Focus On - Bag-Valve Mask Ventilation

ACEP News
September 2008
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Learning Objectives

After reading this article, the physician should be able to:

- Describe the four steps to achieve optimal bag-valve mask (BVM) ventilation.
- Know predictors of difficult BVM ventilation.
- Be able to troubleshoot difficult BVM ventilation.
- Be familiar with some differences when ventilating children.

The management of the emergency airway is continually evolving with the introduction of new airway devices. There is a large body of literature regarding a variety of rescue devices and algorithms for managing the difficult airway. Despite these important advances in emergency airway management, it is imperative for the emergency physician to be facile at basic airway maneuvers. Bag-valve mask (BVM) ventilation is a life-saving skill that can easily be overlooked because of its apparent simplicity. Poor BVM ventilation technique can lead to the need for more invasive means of airway management and their inherent complications. The authors will present a detailed approach to BVM ventilation with a focus on good technique and overcoming obstacles.

BVM ventilation is a critical component of airway management. It provides oxygenation and ventilation prior to the placement of a definitive airway and can be used as a rescue maneuver alone. Proper BVM ventilation is important for pre-hospital providers as well. One study suggests that endotracheal intubation for trauma does not improve survival over BVM ventilation, indicating a vital need for successful BVM ventilation techniques.¹

BVM ventilation is a difficult skill to master. There are many impediments to successful mask ventilation. Kheterpal, et al² described these factors that hinder BVM ventilation:

- a body mass index of 30 kg/square meter or more
- presence of a beard
- Mallampati score of three or four
- age of 57 or older
- severely limited jaw protrusion, and
- snoring.²

Predictors of impossible mask ventilation include snoring and a small thyromental distance (less than 6 cm). In addition to these well-studied factors, emergency care providers must also overcome possible airway obstruction caused by vomitus or blood and trauma to
the face or neck. The edentulous, obese, elderly, or pregnant patient presents additional challenges. A stepwise approach to BVM ventilation is recommended in order to overcome these obstacles.

Components of BVM Ventilation

Equipment: Collection of proper equipment is essential: a pulse oximeter, oxygen source, bag-valve mask device, cushioned rim mask with variable sizes, nasopharyngeal and oropharyngeal airways, tongue blade, water-based lubricant, and a Yankauer suction catheter with vacuum power source. There are several bag options available, such as flow-inflating bags, self-inflating bags, and the T-piece resuscitator. The self-inflating bag-valve mask system is the most commonly used system for emergency department and pre-hospital resuscitation.

An appropriate mask is one that does not cover the patient's eyes and does not extend beyond the chin. Typically, this mask is of anatomic design, with the pointed portion over the nose. The bag-valve mask unit should be attached to high-flow oxygen at 15 liters per minute, at which a typical device delivers about 75% oxygen.

Positioning and preparation: Proper positioning is a crucial element of successful BVM ventilation. The classic teaching for ventilation and intubation positioning involves placing the patient in the "sniffing" position, provided the patient does not require cervical spine immobilization. There is some debate in the anesthesia literature regarding the efficacy of the sniffing position compared to simple extension. It is important to keep in mind that mere adjustment of the atlanto-occipital axis may not be adequate, particularly for obese patients. For more obese patients, a shoulder roll or ramp may be necessary.

Ideal BVM positioning is obtained by aligning the patient's external auditory meatus with the sternal notch (ear-to-sternal notch position, see figure 1). Ear-to-sternal notch positioning provides better alignment of the oropharyngeal axes than does the traditional "sniffing" positioning.

There are additional maneuvers to assist with adequate positioning for BVM ventilation. The head tilt-chin lift is a maneuver that can be done if cervical spine injury is not suspected. The head tilt-chin lift is done by using one hand to apply downward pressure on the forehead, while the other hand lifts the chin.

A jaw thrust maneuver is safer for suspected spinal injuries. The jaw thrust is done by placing both hands on the angles of the mandible to displace the jaw anteriorly. Care should be taken to avoid extending the neck. Both the head tilt-chin lift and jaw thrust should improve airway patency and optimize BVM ventilation.

The use of airway adjuncts may be an important component of successful BVM ventilation. There are two types of adjuncts: the oropharyngeal (OP) and nasopharyngeal (NP) airways. There are several sizes of each airway to consider. The OP airway can be held vertically outside the mouth and should extend from the mouth opening down to the angle of the mandible. When inserting the OP airway, it is helpful to first depress the tongue with a blade to avoid pushing the tongue posteriorly with the OP. Grasping the mandible and tongue in one hand and manually distracting the jaw is also helpful, provided the patient will not bite. The NP airway size is measured from the naris to the angle of the mandible. Lubricant jelly should be applied to the NP tip to assist placement. Either an OP or NP airway should be inserted every time BVM ventilation is performed as part of resuscitation. While both techniques are effective, the authors prefer the use of a NP airway, as it does not traumatize the mouth and can be left in place while other airway maneuvers are attempted.

Seal: Obtaining an adequate seal between face and mask is one of the more challenging components of this procedure. BVM ventilation can be performed with one or two providers. While competency with the single-provider technique is invaluable and necessary, the two-provider technique is typically more effective. Traditionally, the 'EC' hand position is utilized to obtain a seal with the mask (figure 2). This position involves the thumb and index finger holding the mask and the inferior and superior mask borders, respectively. The other three fingers hold the mandible while performing the jaw thrust. If using the two-provider technique, one person should hold the mask with both hands, while the other provider bags the patient (figure 3). A common location of air leak is located around the nasal bridge, which should be detected when attempting ventilation.

Another technique of mask holding has been described as more comfortable, especially with prolonged ventilation. Using this alternative method, the mask holder applies pressure to the mask by placing both thenar eminences parallel to the long axis of the mask. The other four fingers are placed under the mandible to apply jaw lift (figure 4). Either mask holding technique can be used, depending on the level of experience and comfort of the provider.
Oxygenation and ventilation: Once the position and seal are obtained, "bagging" can commence. The rate of ventilation for an adult is 10-12 breaths per minute or, approximately 1 bag squeeze every 5-6 seconds. The bag should be depressed for a full 1-2 seconds and then released. Chest rise should be seen with adequate tidal volumes, approximately 6-7 cc/kg or 400-600 mL. Appropriate oxygenation and ventilation should be reflected by pulse oximetry readings. Providers have a tendency to hyperventilate patients. The emergency medicine literature has demonstrated that hyperventilation can be harmful by increasing intra-thoracic pressure, which decreases venous blood to the heart and subsequently decreases cerebral and coronary perfusion pressures. Be mindful of the potential harmful effects of hyperventilation when bagging your patient.

Problems and Troubleshooting

When encountering problems with ventilation, one should review the key steps of BVM ventilation: equipment, position, seal, and oxygenation/ventilation. Review your equipment: is your oxygen source on? Is your bag functioning? Do you have the appropriate airway adjunct? Evaluate patient positioning: is the ear-to-sternal notch position attained? Repeat your chin lift and jaw thrust, if indicated. Evaluate your seal: Do you need to change your technique to a one- or two-person hold? Does your mask fit properly or is there an air leak? Consider other causes of poor oxygenation and ventilation, such as vomitus, secretions, or difficult anatomy.

Aspiration of gastric contents during BVM ventilation is a potential hazard. Cricoid pressure is traditionally applied during BVM ventilation to help limit regurgitation. However, cricoid pressure also has been shown to cause unwanted airway obstruction. In emergent airway situations, the need for ventilation and the risk of irreversible hypoxic brain injury outweighs the risk of potential aspiration. Additionally, cricoid pressure may not completely protect against aspiration.

While the application of cricoid pressure is still considered the standard of care, practitioners should be cognizant of the potential for airway obstruction from cricoid pressure. If cricoid pressure is impeding ventilation, it should be lessened or released entirely. Gastric inflation can be minimized by using lower inspiratory pressures, which is done by delivering breaths slowly and providing smaller tidal volumes.

BVM in the Pediatric Population

The pediatric airway poses some important differences with regard to effective ventilation. There are some anatomical differences to review. Infants and young children have large occiputs compared to adults. This major difference causes more flexion of the neck when the patient is supine. Also, children have larger tongues which can cause airway obstruction. Extra care must be taken to achieve adequate positioning and relief of tongue obstruction with airway adjuncts.

With regard to equipment, bags have smaller volumes for newborns and young children. Mask sizes vary with children and it is important to choose an appropriately fitted mask. Unlike the adult anatomic mask, a circular mask may be more suitable in infants and young children.
The rate of ventilation rate is different for the pediatric population: for infants, 20-30 breaths per minute; for older children, 16-20 breaths per minute. As for adults, the tidal volume delivered to the child should be appropriate to see chest rise, and care should be taken to not over-ventilate the patient.

**Strategies for Successful BVM Ventilation**

Common pitfalls of BVM ventilation include inadequate positioning, improper mask holding, and failure to use an oral or nasal airway. Having a stepwise approach to performing and troubleshooting BVM ventilation will improve the likelihood of success. In addition, being familiar with the predictors of difficult BVM ventilation can help you anticipate problems. The role of simulation is important for BVM ventilation. It has been shown that simulation of airway management can improve the effectiveness of a provider’s technique in caring for patients. As with any other procedure in emergency medicine, practice is the key.

**References**


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