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Breathing

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Introduction

Respiratory distress often results from either a failure of the patient's airway (covered in another section) or their inability to breathe. Problems with breathing can be further broken down into issues with either oxygenation or ventilation. Understanding which of these functions is compromised will allow the emergency physician to choose specific interventions that are appropriate. It will also help them to quickly identify those interventions that may not work.

Ventilation is the process of moving air in and out of the lungs, driven by changes in intrathoracic pressure. Proper ventilation allows for oxygen-rich air to enter the lungs and oxygen-deprived air to exit, and the process relies upon on a functioning circuit of thoracic musculature, bony stability and diaphragmatic strength. Diseases that affect the body's ability to move air successfully (e.g. pneumothorax, flail chest) will ultimately cause difficulties in respiration.

While oxygen transportation and delivery to body tissue is a complex and multi-system process, it begins with the diffusion of oxygen rich air over the alveoli to the pulmonary capillaries. Any disease process that affects molecular diffusion across the lung tissue (e.g. pneumonia, ARDS) will affect oxygenation and eventually cause the patient to develop respiratory difficulty. Disease processes that lead to respiratory failure will be discussed in a separate section.

This section will focus on the emergency physician's ability to augment ventilation, and often oxygenation, in the face of pulmonary injury or disease. Endotracheal intubation, often the final common pathway to alleviate respiratory failure, will be covered in a different section.

Objectives

- To understand failures of breathing and which interventions may be helpful
- To describe the mechanics of bag-valve mask and its indications and limitations
- To understand and describe non-invasive positive pressure ventilation (NIPPV) and its utilization in the Emergency Department

Bag-Valve-Mask Ventilation

Often deemed assisted ventilation, bag-valve-mask (BVM) ventilation is manually applied positive pressure ventilation delivered directly to a patient's airway. BVM ventilation can be performed via a plastic, well-fitting mask applied to a patient's face (see image below) or accomplished through an endotracheal tube (ETT) inserted directly into the patient's trachea. Properly performing BVM ventilation (especially via a face mask) is a difficult skill, but one which may be life saving, and should be mastered by all emergency care providers.

(https://cdemcurriculum.files.wordpress.com/2015/05/breathing_01_bvm.png)

Bag Valve Mask
The BVM consists (from left to right) of a mask which fits on the face, a valve which allows only one way flow of oxygen, a bag for pumping the air forward and an oxygen reservoir.

Often the most critical and difficult step in BVM ventilation is to ensure the application of a well-sealed, well-fitting mask to a patient's face. Difficulty may be encountered in patients with altered anatomy, dentures, facial hair or obesity. Walls, et al published the mnemonic *MOANS* to help emergency providers predict which patients may be difficult to ventilate with BVM.

- Mask Seal (trauma, blood, beards)
- Obesity

- Age (>55)
- No teeth (leave dentures in)
- Stiff (lungs, neck)

BVM ventilation, whenever possible, should be performed by two providers. One provider should use both hands to apply the facemask, focused on maintaining an adequate seal, while the other provider squeezes the self-inflating bag to deliver oxygen rich air to the patient. One-handed ventilation may be performed if necessary, but difficulty is often encountered establishing and maintaining a patent seal. BVM ventilation may also be optimized by rapidly placing an oral or nasal airway, bypassing much of the physical obstruction caused by redundant tissue or a large tongue.

The facemask should rest on the bridge of the nose, over the malar eminences with the base extending to the mandibular alveolar ridge. In some situations it may be prudent to add or remove air from the mask itself using a syringe.

Two-provider BVM ventilation

To perform “two provider” BVM ventilation, one clinician should place themselves at the head of the bed. Utilizing the thenar eminence of both hands, mild downward pressure is applied to the nasal portion of the mask. Pressure should be distributed equally across the mask. The free digits are used to apply a jaw thrust and pull the mandible *towards* the facemask. The provider’s hands should form a c-shape and provide a tight seal between the facemask and patient’s face (see below).

(https://cdemcurriculum.files.wordpress.com/2015/05/breathing_02b_2hands.png)

Two Provider, Two-handed Bag Valve Mask technique
The E-C grip.

An alternate position is resting both thenar eminences over the lateral aspect of the mask, while the mandible is lifted towards the mask itself, using the free digits to perform a chin lift or jaw thrust maneuver (see below). The second provider stands to the side of the patient and squeezes the self-inflating bag to deliver oxygen at a clinically indicated respiratory rate.

(https://cdemcurriculum.files.wordpress.com/2015/05/breathing_02a_2hands.png)

Two Provider, Alternate Two handed Bag Valve Mask Technique

One-provider BVM ventilation

In single provider BVM ventilation, the same clinician holds a face mask seal, tries to support a patent airway, and squeezes the self-inflating bag to deliver oxygen to the patient simultaneously. Using their non-dominant hand, the provider grasps the face mask with their thumb and index finger, forming a C-shape around the ventilation port. The web space between thumb and index finger may rest upon the mask for stability. Using the middle, ring and small finger of the same hand, the jaw and face is lifted *towards* the mask. If the provider's hands are large enough, the small finger can be placed at the angle of the mandible to simultaneously perform a jaw thrust. Care must be taken not to compress soft tissue, as this may alter the mask seal or cause complete airway obstruction via the tongue.

(https://cdemcurriculum.files.wordpress.com/2015/05/breathing_03_1hand.png)

Single Provider, One-handed BVM Technique

Providing ventilations

The provider should take steps to avoid overly aggressive BVM ventilation. Ideally, patients should receive 5-6 cc/kg, or a tidal volume of 350 cc for a 70 kg patient. Starting respiratory rate should be 10-12 breaths/minute, which can be accomplished by the provider counting 5 to 6 seconds between each delivered breath.

Respiratory rate, tidal volume and other ventilator parameters should be adjusted to best support the specific patient as their disease process requires. All clinicians performing BVM ventilation via facemask should also remember that the delivered air can insufflate the stomach as well as the lungs, putting these patients at risk for vomiting and aspiration. Patients ventilated via ETT will not be at risk for aspiration but will be at risk for pneumothorax or other sequelae of barotrauma.

Adequate ventilation can be assessed by watching for chest rise, by listening for air leaks around the facial mask, and by auscultating for intrathoracic air exchange. If ventilation is not successful, the clinician should make sure that the equipment is functional, the seal is tight and that adequate oxygen is being delivered via the BVM. Troubleshooting techniques may include changing the size of the mask, attempting a new bag-valve mask device, applying lubricant to a beard or insertion of oral or nasopharyngeal airway, or recruiting additional participants.

Noninvasive Positive Pressure Ventilation

In patients with an adequate mental status and deteriorating respiratory status, Noninvasive Positive Pressure Ventilation (NPPV) can augment natural breathing by providing ventilator support through the delivery of pre-set volumes or pressures of air. Various methods of NPPV are available; including high-flow nasal cannula (HFNC), bilevel positive airway pressure (BiPAP) and continuous positive airway pressure (CPAP).

As indicated by its name, high-flow nasal cannula delivers oxygen via an augmented cannula placed under the nose. BiPAP and CPAP can be delivered either via a nasal mask or full-face mask (see below). HFNC and CPAP provided oxygen at continuous pressure (up to 15 cm of water for CPAP) while BiPAP allows for cyclical pressure changes. Inspiratory pressures (IPAP) for BiPAP can be started at 8-10 cm of water with expiratory pressures (EPAP) of 3-4 cm of water. Certain diseases will warrant modification of these settings from the outset. For example, patients with pulmonary edema typically start at IPAP of 15 over EPAP of 5.

The positive pressure delivery of oxygen allows for decreased work of breathing and increased total lung volume. Functional residual capacity goes up, tidal volume goes up and minute ventilation goes up. The positive pressure drives fluid from the intra-alveolar spaces to the extra-alveolar spaces. The ability to deliver positive pressure similar to that delivered via endotracheal intubation without the risk of the intubation procedure itself must be mentioned. Risks of intubation include, but are not limited to: laryngeal injury, tracheal stenosis, necrosis from endotracheal cuff pressure and complications of sedation (both pre and post procedure).

Understanding the benefits and drawbacks to NPPV are important when deciding which patients are good candidates for this treatment modality. Patients who do well on NPPV usually suffer from an acutely reversible pulmonary condition, such as acute pulmonary edema or asthma. Optimal candidates are awake and alert and able to protect their airway.

Patients who suffer from claustrophobia or anxiety often do not tolerate the face mask, and therefore do not do well with NPPV. Since NPPV does not provide the airway protection endotracheal intubation does, it is not an appropriate choice in patients with a compromised airway.

NPPV also allows for the clinician the opportunity to ready other interventions, which may address the underlying cause for respiratory distress. Medications such as nitrogylcerin, albuterol, or steroids can be given while the patient's oxygenation improves, and NPPV may thus be utilized as a bridge toward a more definitive therapy.

Side effects of NPPV are often related to the mask itself, as skin breakdown may occur when associated with long-term use. Also, excessive positive pressure via face-mask is no different than that through an endotracheal tube, as it may cause the same side effects as prolonged bag-valve ventilation or intubation: namely; increased intrathoracic pressure, decreased venous return, leading to decreased blood pressure. The mask itself is tightly secured to the patient's face in BiPAP or CPAP, and is thus contraindicated in an actively vomiting patient, and carries the risk of aspiration if a patient does begin vomiting. Prolonged positive pressure also places patient at risk for barotrauma and air trapping. Lastly, as discussed with BVM ventilation, excess air insufflation can cause gastric distension and possibly increase the risk of aspiration.

References

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