A CHALLENGING TECHNIQUE

Mechanical Ventilation of the Asthma Patient

by Nicholas A. Widder, RRT, CPFT

With the reported rise in fatal asthma over the last several years, there is, by default, a rise in the number of ventilated asthma patients. What was once considered a rarity is now becoming more common. Over the years, respiratory therapists have modified the approach to ventilating these patients so that even though this is a mode of therapy that still requires careful attention, it is no longer uncharted territory.

Asthma is characterized by increased responsiveness of the airways.[1] This causes increased airways resistance and includes reduction in the caliber of the airways due to smooth muscle contraction, edema from mucosal inflammation, and collection of viscid secretions in the lumen of the airway.[2] The therapist must address these three factors — bronchoconstriction, bronchial inflammation, and mucous plugging — when mechanically ventilating the asthmatic patient. Of course, therapists must make every effort to address these factors without doing further harm to this already sick patient.

The decision to intubate the asthma patient should be based upon clinical examination. The indications for intubation include apnea, near apnea, a sustained respiratory rate of more than 40 breaths per minute (in an adult), depressed level of consciousness, changes in mental status, central cyanosis, or appearance of severe distress.[3] The decision can be made in absence of laboratory values indicating respiratory failure. The decision can also be made to avoid intubation and its multiple sequelae, in the case of the rapidly improving patient, despite an increased arterial carbon dioxide tension ($PaCO_2$).

Once the decision to intubate the patient is made, several things must be considered. Whenever possible, an 8 mm or larger endotracheal tube should be used to allow for better air movement and secretion removal. Rapid sequence induction of anesthesia for intubation may be beneficial. Intubation while the patient is awake is possible; however, it requires a certain level of patient cooperation, and this may be quite difficult with a young air-hungry patient.

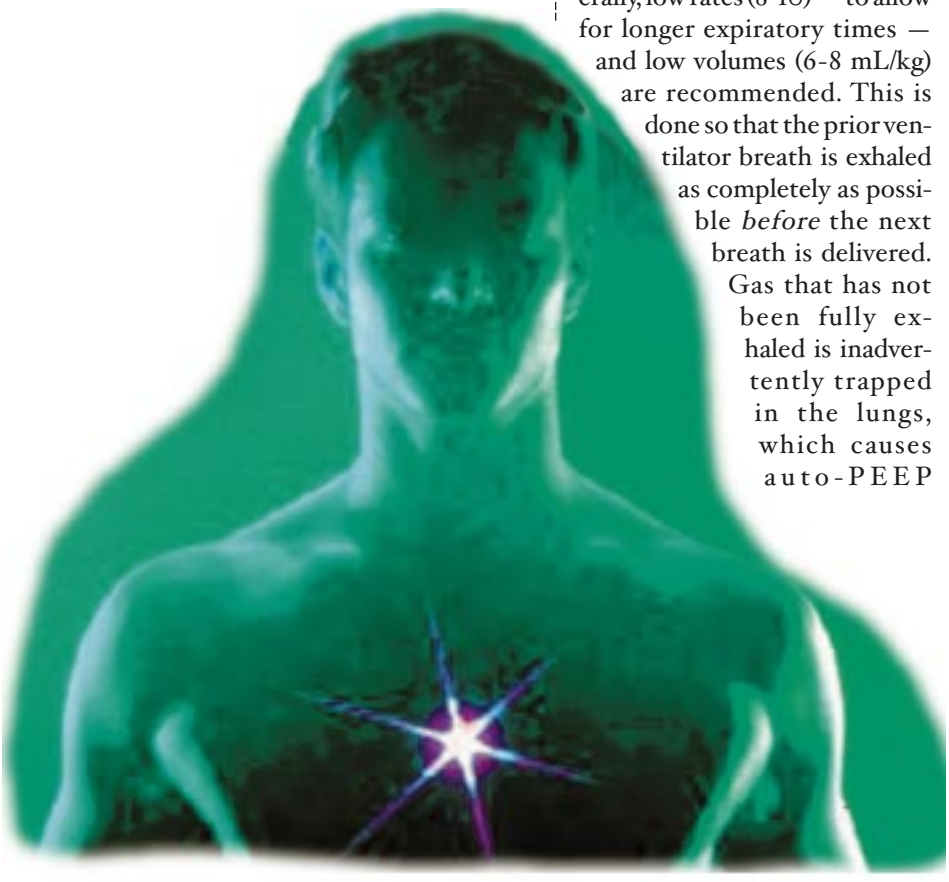
Further, one induction agent, ketamine, is known to enhance bronchodilation. Unfortunately, it is also known for producing a high incidence of

dreams, hallucinations, and emergence delirium.[4] Some practitioners believe that another induction agent, propofol, may also have some mild bronchodilator effects. Once the patient is intubated, there is an overwhelming reflex action for caretakers to manually hyperventilate the patient. This should be avoided, as the high volume and rapid rate will cause markedly increased gas trapping. Once tube placement is confirmed, it is often useful to allow the patient to exhale as fully as possible, by disconnecting the bag for up to 60 seconds, while monitoring oxygen saturation. This may help overcome some of the negative hemodynamic effects that can occur with the intubation.

While there is a high intrathoracic pressure associated with forced exhalation during the asthma attack, there is a negative intra-thoracic pressure associated with inspiration. There is no significant negative pressure during mechanical ventilation, and venous return tends to be impaired. This may result in the need for fluid resuscitation.[3] Additionally, hypotension may also be a result of tension pneumothorax, a potentially life-threatening condition that requires immediate tube or needle thoracostomy.

Mechanical ventilation

Ventilation of asthmatics can be challenging. Therapists need to understand several concepts before providing this therapy. Patients in status asthmaticus already have hyper-inflated lungs and will not benefit from high-volume ventilation. Generally, low rates (8-10) — to allow for longer expiratory times — and low volumes (6-8 mL/kg) are recommended. This is done so that the prior ventilator breath is exhaled as completely as possible *before* the next breath is delivered. Gas that has not been fully exhaled is inadvertently trapped in the lungs, which causes auto-PEEP (unintended, positive end-expiratory pressure). Serial measurements of auto-PEEP may be useful in tracking the amount of air trapping that occurs with mechanical ventilation.



Periodic disconnection of the patient from the ventilator may reduce the trapped gas volume, and hence reduce the auto-PEEP. Though counter intuitive, increasing inspiratory flow rates (which increases peak airway pressure) and lowering respiratory rates (which lowers minute ventilation) will generally allow for better ventilation of these patients. It may also be useful to increase tidal volume before increasing respiratory rate when adjusting the ventilator to correct for sever hypercarbia. Generally, permissive hypercapnia is well tolerated by the asthmatic patient and can be used for safe ventilation. However, in many cases, simply lowering the respiratory rate will bring the carbon dioxide (CO_2) level under control. In cases where CO_2 cannot be managed with ventilation, intravenous (I.V.) buffer solutions (either $NaHCO_3$ or tromethamine) may be used to treat acidosis.

Patients should be sedated so they will not fight the ventilator. Increased respiratory rates caused by spontaneous respiratory efforts may only hinder the excretion of CO_2. Paralytics may be necessary. However, long-term use of paralytic agents, especially in light of steroid administration, may cause critical care neuropathy, a condition of prolonged weakness that may require many months of rehabilitation after discharge from the intensive care unit.

Interventions aimed at relieving bronchospasm should be continued after initiation of mechanical ventilation. This includes the use of continuous nebulizer therapy, high-dose metered dose inhaler (MDI) therapy, parenteral administration of bronchodilators, treatment with anti-inflammatory agents (steroids), and a few less conventional approaches. Adequate humidification of the ventilator circuit cannot be overemphasized, as the thick mucus produced with this disease can lead to severe plugging.

references

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Continuous aerosolized bronchodilators

Continuous nebulization of beta-2 specific sympathomimetics is often used for the treatment of the ventilated asthmatic. There are three types of nebulizers that can be used for this purpose.

First, there are high-volume medication nebulizers, which were designed for use with the unintubated, spontaneously breathing patient. They use high gas flow (10-15 L/min) to produce the aerosol. These devices can be used with the ventilator circuit, but adaptations may be needed to compensate for the increased volume that the nebulizer produces in the ventilator circuit.

The second type of continuous nebulizer is a lower-volume device that uses low flow (1-2 L/min) to produce its aerosol. This reduces the potential for both greatly increasing the delivered tidal volume and reducing any potential resistance to exhalation that high continuous flow in the ventilator circuit may cause.

Finally, the conventional hand-held nebulizer can be used as a continuous nebulizer by adapting it to accept a continuous feed of medication from either an I.V. or syringe pump. Depending upon the flow needed to power this type of device, therapists may need to adapt the nebulizer as described in the first type of nebulizer discussed.

A high-dose MDI may also be of benefit; though after a certain length of time, it is more efficient to use a continuous nebulizer.

Additional options

Parenteral delivery of bronchodilators should be considered for certain patients. Parenteral administration allows for the delivery of medication to areas of the lung that are well perfused but may not be well ventilated. While controversial, I.V. theophylline may be of benefit. Theophylline has a narrow therapeutic index, and its risks must be considered relative to its benefits. Additionally, epinephrine and terbutaline can be given subcutaneously, and isoproterenol[5] and terbutaline can be given by continuous I.V. infusion. All of these drugs can have severe side effects, so all must be used with special care.

Volatile anesthetic agents such as ether, halothane, enflurane, and isoflurane can be used for the treatment of severe bronchospasm.[6] All of these agents require special considerations for delivery, as well as an understanding of side effects. It is essential that the respiratory therapist consult with an anesthesiologist before using these drugs.

Helium/oxygen mixtures (heliox) have been touted for use with mechanical ventilation in an effort to decrease air trapping and improve ventilation. Helium is used in place of nitrogen to reduce the viscosity of the gas ventilating the patient. This allows greater gas flows through obstructed areas, hence improving CO_2 elimination. While adapting a ventilator to accept heliox in place of medical air is fairly simple, there are many unknowns associated with its delivery by mechanical ventilator.

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Generally, the newer generation of ventilators do not deliver helium mixtures well because their internal gas-metering devices are not calibrated to such mixtures. Volume measurements (both inspiratory and expiratory) are usually subject to error. Therefore, it may be more reasonable to use pressure-limited, time-cycled modes of ventilation when using heliox. However, great care must be exercised when using mechanical ventilators to deliver low-density gases.

Airways inflammation

Inflammation of the airways should be treated with steroids. As mentioned above, the therapist should closely monitor the interactions between steroids and other drugs being used. While there is a potential for reduced side effects with the use of topical steroids, no health care facility can avoid parenteral administration of steroids in status asthmaticus.

Finally, mucous plugging in the ventilated asthmatic needs to be treated. This is most easily done with hydration, both systemic and to the airways. As noted above, an 8 mm or larger endotracheal tube should be used whenever possible. Heated humidification of the ventilator circuit is extremely important. Therapeutic bronchoscopy may be indicated to treat segmental or lobar collapse. This is a treatment that is far from benign and should be done only by those who are familiar with both the technique and the risks associated with it.

Successful, safe ventilation of the patient suffering from status asthmaticus is challenging, but by no means impossible.

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