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Brief Reports

FACE MASK VENTILATION: A COMPARISON OF THREE TECHNIQUES

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□ **Abstract—Background: There are multiple techniques for face-mask (FM) ventilation. To our knowledge, the one-handed vs. two-handed C-E technique has been compared in children and adults, but no studies have compared the various two-handed methods. Objective: To compare the effectiveness of mask seal using three different FM techniques on a model intended to simulate difficult FM ventilation and measure ventilation performance. Methods: This was a prospective randomized study of health care providers. A standard airway-training mannequin was modified to produce variable airway resistance and allow measurements of ventilation volume and pressure. Each subject performed FM ventilation for 3 min per technique (30 breaths) in a randomized order. Median exhaled tidal volume and proximal peak flow pressure were determined and compared. Results: Seventy subjects were enrolled. Both two-handed ventilation techniques were more effective than the one-handed technique by both volume and pressure measurements. The one-handed C-E technique yielded a median volume of 428.4 mL, vs. the two-handed C-E technique with 550.8 mL, and the two-handed V-E technique with 538 mL ($p < 0.001$). Peak pressure measurements revealed a median of 54.6 cm H_2O for the one-handed C-E technique, 66 cm H_2O for the two-handed C-E technique, and 66.6 cm H_2O for the two-handed V-E technique ($p < 0.001$). There was not a difference between the various two-handed techniques. Conclusions: This model for FM ventilation is able to differentiate the efficacy of FM techniques. Both two-handed ventilation methods were superior to one-handed ventilation, both of which should perhaps be included in airway training for health care providers.** © **2013 Elsevier Inc.**

□ **Keywords—airway; bag valve mask; face mask; ventilation; simulation; simulator; mannequin; manikin**

INTRODUCTION

Face-mask (FM), or bag-valve-mask, ventilation is the single most important skill for emergent airway management. Although the FM method of ventilation seems to be simple, it can be difficult to perform correctly and effectively. Proper position of the head and neck, manually opening the airway with a jaw thrust maneuver, placing a nasopharyngeal or oropharyngeal airway device, and achieving a tight face mask seal are the keys to successful FM ventilation (1–3).

There are multiple techniques for hand positioning during FM ventilation, including the one-handed C-E technique (Figure 1), the two-handed C-E technique (Figure 2), and the alternative technique, which we will refer to as the V-E technique (Figure 3). Despite the importance of this skill, there have only been a few studies comparing the efficacy of these techniques in adults. To our knowledge, there are no studies comparing the various two-handed methods, which include the two-handed

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Figure 1. The one-handed C-E technique.

C-E technique and the V-E technique, which is taught in a few airway courses (1).

The double C-E technique is the only two-handed method taught in the American Heart Association Courses (Basic Life Support, and Advanced Cardiac Life Support) and cited in major anesthesia textbooks for FM ventilation (2–5). Some practitioners prefer the alternative V-E technique. Our aim is to compare the efficacy of FM ventilation using these three techniques on a difficult airway model.

Figure 2. The two-handed C-E technique.

Figure 3. The two-handed V-E technique (also known as the alternative technique).

METHODS

Study Design

Institutional review board approval was obtained for this prospective randomized study of health care providers.

Setting

This study took place in an Emergency Department (ED) in a large Level I trauma center.

Selection of Participants

Eligible subjects were health care providers in the ED, including Emergency Medicine (EM) attending physicians, residents (EM residents and residents from other programs rotating in the ED), physician assistants, nurses, paramedics, and respiratory therapists. Exclusion criteria were subjects who had never ventilated a patient with a mask and anyone with an injury or disability that would limit their ability to perform FM ventilation for an extended period of time.

Interventions

A standard airway-training mannequin was modified to produce variable airway resistance. To achieve this, the distal trachea of the mannequin was attached to a $^{3}/_{4}$ -inch internal-diameter vinyl tube connected to a water column. This model provided a quantifiable amount of distal tracheal airway pressure via hydrostatic forces created by altering the height of the water column. A standardized height of 55 cm H_2O was used, as it created a simulation in which FM ventilation was difficult, but not impossible. A standard ventilator was used to deliver a fixed volume of 500 mL at a rate of 10 breaths/min to a standard transparent disposable plastic FM with a high-volume, low pressure cuff.

The techniques studied included the one-hand C-E technique, the two-hand C-E technique, and the V-E technique. For the single-rescuer C-E technique, only one hand can be used to achieve the FM seal. The thumb and index finger form a "C," providing anterior pressure over the mask, while the third, fourth, and fifth fingers form an "E" to lift the jaw. When more resources are available or ventilations are difficult, two-person techniques are preferred for FM ventilation. With the two-handed C-E technique, the thumb and index finger of both hands form a "C" while providing anterior pressure over the mask, while the third, fourth, and fifth fingers form an "E" to lift the jaw. In the V-E technique, the provider's thumb and thenar eminence of each hand are held parallel, adjacent to the mask connector, and depress each side of the mask. The second through fifth digits wrap around and elevate the mandible to draw it anteriorly into the mask establishing both a jaw-thrust and chin-lift maneuver when appropriate.

Airway adjuncts such as a nasopharyngeal or oropharyngeal airway were not inserted into the mannequin. Before performing each technique, the subject was asked if they were familiar with the technique. If they were not familiar with the technique, the operator would explain and demonstrate it for them. The subjects were also given breaks between techniques; when they felt ready to continue, they would move on to the next technique.

Outcome Measures

Exhaled tidal volume in mL and proximal peak flow pressures in cm H_2O were measured by and recorded from the ventilator with each breath. These values correlated directly with the effectiveness of the FM seal, as maximal values were obtained via intubation of the mannequin. There does not seem to be a definitive conclusion from prior literature regarding whether pressure or volume is a more accurate reflection of effective FM ventilation. A number of studies show a positive correlation between pressure and volume, whereas other studies that have calculated the percentage mask leak, based on inspiratory and expiratory tidal volumes, have concluded that this measurement may be a better estimate of effective ventilations than pressure measurements (6–10).

Data Collection and Processing

Each subject performed FM ventilation on the difficult airway model for 3 min per technique (30 breaths); techniques were performed in a randomized order. Mean exhaled tidal volume and proximal peak flow pressure for each subject using each technique was determined and used for statistical analysis.

Data Analysis

The volumes and pressures obtained for the three techniques were compared using k sample for equality of medians tests.

RESULTS

Seventy subjects were enrolled in the study. One subject did not complete measurements, leaving 69 for analysis. All 69 did three techniques; 6280 breaths were measured; mean volume and pressure for each subject at each technique were determined for analysis. The median was 30 breaths per subject per technique, range 26–38 (each technique was done for 3 min). There were 13 EM attending physicians, 20 EM residents, six residents of other specialties, seven physician assistants, 13 nurses, three paramedics, and seven respiratory therapists.

Both two-handed ventilation techniques were more effective than the one-handed technique. Volume measurements revealed that the one-handed C-E technique yielded a median of 428.4 mL (interquartile range [IQR] 309.7–497.6), the two-handed C-E technique yielded a median of 550.8 mL (IQR 514.3–560), and the two-handed V-E technique yielded a median of 538 mL (IQR 518–555) ($p < 0.001$). Peak pressure measurements revealed a median of 54.6 cm H_2O (IQR 43.1–62.5) for the one-handed C-E technique, 66 cm H_2O (IQR 64–68.2) for the two-handed C-E technique, and 66.6 cm H_2O (IQR 65.2–68.4) for the two-handed V-E technique ($p < 0.001$). Volume measurements by training level are in Table 1. Pressure measurements by training level are in Table 2.

DISCUSSION

Although it is generally accepted that two-handed FM ventilation is superior to one-handed FM ventilation, our study is the first to compare the two-handed C-E technique with the two-handed V-E technique. There are a number of studies that have compared the one-handed C-E technique (Figure 1) to the two-handed C-E technique (Figure 2), all of which found that the two-handed C-E technique was more effective (6,11–15). Some of these studies compared various one-handed techniques to the standard C-E two-handed technique, but none of the studies compared various two-handed ventilation techniques. Two of these studies used patients as the subjects, and the remainder used a mannequin modified to measure volume or pressure. There are also three studies comparing one- vs. two-handed techniques in children or infants, and one adult study comparing various hand positions in a model built to represent difficult FM ventilation with decreased lung compliance (7–9,12).

Table 1. Volume in mL (Median, IQR)

Training Level	One-Handed C-E	Two-Handed C-E	Two-Handed V-E
EM attending	462, 391–490	547, 513–556	532, 516–548
Physician assistant	457, 376–489	536, 518–558	541, 514–555
EM resident	348, 256–500	552, 520–567	551, 534–559
Other resident	482, 463–506	518, 471–559	530, 518–539
Paramedic	489, 347–515	517, 514–553	552, 484–557
Nurse	438, 282–510	554, 530–564	536, 524–564
Respiratory therapy	412, 275–471	527, 498–553	520, 505–564

IQR = interquartile range; EM = Emergency Medicine.

This model for difficult FM ventilation is able to differentiate the efficacy of various FM techniques, revealing that both two-handed methods are more effective than the one-handed method. These two techniques did not seem significantly different with respect to volumes and pressures produced in this difficult airway model with increased airway resistance. It seems feasible to use and modify this model in future studies to compare the various two-handed techniques, perhaps with more difficult ventilation scenarios. It is also possible that one technique works better for certain individuals, whereas the other technique works better for others. This could be dependent on multiple variables such as hand size, prior experience, and grip strength, which deserve further investigation. Based on these data, we believe that the V-E technique, which is currently taught in some courses, is an important skill for airway management, and perhaps should be incorporated more broadly into airway training for health care providers.

These are important findings, as FM ventilation is the most important emergency airway skill. Our results also show a correlation between proximal peak pressures and exhaled tidal volume, suggesting that these may both be valid tools for assessment of FM ventilation. Further study may also include using this model for education of health care providers performing FM ventilation. This will enable us to start to define what type or duration of education is required to achieve competency in this important airway skill.

Table 2. Pressure in cm H_2O (Median, IQR)

Training Level	One-Handed C-E	Two-Handed C-E	Two-Handed V-E
EM attending	57, 52–62	67, 66–69	67, 66–68
Physician assistant	56, 47–60	66, 64–68	66, 65–67
EM resident	51, 35–65	67, 65–69	68, 65–70
Other resident	62, 56–63	64, 61–70	66, 64–69
Paramedic	62, 47–66	64, 62–66	66, 65–68
Nurse	52, 38–63	65, 64–67	66, 66–67
Respiratory therapy	50, 35–56	64, 62–68	67, 63–68

IQR = interquartile range; EM = Emergency Medicine.

Limitations

This was a study on a simulated difficult airway model. It is currently unclear how well this model translates to the success of FM ventilation in actual patient care scenarios. Airway adjuncts, such as a nasopharyngeal or oropharyngeal airway, were not needed in our airway model, but can often be required for effective ventilation in apneic unresponsive patients. We also did not account for the crossover effect and the fatigue that may be associated with performing the subsequent two techniques. Additionally, a greater difference may be revealed between techniques when using a more difficult airway model, when performing ventilation for a prolonged period of time, or when separating novices and experts.

CONCLUSION

Two-handed FM ventilation is more effective than one-handed FM ventilation, in both routine and difficult airway situations. We found no significant difference between the two-handed C-E technique and the two-handed V-E technique in this study. However, each health care provider had variable success with each technique. Therefore, it seems that teaching both techniques for airway training may be optimal.

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ARTICLE SUMMARY

1. Why is this topic important?

Face-mask ventilation is the most important airway skill.

2. What does this study attempt to show?

This study compares the traditional one- and two-handed C-E techniques, and the alternative V-E technique, in a difficult airway model.

3. What are the key findings?

Both two-handed methods are superior to the one-handed method.

4. How is patient care impacted?

Perhaps both two-handed methods should be taught to health care providers who will be managing difficult airways.