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Technical White Paper

Life Threatening Risks in Manual Ventilation: Training to Improve Technique and Patient Outcomes

By Jennifer Bacior

Correct manual ventilation technique is critical for the survival of patients in respiratory arrest. Unfortunately, multiple studies have shown that ventilation technique in the field is widely varied and inconsistent. Current efforts at ventilating prehospital patients often result in dangerous performance and application of both manual and bag-valve mask (BVM) ventilation, which, in turn, results in life-threatening consequences for patients.

In order to amend these potentially life-threatening conditions, simulation training must be brought to the next level to ensure proper patient care in a wide range of real-life scenarios.

Executive Summary

This paper discusses manual and bag-valve mask ventilation, specifically harmful complications during use, and introduces a new approach to training that will aid in resolving these problems in the clinical setting.

Overview

In life-threatening situations, initial ventilation is commonly provided to patients who cannot breathe by themselves via a self-inflating bag-valve mask (BVM). This technique is widely considered to be a critical aspect of managing out-of-hospital medical emergencies.¹

However, when this technique is performed improperly, lungs may experience barotraumas from high pressures and cardiac perfusion may suffer due to increased intrathoracic pressure. Another risk of incorrectly performed BVM ventilation is increased airway pressure allowing air to enter the stomach. This gastric inflation can cause gastric regurgitation, aspiration of stomach contents, and reduced tidal volume delivery into

the lungs (because part of the volume introduced into the patient goes into the stomach.)

The Mechanics of Ventilation

When lungs are ventilated using manual or BVM ventilation techniques, the total volume of air that reaches the lungs depends on several factors; of these, airway resistance and respiratory system compliance may be two of the most commonly acknowledged. As resistance increases or compliance decreases, it becomes progressively harder for a first responder to inflate the lungs.

Another factor is, of course, the technique of the patient care provider, specifically: head position, tidal volume, and inflation flow rate and duration, (which aid in establishing peak airway pressure,) are crucial when ventilation is administered.²

The unique interaction of these variables combines to determine the gas distribution of the air introduced into the body via manual or BVM ventilation.

Minor Changes Yield Major Impacts

Since the balance of gas distribution weighs not only on the patient parameters of a given patient, but also on the person providing ventilation to the patient, even minor differences in technique can lead to major complications in ventilation.

Studies have found that even among highly trained and experienced medical personnel, the quality of manual and BVM ventilation is inconsistent and does not meet published guidelines.³⁻⁸

In a clinical observation study, it was found that ventilation rates during the field application of CPR in a city with well-trained EMS personnel were observed to be far in excess of those recommended by the American Heart Association (AHA).⁷ During this study, professional rescuers consistently and inadvertently hyper-ventilated patients during actual resuscitations.⁷

This hyperventilation can lead to detrimental hemodynamic and survival consequences during low flow states such as CPR.⁸

In fact, the study continues:

Unrecognized and inadvertent hyper-ventilation may be contributing to the currently dismal survival rates from cardiac arrest.⁸

Incorrect performance of manual or BVM ventilation has also been shown to result in another detrimental consequence: stomach inflation. This leads to gastric regurgitation,^{2,9} aspiration,⁹ pneumonia,⁹ and even death⁹. In addition, inflation of the stomach may increase intra-gastric pressure, elevate the diaphragm, restrict lung movements, and so reduce the respiratory system compliance.⁹ This compliance reduction has been shown to direct even more of the ventilation volume into the stomach,¹⁰ thereby reducing the effectiveness of the manual or BVM ventilation even further.

Moreover, when ventilation, (specifically BVM ventilation,) is performed, it is generally done with a short ventilation time and a high peak airway pressure.² This increased airway pressure is another contributor to the introduction of air into the stomach. In addition, the high airway pressure can cause lung overdistention that may

be damaging if the pressure is transmitted through to the alveoli.¹¹

Simulation Training Can Improve Performance

Despite what may seem like overwhelming complications in performance of manual or BVM ventilation, in many situations, it is the only option. So what can we do to significantly reduce the potential for negative occurrences during manual ventilation?

Many medical educators believe that advanced medical simulation training is the answer. The regular use of simulators incorporated into structured, continuing medical education programs, as well as in self-assessment and self-directed remediation programs offers great promise for lifelong professional development.¹²

Simulation has been effectively used in a large variety of industries—including the use of flight simulators for aviators, management games for business executives, technical and disaster scenarios for plant technicians, and even professional athletes use simulators to hone their craft. So why should any aspect of health care be different?

Several versions of high- and low-tech task trainers for various aspects of medicine currently exist, ranging from sophisticated full body patient simulators to the use of disembodied manikin arms to train phlebotomists in drawing blood.

The 2005 Basic Life Support Guidelines, published by the AHA, recommend “considerable practice for competency” in performance of BVM ventilation.¹⁵

Currently, the standard for teaching manual and BVM ventilation is a low-fidelity resuscitation manikin that consists of a head and upper torso and allows for basic practice of ventilation techniques.

This manikin has been the standard for many years; however, the statistics point to a lack of efficacy in producing solid and competent field personnel. Perhaps the current manikin simulator is too basic in its design.

The Ideal Ventilation Trainer

So what characteristics would make up an ideal ventilation simulator?

The two most important characteristics of this simulator would be realism and feedback.

The simulator should not only to look and feel like a patient, but it should also simulate several different combinations of patient parameters, specifically airway resistance and respiratory system compliance. Patients come in all shapes and sizes—a simulator that only accounted for averages would have limited use in training personnel in a realistic and accurate way.

In addition, the simulator should allow for real-time feedback to its users.

A direct feedback mechanism that would immediately indicate to the clinician what he or she is actually doing could help in adjusting bag-ventilation technique.¹⁶

Both the trainer and the student should be able to see and understand exactly what is going on. The purpose is to allow the user to make minute changes in ventilation technique while administering breaths that would register a real-time response in the system. It is of limited help to a trainee to find out ten minutes after completion of training that hyperventilation or stomach inflation occurred in the patient. To perfect technique, the user needs to know what they are doing to the patient *as they are doing it*.

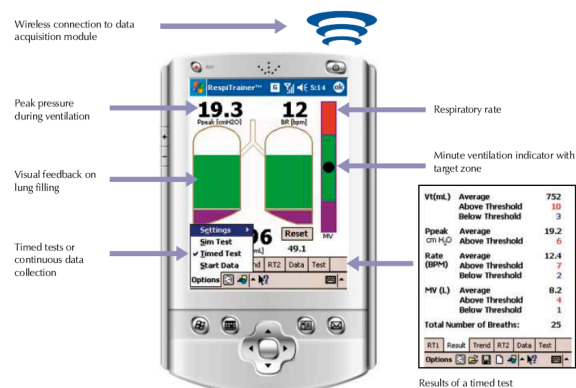


Introducing the RespiTrainer™

The RespiTrainer from IngMar Medical, Ltd., is a novel new product that was specially developed for training proper manual ventilation technique.

This unique tool provides real-time feedback via a wireless connection to a PDA (included) It allows you to observe and practice ventilation patterns, as well as vary delivered volume, flow, and pressure. The real-time response of the system shows the user several factors, including:

- Tidal volume, (V_t), in mL, including visual feedback on lung filling
- Peak pressure, (P_{peak}), in cmH_2O during ventilation
- Respiratory rate, (BR), in breaths per minute
- Minute ventilation, (MV), in L, including a visual indicator with a target zone



In addition, an included stomach bag simulates gastric inflation, seen to be a common and life-threatening complication of incorrect manual ventilation.

The innovative use of IngMar Medical's adjustable QuickLung® test lung allows for a wide range of simulated patient models, including a compliance range from 10-50 mL/ cmH_2O and a resistances range from 5-50 $\text{cm H}_2\text{O/L/s}$.

In addition, the RespiTrainer has both a timed test mode and a continuous data collection mode, making it not only useful for acquiring skills and learning proper technique over an extended period of time, but also for certification testing within a timed framework.

Furthermore, the RespiTrainer is highly portable. IngMar Medical provides a convenient carrying case to allow the RespiTrainer to be taken to trade

shows, training workshops, or room-to-room within the same facility.

Summary

Given the importance of correct ventilation technique in proper patient care, simulation training is an imperative part of any life-support training regimen. Current efforts have been shown to result in inconsistent and often dangerous performance and application of both manual and bag-valve mask (BVM) ventilation. Simulation training must be brought to the next level to

ensure proper patient care in a wide range of real-life scenarios, utilizing feedback apparatuses that allow the user to practice correct manual ventilation techniques.

The portable, easy-to-use IngMar Medical RespiTrainer allows for proper instruction of manual ventilation with real-time feedback and a user-friendly interface. The RespiTrainer streamlines the training process and gives medical professionals the ability to administer a higher quality of patient care.

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