ORIGINAL RESEARCH

Training Medical Students in Bag-Valve-Mask Technique as an Alternative to Mechanical Ventilation in a Disaster Surge Setting

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Abbreviations:
BLS = Basic Life Support
BVM = bag-valve-mask
CPR = cardiopulmonary resuscitation

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Abstract

Objective: The objective of this study was to evaluate the rapid training of medical students and their ability to provide effective manual ventilation using the bag-valve-mask technique.

Methods: A rapid training session highlighting essential aspects of the correct bag-valve-mask technique was given to 31 medical students. This was followed by a simulated experience with a certified respiratory therapist, monitored according to a checklist of essential bag-valve-mask (BVM) competency requirements. Pre-test and post-test surveys assessed the medical students' knowledge and ability to provide adequate BVM technique.

Results: Thirty-one students participated. Pre-survey results demonstrated a clear identification of the potential risk for a disaster (pandemic, natural, bioterrorist) with 55% of students responding that a definite risk did exist. Their usefulness in such an event also was ascertained with 55% of students replying they would assist with basic medical tasks, assist doctors, or assist with cardiopulmonary resuscitation. Post-survey results administered after a 30-minute didactic session on the basic features of resuscitation equipment and the essential components of BVM technique demonstrated that a majority of students knew the proper head positioning maneuvers in cases not involving trauma (93%) and in cases involving trauma (72%). All students completed and passed the competency checklist.

Conclusions: Medical students can be rapidly trained and be utilized as a potential resource to carry out the potentially lifesaving task of manual ventilation using the BVM technique in a disaster situation in which the availability of mechanical ventilators and respiratory therapists may be limited.

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Background

The recent occurrence of disasters due to natural hazards, the threat of terrorism, and the dangers of acute respiratory failure due to a possible pandemic of influenza have forced healthcare providers to not only develop disaster preparedness models, but also to focus on the need for mass-casualty mechanical ventilation. In such an event, the local supply of mechanical ventilators available immediately to healthcare providers may be insufficient.[1] The US Centers for Disease Control and Prevention's Strategic National Stockpile (SNS) Program owns and maintains mechanical ventilators for distribution to states in the event of a mass-casualty incidents. Hospitals in the US currently maintain a sufficient supply of ventilators to meet current healthcare demands and rent additional ventilators to supplement their inventories at times of peak demand, such as during the flu season. In a disaster surge setting, most hospitals may be unable to respond appropriately. In May 2006, the American Association for Respiratory Care published "Guidelines for Acquisition of Ventilators to Meet Demands for Pandemic Flu and Mass

Casualty Incidents". It recommended the expansion of current national ventilator stockpiles, emphasized the need to establish a procedure for appropriate distribution of local ventilator stockpiles and ensure proper and versatile mechanical ventilators, the importance of logistical support, as well as the need for addressing human resource issues in disaster surge settings and having a plan for adequately trained support staff.[2] Although the guidelines recommend the acquisition of gasoline- or diesel-powered generators to support mechanical ventilators in the event of a loss of electricity, situations may occur in which this may not be adequate to provide immediate emergency lifesaving airway-ventilation management.

Historical precedent has provided the healthcare community with important examples of alternative methods for providing mechanical ventilation for mass-casualty airway-ventilation management for acute respiratory failure. During the 1952 Copenhagen poliomyelitis epidemic, approximately 3,000 patients presented with poliomyelitis between the months of August and December. About 1,250 patients presented with paralysis. Approximately 345 patients had ventilatory paralysis. In the first three weeks of this epidemic, 27 of 31 patients with poliomyelitis complicated by ventilatory muscle paralysis died, 19 of them within three days of admission to the hospital. The Blegdam Hospital lacked an adequate number of ventilators, with a supply of one Emerson tank respirator (iron lung) and three cuirass respirators at the outbreak of the epidemic. The hospital quickly became overwhelmed, with 70 patients requiring mechanical ventilation at one time during the height of the epidemic.

Due to the innovative proposal of Dutch anesthesiologist, Bjorn Ibsen, manually ventilating patients through tracheostomy tubes and utilizing medical and dental students saved several hundreds of lives. More than 200 medical students performed manual ventilation in shifts of 6 to 8 hours in relay. The result of this ingenious solution was a reduction in the mortality rate from approximately 90% to about 25%.[3] During more recent events, such as Hurricane Katrina, the use of manual ventilation provided by respiratory therapists, nurses, residents, and even family members proved to be an invaluable life-saving tool. With the loss of emergency electrical generators submerged in floodwaters and gas-driven transport ventilators inadequate for patients who required high levels of positive end-expiratory pressure or high levels of minute ventilation, the use of bag-valve-mask (BVM) devices by properly trained hospital staff and family members taking turns providing manual ventilation still proves to be an extremely resourceful method for airway management in a mass-casualty setting.[4]

Introduction

Due to recent disasters and the possibility of mass casualties due to various causes, hospitals are assessing their ability to address surge capacity. During a disaster requiring advanced ventilatory support, alternative means of ventilation will need to be sought. In addressing such areas of disaster preparedness, all levels of medical response from local to tertiary-care facilities will need to ascertain their ability to address and manage airway-ventilation management.

Although plans for local hospitals to pool and share resources and stockpiles exist, mechanical ventilators are a finite resource. Not only is it possible that their number may be insufficient for mass-casualty care of patients with acute ventilatory failure, it is likely they will not be available in the immediate aftermath of such an event. Manual ventilation will be necessary to maintain adequate advanced airway and ventilation in both the immediate response period and, depending on the type of event and the resources available, in the long-term care of patients arriving with ventilatory failure. Respiratory therapists properly trained to provide proper bag-valve-mask (BVM) ventilation also are a limited resource. Many other healthcare professionals will be overextended during emergency disaster situations.

In the academic hospital setting, medical students are a large, potentially underutilized resource. They often are eager to help, but are not licensed to practice and often can feel superfluous in emergency settings. While medical students cannot perform medical decision-making or unsupervised invasive procedures, they can be trained to perform important essential tasks. Teaching and assessing the ability of medical students to adequately provide manual ventilatory support can utilize an invaluable medical resource to provide a necessary lifesaving task.

If mechanical ventilators are unavailable during complex emergency events in an academic hospital, a possible solution may be to use medical students to provide manual ventilation to patients in need of airway-ventilatory support, but who cannot be placed on ventilators due to a paucity of machines. The main objective of this study is to evaluate the rapid training of medical students and their ability to provide proper and effective manual ventilation utilizing the BVM technique after completion of a targeted training session.

Methods

Study Participants

Medical students were informed of the opportunity to be involved in this study and participate in training sessions provided to pre-formed small groups, student representatives, and an emergency medicine interest group. The training session was open to all medical students and participation was voluntary.

Setting

The training session was conducted in a large auditorium in the medical school on the campus of the University of Illinois at Chicago Medical School.

Course Content

Emergency medicine physicians in consultation, with the Department of Respiratory Therapy developed a training session based on existing guidelines for disaster management and respiratory care practice. The content was adapted for practical application by medical students. The training session included an introductory lecture about pandemic influenza and the identification of the role of medical students within a team of healthcare providers presented by an emergency medicine physician. This was followed by a session that was conducted by a trained respiratory therapist highlighting the basic features of necessary equipment

	n (%)
Year of Medical School (MS) training?	MS2: 28 (96.6) MS4: 1 (3.4)
Gender?	Male: 16 (55.2) Female: 13 (44.8)
Previous CPR training?	BLS: 28 (96.6) ACLS: 2 (6.9)
Prior healthcare experience?	Yes: 1 (3.4) No: 28 (96.6)
Prior experience assisting in CPR?	Yes: 4 (13.8) No: 25 (86.2)

Table 1—Pre-survey demographic data
(ACLS = Advanced Cardiac Life Support; BLS = Basic Life Support; CPR = cardiopulmonary resuscitation)

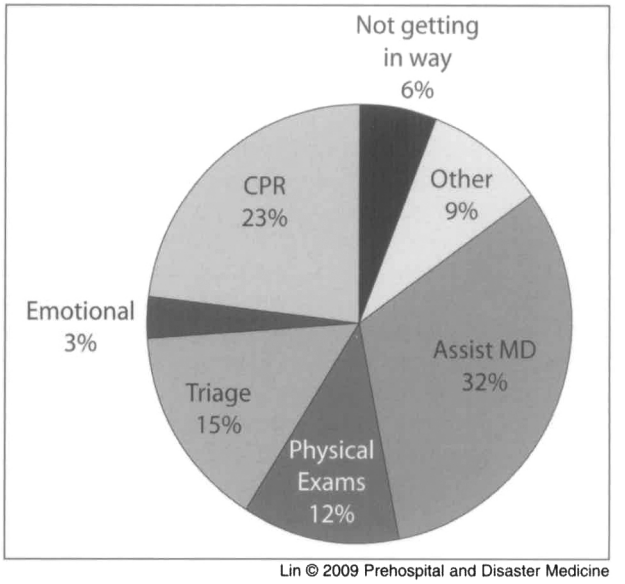

Figure 1—Pre-survey results, question four: As a medical student, how do you think you might be able to contribute or assist in such an event?
(CPR = cardiopulmonary resuscitation)

involved and the essential aspects of correct BVM technique. Afterwards, medical students were placed into small groups consisting of 7–8 students assigned to one respiratory therapist. They underwent simulated scenarios and performed the BVM technique under the supervision of one of the trained certified respiratory therapists and completed a competency checklist. Each group was provided with plastic infant and adult resuscitation models with airway and ventilatory functionality and an array of respiratory equipment in different sizes. Pre-and post-surveys were administered at the beginning of the training session and upon completion of the training and simulation sessions to assess the medical students' knowledge and ability to provide adequate BVM technique.

The training session was conducted in three hours with two didactic lectures and hands-on simulations, each lasting approximately 30 minutes.

Survey Tools

A pre-survey was administered to obtain basic demographic information, previous experience, and awareness about disaster preparedness (Appendix 1). A checklist was completed during simulation sessions by certified respiratory therapists to assess competency in performing effective BVM technique. A post-test was completed by the medical students at the end of training session to assess their ability to retain key aspects of proper BVM technique and skills at the end of the training session (Appendix 2). The Institutional Review Board at the University of Illinois at Chicago approved the study consent forms and study survey forms.

Data Analysis

Quantitative data were analyzed using Microsoft Excel and SPSS version 11 (SPSS Inc., Chicago, Illinois). Qualitative data were tabulated manually and either adapted into a quantitative format or analyzed descriptively.

Results

Thirty-one students participated. Two students were not included in the study due to dropping out prior to the end of the training session and incomplete involvement (n = 29). There were 28 second-year medical students and one fourth-year medical student. Gender was equally represented (55.2% male, 44.8% female).

The pre-survey results (Table 1) indicate that 28 medical students (96.6%) and two others (6.9%) had undergone previous Basic Life Support (BLS) and Advanced Cardiac Life Support training, respectively. One student (3.4%) had prior healthcare experience, while the majority (96.6%) had none. Twenty-five students (86.2%) had no prior experience assisting with or performing CPR. When asked about their opinion about the risk of a potential disaster (pandemic, natural, or bioterrorist), 16 students (55%) replied that there existed a "definite risk", eight (28%) responded "possible risk", and five students (17%) responded there existed "no risk". When asked about how they felt they might be most useful in such an event, most (31%) of students responded "basic medical tasks" or "assisting MDs" (Figure 1). Other answers included: (1) assisting with CPR; (2) triage assistance; (3) performing physical examinations; (4) not getting in the way; and (5) emotional support.

A checklist was completed by certified respiratory therapists after assessment of medical students performing BVM during simulation exercises. Information assessed was proper BVM technique and skills including: (1) choice of appropriate size bag and mask; (2) use of C-E grasp; (3) ability to achieve proper seal with mask; (4) effective ventilations with proper ventilation rate; and (5) ability to troubleshoot and correct inappropriate BVM technique. All of the students demonstrated appropriate technique.

The post-test survey was completed by all 29 participants. A majority of the students knew the proper head positioning head-tilt maneuver in cases not involving trau-

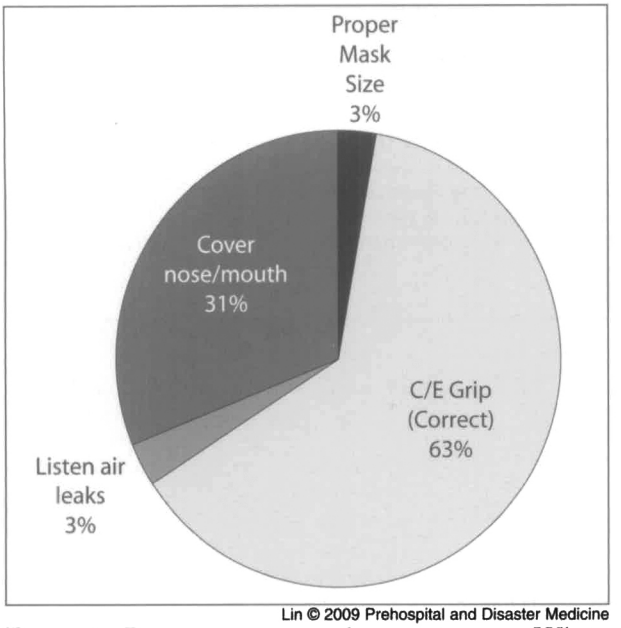

Figure 2—Post-test survey results, question two: What are possible methods for ensuring a proper seal?

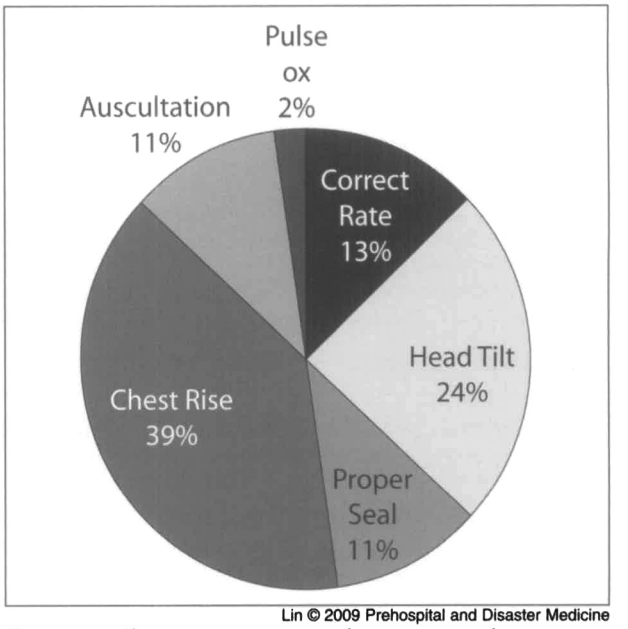

Figure 3—Post-test survey results, question three: What are methods for ensuring adequate ventilation?

ma (93%) and the use of the jaw-thrust maneuver in cases with trauma (72%). A majority of students were able to identify the proper ventilation rates for neonates, children, and adults (89.6%, 89.6%, 86.2% respectively). A majority of students (63%) correctly identified "C-E grip" as the best method to ensure a proper seal (Figure 2). While 39% correctly identified "chest rise", 11% of students identified "auscultation" as appropriate means of ensuring adequate ventilation (Figure 3).

Discussion

The pre-survey was designed to obtain basic demographic information and assess the student's basic knowledge about basic life support BLS and BVM skills. The majority of the students were second year medical students with limited clinical experience. More than 96% of students had received basic BLS training; however, their responses reflected uncertainty in essential components of BVM techniques, and insecurity in how they may be useful in a disaster surge setting. More than 86% had no prior clinical hands-on experience performing or assisting in CPR and 66% of the students responded they were unsure of the key components of BVM to a question in the pre-survey. Only 17% were able to list correct components, including proper placement.

The post-survey demonstrated that medical students showed significant improvement both in knowledge of BVM technique as well as effective BVM skills. After the rapid overview of the basic features of BVM and effective manual ventilation was demonstrated by all students (100%) monitored by certified respiratory therapists during the 30-minute simulated sessions, the post-survey demonstrated that a majority of students now were able to correctly answer questions relating to BVM technique.

In many emergent medical situations, there often are several tasks that must be completed within a short period of time. Resources such as trained healthcare personnel and certain medical equipment such as mechanical ventilators may be scarce in such disaster surge situations. Although there have been strides in respiratory medicine and disaster preparedness since the experience of the 1952 Copenhagen poliomyelitis epidemic, the potential threats of bioterrorism and pandemic influenza may stretch resources beyond the reach of the current availability. This study demonstrates that medical students can be trained quickly to provide the potentially life-saving task of providing life support using a BVM in the event of a disaster situation where the availability of mechanical ventilators and respiratory therapists may be over-extended. Students often feel extraneous in a medical emergency. However, students often are an underutilized resource that could play an essential role in the outcome of patients requiring advanced respiratory support.

While a short course does not provide students with airway expertise, a rapid BVM training session allows the student to participate as part of the medical team and gain a useful and potentially lifesaving skill. Future studies are needed to compare less experienced medical students versus those with more clinical training. It also would be beneficial to repeat the BVM simulation at a later date to evaluate their retention of material learned.

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Appendix 1—Pre-survey questions (CPR = cardiopulmonary resuscitation; EMT = emergency medical technician; RN = registered nurse)

1. What year of medical school are you in?
2. Gender: Male/Female
3. Do you think we are at risk for a pandemic (e.g., bird flu) or disaster (natural/bioterrorist)?
4. As a medical student, how do you think you might be able to contribute or assist in such an event?
5. Have you ever received formal training in Basic Life Support (BLS) or Advanced Care Life Support (ACLS)?
6. Do you have any training in the medical field prior to medical school (e.g., EMT, Respiratory therapist, RN)?
7. In your current training as a medical student, have you ever assisted in CPR or performed bag-valve-mask manual ventilation on a patient?
8. What are the key components of bag-valve-mask ventilation?

Appendix 2—Post-survey questions

When performing manual bag-valve-mask technique for ventilation:

1. How many breaths per minute should be administered to a:
   a. Neonate?
   b. Child?
   c. Adult?
2. What are possible methods for ensuring a proper seal?
3. What are methods for ensuring adequate ventilation?
4. What maneuver can be used to open the airway if there is no trauma is present?
   If trauma is present?
5. What minimum oxygen liter flow do you use with the resuscitation bag?
6. In the case of ventilation of a patient with an airborne pathogen, is there a method to filter the exhalation from the bag?
   If so, what?
7. Why is there a pressure pop-off on child and infant bags?
   Can the pop-off be deactivated?

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