir. The crystal vibration generates a vapor which is delivered to the patient. Because they do not require a compressed air source, ultrasonic nebulizers are quieter and lighter than comparably priced and equipped jet nebulizers. A disadvantage of ultrasonic nebulizers is that the electronic oscillator generates heat that is capable of degrading heat sensitive materials, including some drugs and biologicals. They also generally have a larger residual volume, meaning that the nebulizer reservoir may not be completely emptied in some versions, resulting in some wasted product [5].

Mesh nebulizers generate aerosol by forcing liquid through apertures in a mesh or an aperture plate. Mesh nebulizers generally use a self-contained battery or plug-in power source, are very quiet, and are among the fastest and most efficient nebulizers. However, their cost is often prohibitive for routine use in veterinary medicine.

Administration of nebulized liquids.
Nebulized liquid can be delivered to dogs and cats by several methods. Face masks can be attached directly to some nebulizer units, or can be connected to nebulizers via specialized tubing. Nebulizers can be discharged directly into contained spaces including commercially available nebulizer tents, incubators, or aquariums for small patients. Where these devices are not available, nebulized fluids can be delivered to the breathing zone of patients using modified Elizabethan collars with the openings partially covered with plastic wrap. All of these routes are suitable for delivery of saline to the lower airways and alveoli. However, delivery of drugs (e.g., antibiotics) is more efficient via facemask, while the other methods result in more of the drug being delivered outside of the respiratory tract.

METERED DOSE INHALERS

Indications

Metered dose inhalers (MDIs) are designed to allow patients to deliver aerosolized liquid or dry powder medications at home on a chronic basis for maintenance therapy. These devices are now the standard method for delivery of inhaled glucocorticoids, anti-cholinergics, and bronchodilators for chronic airway diseases (chronic bronchitis/COPD, asthma) in people. Particles generated by MDIs are generally in the range of 10-50 µM in size, which results in deposition in the airways rather than the alveoli [6].

Inhaled corticosteroids (fluticasone, budesonide) have been used extensively in human medicine as a means of controlling airway inflammation while minimizing systemic side effects. Experimental data in veterinary species have led to increased use of inhaled steroids in dogs and cats for the management of both upper airway and lower airway inflammation. Veterinary-specific facemasks and spacer devices similar to those designed to facilitate metered dose inhaler (MDI) use by infants are also available that allow delivery of inhaled drugs with tidal breathing methods.

Short-acting β-agonists are available as metered dose inhalers, but are subject to the same limitations as nebulized forms listed above (short duration, potential for worsening of airway inflammation). Newer long-acting beta agonists (LABAs) are available in combination with metered dose inhalers combined with glucocorticoids. The combined products are associated with fewer of the long-term adverse effects, and early results from the use of these drugs via inhalation suggest that they may play a role in the long-term management of small airway disease in cats [7].

Mechanism

Metered dose inhalers are composed of a container that houses a drug formulation in liquid or powder phase, a gas propellant, a metering valve, an actuator, and a mouthpiece. Drug administration in people requires a coordinated effort involving inserting the mouthpiece, depressing the container (which opens the actuator), and inhaling as deeply as possible over a short period of time. While this method of drug delivery is effective in adults, it is a highly inefficient system, as only 10-20% of the drug reaches the lungs (most is delivered to the oropharynx) [6]. The degree of coordination required makes the system difficult to use for children and infants.

Spacer devices that are attached to the MDI allow modifications to the delivery technique that makes them suitable for use by children. The spacer device increases the distance between the MDI and the patient, which eliminates the need for precise coordination of inhalation and actuation. Spacer devices can also serve as holding chambers, which allows drug delivery using tidal breathing methods. Spacer devices consist of a plastic tube with a Heimlich valve that opens during inhalation, allowing aerosolized drug to enter the airway, and closes during expiration, allowing exhaled air to exit the airway around the chamber. Combining spacer devices and facemasks allows drug delivery to the lower airways through nasal breathing, where up to 60% of the drug can reach the lower airways. These modifications also allow MDIs to be adapted for use in veterinary medicine.

Administration of Metered Dose Inhalers

The advantage of metered dose inhalers is that they can be administered to pets fairly easily by clients following a brief training period. The first goal is to allow the pet to become acclimated to breathing through the facemask and spacer device without attaching the MDI. Cats and small dogs should be positioned in sternal recumbency facing away from their owner, while larger dogs should be in a seated position. The spacer device and facemask are applied over the mouth and nose of the patient, and the patient is allowed to take 5-10 normal breaths of adequate strength to deploy the Heimlich valve. If successful, this procedure is repeated twice daily for 5-7 days. After one week of successful training, the MDI is introduced. The MDI, spacer, and facemask are assembled, the MDI is shaken for 5-10 seconds, followed by applying the facemask over the nose and mouth of the patient. After 1-2 normal breaths have been taken, the MDI is actuated, and the patient is allowed to take 5-10 normal breaths to deliver the drug from the spacer to the patient.

Cough Management and Physical Therapy

Strategies designed to improve respiratory clearance are important adjunctive tools in the management of respiratory diseases. These can vary from simple strategies for clients to perform at home (which also serve to engage pet owners in their pet's treatment) to advanced techniques primarily targeted for management of hospitalized patients.

Cough is a protective reflex that indicates the presence of an abnormality in the airways. Cough is effective in clearing inhaled particles and excessive airway secretions from the trachea and bronchi. When combined with an intact mucociliary clearance system, coughing serves as an important part of the pulmonary clearance system. In most cases, coughing provides an important benefit to the patient with respiratory disease. For this reason, ***productive*** coughing should not be suppressed. In cases in which productive coughing is desired (pneumonia, smoke inhalation), "protussive" or "mucokinetic" therapy can facilitate effective coughing and airway clearance. Mucokinesis can be achieved by decreasing the viscosity of airway secretions, or by enhancing airway ciliary action. Airway hydration is essential in maintaining fluidity in airway secretions, and parenterally administered fluids provide the most effective means of ensuring adequate airway hydration. Adjunctive hydration therapy can be provided through saline nebulization (see above).

Thoracic coupage is the action of firmly striking the thoracic wall of the patient with a cupped hand or a percussion device. When combined with saline nebulization, coupage aids in stimulating the cough reflex, dislodging adhered airway secretions and facilitating their clearance. Nebulization and coupage can be performed several times daily (every 4-6 hours) in hospitalized patients. Coupage is contraindicated in patients with thoracic wall trauma.

Techniques to improve tidal volume, including forced exercise (frequent leash walks), facilitate clearance by recruiting and expanding collapsed lung units and providing a "milking" action to the tracheobronchial tree. For critically ill hospitalized patients, frequent turning and walking (when possible) minimizes the gravitational effect of atelectasis of the down lung.

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