ISSN: 2378-3516

Leigh et al. Int J Respir Pulm Med 2019, 6:108
DOI: 10.23937/2378-3516/1410108
Volume 6 | Issue 1
Open Access

International Journal of
Respiratory and Pulmonary Medicine

RESEARCH ARTICLE

Simulation Training on Mechanical Ventilation Using a High-Fidelity Ventilator Mannequin for Residents and Respiratory Therapists

Yasmin Leigh[1], Christian de Elia[1], Murali Krishna[2], La Tanya Taylor[3], Rachel Morales[3], Beth Kellogg[3] and Frank Salvatore[3]*

[1]*Internal Medicine Residency Program, Orange Regional Medical Center, Middletown, USA*

[2]*Department of Pulmonary, Critical Care and Sleep Medicine, Orange Regional Medical Group, Middletown, USA*

[3]*Department of Respiratory Therapy, Orange Regional Medical Center, Middletown, USA*

***Corresponding author:** *Murali Krishna, MD, Department of Pulmonary, Critical Care and Sleep Medicine, Orange Regional Medical Group, Middletown, NY-10940, USA*

Abstract

Purpose: Simulation-based education is thought to be more effective than traditional teaching and recent studies have described its benefits on physician performance in several clinical areas. Despite this, not many studies have researched the benefits of simulation training in teaching mechanical ventilation. With that said, this study was composed to assess the approach of mannequin simulation-based training as a method to provide an interactive learning experience for residents and respiratory therapists, which could translate into better ventilator management performance.

Methods: Residents and respiratory therapists were randomized into 10 groups of 4 participants and each group was presented with the clinical scenarios of ARDS and COPD using the mannequin-based ventilator simulator. A 20 question multiple choice assessment which highlighted the principles of mechanical ventilation was administered before and after the simulation training.

Results: The data from the combined 40 participants was analyzed using a two-tailed paired t-test. The results demonstrated a significant improvement in scores (p-value 0.019) after mannequin based training supporting the proposed hypothesis.

Conclusions: Mannequin based simulation training on mechanical ventilation can be a vital addition to traditional learning methods as demonstrated in this study. Mannequin based training does provide a more interactive learning experience which could translate into better performance.

Clinical implications: Simulation training is more likely to be superior to traditional lecture based format in teaching mechanical ventilation to medical trainees (resident physicians) and respiratory therapists. Simulation can also be used to assess competency on an ongoing basis. Further studies are needed to assess how improvements in the simulation setting translates to the bedside performance and outcome measures.

Background

Simulation-based training has been shown to be a beneficial compared to traditional didactic medical education [1]. Simulation-based education is thought to be more effective than traditional teaching methods, therefore it is proposed that simulation could provide added benefits that traditional teaching methods cannot. Recent studies have described the benefits of simulation-based training on physician performance in several clinical areas, but few have researched the benefits of simulation training in teaching mechanical ventilation to clinicians using lifelike mannequin-based simulation [2].

With this in mind, this study was performed to assess the approach of mannequin simulation-based training as a method to learn mechanical ventilation strategies with the proposed hypothesis of '*introducing mannequin based simulation training would lead to more adequate learning with quicker recognition of the clinical problem when compared to traditional lecture based education*' [3,4].

Citation: Leigh Y, de Elia C, Krishna M, Taylor LT, Morales R, et al. (2019) Simulation Training on Mechanical Ventilation Using a High-Fidelity Ventilator Mannequin for Residents and Respiratory Therapists. Int J Respir Pulm Med 6:108. doi.org/10.23937/2378-3516/1410108

Accepted: May 30, 2019; **Published:** June 01, 2019

Different clinical scenarios were developed which targeted specific mechanical ventilation problems, such as patients on mechanical ventilation with acute exacerbation of chronic obstructive pulmonary disease (COPD) and adult respiratory distress syndrome (ARDS). A twenty question pretest and post-test assessment related to the simulation training was administered to twenty resident physicians and twenty respiratory therapists, who were further evaluated by key actions and overall problem solving skills of each simulation scenario.

Materials and Methods

Study design

Resident physicians and respiratory therapist participated in a short didactic lecture session on respiratory pathology as it applied to mechanical ventilation which provided a baseline foundational learning base for all participants at which time objectives were discussed prior to the administration of the pretest. No further learning objectives were given prior to the final assessment compared with the beginning to avoid influence by solo studying of the residents and respiratory therapists. Residents and respiratory therapists were randomized into 10 groups of 4 participants who were trained using the mannequin-based simulator. During the simulation, the instructor (Respiratory therapy director) assessed the skills of each participant (via training assessment) and each session was followed by a debriefing session of each group to discuss the correct actions and best approaches to solving each scenario along with the administration of the post-test. All participants were challenged on the same ARDS and COPD exacerbation scenarios (see Appendix 1, which contains all scenarios explained in detail).

Study population

20 Resident physicians from the Internal Medicine Residency program and 20 practicing Respiratory therapists.

Informed consent

A signed consent form was obtained from each participant by the non-clinician instructor prior to participating in the mechanical ventilation scenario. The consent form described the purpose of the study, the procedures to be followed, and the risks and benefits of participation. A copy was given to each participant and documented in the participant's record (see Appendix 2, which contains a copy of the consent form).

Baseline assessment

After the didactic lecture, but before simulation training, a pretest was administered to each group in order to assess whether the groups had equal distributions of knowledge and training. The test consisted of 20 multiple choice questions that covered the principles of mechanical ventilation (see Appendix 3, which contains the complete questionnaire).

Simulation training

The mechanical ventilation simulation allowed residents and respiratory therapists to set up the ventilator in presence of various diseases (ARDS, COPD) and to modify the parameters of respiratory mechanics including resistance, compliance, tidal volume, respiratory rate, and inspiratory and expiratory pause. Any changes in the respiratory variables were displayed on the computer screen and participants were then able to make adjustments to optimally decide on the treatment course. Simulation training was performed using a mannequin and a high fidelity ASL 5000 breathing ventilator simulator connected to a GE ventilator (Siemens-Elena, Solna, Sweden). The ASL 5000 is a digitally controlled, high fidelity breathing simulator able to simulate spontaneously or passively breathing patients from neonate to adult.

Training assessment

Performances in management of the training scenarios were evaluated by one instructor (respiratory therapy director) who presented the scenarios to each group in random order. Fifteen minutes were allotted for completion of each scenario. A 15-minute debriefing session followed completion of both scenarios [5]. The performance of each participant during the training was assessed by a standard scoring/rating tool. The scoring system reflected the number of correct actions performed (diagnosis, initial treatment, and final treatment) for successful patient management. In addition, the scoring scale used assesses the overall performance (both technical and nontechnical skills) by the instructor using a 1-4 scale (1 = Poor: Problem not identified; 2 = Marginal: Problem identified but not solved; 3 = Acceptable: Problem identified and partially solved; and 4 = Good: Problem identified and completely solved) [6].

Results

Resident and respiratory therapist characteristics and baseline knowledge assessment

Demographic scoring characteristics of participants pre-test knowledge are summarized in Table 1. Both groups average scores were within reasonable limits of each other to deem them equivocal. Initial comparison of data showed no significant difference between the two groups ($p = 0.49$) which indicates that neither group had an advantage prior to beginning the ventilation simulator.

Training assessment

The combined results of the 40 participants, as well as the separate groups of 20 Respiratory therapist & 20 internal medicine residents, were analyzed using a two-tailed paired t-test and $p < 0.05$. The combined data between pre and posttest scoring demonstrated a statistical difference ($p = 0.02$) which supports our

Table 1: Pre-test scoring.

	M	SD
Respiratory Therapists	4.4	1.6
Medical Residents	4	1.45

Table 2: Combined raw scoring data.

Combined Data	M	SD
Number Correct - PreTest:	4.2	1.52
Score - PreTest:	42%	15.20%
Number Correct - PostTest:	5.08	1.65
Score - PostTest:	51%	16.50%
Change Pre- vs. PostTest:	9%	

Table 3: Post-test mean scoring comparison between both groups.

	M	SD
Respiratory Therapists	4.95	1.36
Medical Residents	5.2	1.95

hypothesis that Mannequin based training would lead to improved learning. Table 2 shows the raw data collected showed an average score improvement of 9% after mannequin based training which further supports the hypothesis. Table 3 shows the post-test mean scoring comparison between both groups.

Discussion

Our results support the hypothesis that simulation training contributes toward strengthening skills in mechanical ventilation [7]. The Internal Medicine resident participants had much less experience but when placed in real life scenarios with mannequin-based training demonstrated a much improved outcome on scoring. The outcome of our study may imply better understanding of ventilation management in particular events. Continued mannequin based training may also translate to improved resident training and information retention due to the hands on nature of the learning experience.

Validity of training and final assessments

The Pulmonary Critical care specialist constructed the assessment questions that reflected fundamental knowledge to the decision making necessary to manage ventilators.

Relation between experience and performance

This study included residents and respiratory therapists with different levels of experience which likely lead to differing levels of improvement [7]. As demonstrated by the results, respiratory therapist did not see any significant change in scoring likely due to their familiarity with the material and experience with the ventilator. Internal Medicine residents demonstrated rudimentary familiarity with each scenario but greatly improved with training made evident by raw data and posttest analysis.

The role of high-fidelity simulation

We chose COPD exacerbation and ARDS complex scenarios which were also tested on in the pre- and post-test assessments. The mannequin connected lung simulator to create a realistic clinical environment which allowed the improvement or decompensation of the mannequin according to the participant's treatment decision.

Limitations

This study did experience some limitations. First, the sample size was small which negatively affects the data results. In addition, the pre- and post-tests did not perfectly mirror what was being presented in the mannequin-simulated training sessions. There was also some variation pertaining to the teaching of each group as the moderator did not follow a strict guide. The moderator was only following a loose footprint during each teaching course which allowed for a more liberal approach to each training session (i.e. some groups may have been given deeper explanation during each simulation than others.) Other limitations were recognized with the post-test questionnaire; certain questions in the quiz were not reflected during the staged scenarios which may have negatively skewed results.

Conclusion

Our results show that simulation training can be a vital addition to traditional learning methods in teaching mechanical ventilation as demonstrated in this study likely because mannequin-based high fidelity simulation training does provide a more interactive learning experience which could translate into better bedside management of the mechanical ventilator.

References

1. Tainter CR, Wong NL, Bittner EA (2015) Innovative strategies in critical care education. J Crit Care 30: 550-556.
2. Wax RS, Kenny L, Burns P (2006) Educating providers of mechanical ventilation: an update. Curr Opin Crit Care 12: 61-66.
3. Schroedl CJ, Corbridge TC, Cohen ER, Fakhran SS, Schimmel D, et al. (2012) Use of simulation-based education to improve resident learning and patient care in the medical intensive care unit: A randomized trial. J Crit Care 27: 219.
4. Fanning RM, Gaba DM (2007) The role of debriefing in simulation-based learning. Simul Healthc 2: 115-125.
5. Cox CE, Carson SS, Ely EW, Govert JA, Garrett JM, et al. (2003) Effectiveness of medical resident education in mechanical ventilation. Am J Respir Crit Care Med 167: 32-38.
6. Nyssen AS, Larbuisson R, Janssens M, Pendeville P, Mayné A (2002) A comparison of the training value of two types of anesthesia simulators: computer Screen-based and mannequin-based simulators. Anesth Analg 94: 1560-1565.
7. Khanduja PK, Bould MD, Naik VN, Hladkowicz E, Boet S (2015) The role of simulation in continuing medical education for acute care physicians: A systematic review. Crit Care Med 43: 186-193.

Appendix 1

Scenario 1: Patient with an acute exacerbation of chronic obstructive pulmonary disease (COPD) on mechanical ventilation. Participants were provided with a brief description of the clinical scenario and asked to analyze the ventilator waveform. Chest X-ray, arterial blood gas results, auscultation were available on request. The participants were expected to recognize ventilator-patient dyssynchrony and make appropriate changes to the ventilator settings to improve synchrony. With appropriate changes, patient shows improvement. With incorrect changes, patient shows worsening. Improvement and worsening can be detected with changes in waveforms, oxygen saturation and arterial blood gases. Initial changes were expected to be an increase in inspiratory to expiratory (I:E) ratio and detection of intrinsic PEEP. Subsequent changes were expected to be lowering of respiratory rate to decrease auto-PEEP.

Scenario 2: Patient with an acute respiratory distress syndrome (ARDS) on mechanical ventilation. Participants were provided with a brief description of the clinical scenario and asked to analyze the ventilator waveform. Chest X-ray, arterial blood gas results, auscultation were available on request. The participants were expected to recognize inappropriately high tidal volume and make appropriate changes to the ventilator settings to improve synchrony. With appropriate changes, patient shows improvement. With incorrect changes, patient shows worsening. Improvement and worsening can be detected with changes in waveforms, oxygen saturation and arterial blood gases. After changes to tidal volume, participants were expected to increase PEEP to improve hypoxia.

Appendix 2

CONSENT FORM FOR RESEARCH PARTICIPATION

Project title: Simulation training for Residents and Respiratory Therapist on Mechanical Ventilation using Computer-based Simulation

Investigators: Yasmin Leigh, D.O., Christian De Elia, D.O., Murali Krishna, M.D., LaTanya Taylor, R.T., Rachel Morales, Beth Kellogg, Frank Salvatore.

We are planning to conduct a research study, which I invite you to take part in. I am doing this study in conjunction with my colleagues at Orange Regional Medical Center in Middletown NY. This form has important information about the reason for doing this study, what we will ask you to do throughout the study and upon completion of the research project.

Why are you doing this study?

You are being asked to participate in a research study about Simulation based training in mechanical ventilation. The purpose of the study is to to assess the approach of mannequin simulation-based training as a method to provide a more interactive learning experience which may lead to better therapeutic performance in real-life clinical settings

Study time: Study participation will take approximately: 1.5 hours

Study location: All study procedures will take place at Orange Regional Medical Center in the respiratory therapy department

What are the possible risks or discomforts?

Participating in mechanical ventilation scenarios involves minimal psychological, social, or other risks. We do not expect any serious adverse events during these non-invasive assessments. Since there are no significant risks associated with the procedures, this study is justified because useful new scientific knowledge will be obtained.

Protection against risk

All pretest and posttest assessments will be completed within an adequate time frame to allow for participants to answer the questions without an mental distress or discomfort.

Dissemination of information: Results of questionnaires as requested will be provided to the participant. Subjects will be advised that the results may be published in a manuscript, but their identities will not be divulged.

To the best of our knowledge, the things you will be doing have no more risk of harm than you would experience in everyday life.

Financial Information

Participation in this study will involve no cost to you. You will not be paid for participating in this study.

Who can I contact if I have questions or concerns about this research study?

If you have questions, you are free to ask them now. If you have questions later, you may contact the researchers at ORMC:

Yasmin Leigh DO: phone: 845-467-1421, email: yleigh@ghvhs.org

If you have any questions about your rights as a participant in this research, you can contact the following office at the Orange Regional Medical Center:

ORMC Institutional Review Board

Clinical Trials

707 E. Main St.

Middletown, NY 10940

Phone: (845)-333-1133

Email: jgerlach@ormc.org

Consent

I have read this form and the research study has been explained to me. I have been given the opportunity to ask questions and my questions have been answered. If I have additional questions, I have been told whom to contact. I agree to participate in the research study described above and will receive a copy of this consent form.

___________________Date/Time__________________

Participant's Signature

_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

____

Participant's Name (printed)

I hereby certify that I have explained the nature, benefits, risks of, and alternatives to including no treatment and attendant risks, the proposed operation(s) and/or procedure(s). I have offered to answer any questions and have fully answered such questions. I believe that the patient/relative/guardian fully understands what I have explained and answered.

_ Date/Time _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

Physician's Signature

____

___

Print Name

Witness:

____Date/Time__________________

Witness Signature

_ _

Witness Print Name

Appendix 3

Study Questionnaire:

1. In s volume-controlled ventilation

A. Tidal volume is given according to a pre-set pressure target

B. If the inspiratory time is fixed, the peak and mean airway pressure is independent of pulmonary compliance

C. If the minute volume and frequency iset, it is not possible to adjust the tidal volume

D. If tidal volume and minute volume is set, the ventilator frequency must be set between 10 and 20 breaths per minute

2. Which is/are correct statements regarding the inspiratory time (Ti)

A. At the end-inspiratory time, the expiration phase always starts

B. If Ti is set by the Inspiration:Expiration ratio, the Ti is independent of ventilator frequency

C. If Ti is directly set, the expiratory time decreases with increasing ventilator frequency

D. Normal Ti is in the range of 3-4 seconds

3. Ventilation-induced lung injury may be minimised by the following:

A. Volume-controlled ventilation mode

B. Tidal Volume restriction to 6 ml/kg

C. Limit plateau pressure below 35 cmH_2O

D. Limitation of PEEP below 5 cm/H_2O

4. Regarding the I:E ratio (all true except)

A. Is normal set between 1:3 and 1:4

B. Should be lowered to decrease intrinsic PEEP

C. Increase I:E ratio may improve alveolar recruitment and oxygenation in ARDS

D. Adjustment of I:E ratio must be matched with respiratory frequency

5. Various methods to set optimal PEEP at the bedside include:

A. Arterial PaO_2

B. Analysis of the pressure-volume curve (lower inflection point)

C. Recording of the oesophageal pressure to estimate transpulmonary pressure

D. Measurement of end-expiratory lung volume variations EDIC-style Type A

E. All the previous

6. Effective methods to decrease an elevated PaCO2 may include all of the following EXCEPT:

A. Increase tidal volume

B. Increase frequency

C. Decrease circuit dead space

D. Increase PEEP

E. Increase inspiratory pressure

7. Adverse effects of PEEP include the following EXCEPT:

A. Over distension of normal alveoli

B. Barotrauma

C. Decreased cardiac output

D. Increased intracranial pressure

E. Increased cyclic collapse of unstable alveoli

7. To increase oxygenation during IPPV all of the following are useful EXCEPT:

A. Increase FiO_2

B. Increase PEEP

C. Decrease I:E ratio

D. Increase peak inspiratory pressure

E. Alveolar recruitment

8. Titrating PEEP levels in life-threatening asthma should include:

A. Limitation of PEEP below 5 cm/H_2O

B. Zero PEEP level

C. Analysis of the pressure-volume curve (lower inflection point)

D. The analysis of static compliance

9. Expiratory pause allow to calculate:

A. Intrinsic PEEP

B. Plateau Pressure

C. Driving Pressure

D. Flow resistance

E. Peak Pressure

10. In volume-controlled ventilation, the peak inspiratory pressure increases when the patient's:

A. compliance or airway resistance is increased.

B. compliance or airway resistance is decreased.

C. compliance is increased or airway resistance is decreased.

D. compliance is decreased or airway resistance is increased.