In Situ Simulation for Ventilator Management in Emergency Medicine

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ABSTRACT

Background: Emergency physicians have a residency graduation milestone to effectively manage the airway and initiate mechanical ventilation. However, many emergency medicine (EM) residents report rarely or never feeling comfortable managing mechanically ventilated patients. Our goal was to determine the effectiveness of an in situ simulation program for EM residents to successfully manage a ventilator on a high-fidelity patient simulator.

Methods: This was a prospective observational educational study of EM residents executed in four steps. Baseline performance was assessed by observed standard clinical examination (OSCE) in a checklist manner after our routine classroom-based annual ventilator teaching. The in situ simulation was executed in a small-group format located in the trauma bay of the ED using only equipment available in the clinical setting. Performance at 1 week and 8 months after the educational intervention was assessed by repeat OSCE. The results were assessed using paired Student's t-tests.

Results: There was a statistically significant improvement in all checklist markers of successful ventilator management on repeat OSCE after the in situ simulation intervention. A final unannounced retention OSCE was administered 8 months after the intervention with no additional interval training. The improved performance persisted 8 months later.

Conclusions: This in situ simulation study demonstrated improved checklist scoring on ventilator management in simulated critically ill patients by EM residents. This improvement persisted 8 months after the educational intervention.

Initiation and management of mechanical ventilation across the spectrum of pulmonary pathologies is essential to the practice of emergency medicine (EM). Emergency physicians (EPs) are trained during residency to effectively manage the airway and initiate mechanical ventilation; in fact, it is an essential graduation milestone.[1] However, the literature has suggested an educational gap in the training of EPs during residency in the management of mechanical ventilation.[2,3] In a recent survey of 218 U.S. EM residents, 45% of respondents reported rarely or never feeling comfortable managing mechanically ventilated patients.[2] While general mechanical ventilation strategies lend themselves well to traditional didactic instruction, the modern ventilator is a complex piece of equipment that may require specialized training to operate effectively and safely. EM residents may feel comfortable understanding the theory of ventilator management, but they may nonetheless feel uncomfortable when asked to actually hit the buttons and turn the knobs to correctly apply that theory. We hypothesized that In-situ simulation could improve

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performance on effecting ventilator management among our residents. in situ simulation may serve to be an effective educational bridge between the classroom and the patient's bedside and may improve real patient outcomes.[4] In situ simulation may be defined as simulation that occurs in the actual clinical environment where the participants work and often occurs during their actual workday.[5] In situ simulation enhances experiential learning by maximizing realism, both in situational context and in identical equipment.[6] Kolb's theory of experiential learning provides an educational rationale for conducting in situ simulation by providing concrete learning experiences in the actual clinical environment.[7] In this brief educational study, our goal was to determine the effectiveness of an in situ simulation program for our EM residents to successfully manage a ventilator on a high-fidelity patient simulator as assessed by a checklist observed standard clinical examination (OSCE) across a range of common pathologies.

METHODS

This was a prospective observational educational study conducted within the department of EM. Twenty-two EM residents (program years 1–3) were recruited to participate in this study during routine scheduled weekly simulation training. This study used educational concepts and techniques currently in routine standard practice and thus was deemed exempt from institutional review board (IRB) review by the East Virginia Medical School IRB.

The educational project was broken down into four steps.

1. *Baseline Performance*: To establish baseline practical ventilator management proficiency each participant's ability to initiate and manage a ventilator was tested in a single test case using an OSCE style format. This is reflective of the performance after the customary ventilator training received by EM residents annually that included a 1-hour didactic session, a 30-minute simulation lab–based session, and an asynchronous podcast (http://emcrit.org/archive-podcasts/vent-part-1). Baseline performance as well as all subsequent OSCEs were conducted by one of our study coordinators with over 12 years of EM experience (MDK). We prespecified what were considered acceptable ranges in terms of all settings on the ventilator based on current ED-based expert recommendations.[8] The initial test case was that of a 26-year-old male suffering from chest trauma requiring intubation. No feedback from this initial baseline testing was given to the residents.
2. *In Situ Simulation*: Hands-on training with a portable ventilator was executed in a scripted small group format physically located in the trauma bay of the emergency department. A Laerdal SimMan and a QuickLung test lung were used to simulate a variety of pathologies: specifically, sepsis, a typical trauma intubation, and chronic obstructive pulmonary disease. The facilitators included EM study faculty (MDK) and two respiratory therapists. The groups consisted of four to six residents working through the three cases with direct feedback from respiratory therapy and the faculty member.
3. *OSCE*: All subjects underwent a one-on-one OSCE style examination in the emergency department to assess their ability to initiate and manage a ventilator in the week following the educational intervention. The examination case was a patient presenting with an acute asthma exacerbation. Again, these were all conducted by the same study coordinator as conducted baseline performance. Individual feedback on performance was given at the completion of testing.
4. *Skill Retention OSCE*: Approximately 8 months later, all subjects underwent a repeat OSCE-style examination administered by the same study coordinator in the emergency department to assess their retention of the skills required to initiate and manage a ventilator in a critically ill simulated patient. This case was a patient presenting with sepsis from pneumonia. Again, individual provider feedback was given following completion of the testing.

Method of Evaluation

The OSCE covers the patient care of an intubated patient both in the ED and in the early stages of intensive care unit care with common pulmonary pathologies. The examinee was expected to initiate ventilator management and make appropriate changes in the ventilator settings based on patient expected response as determined by the examiner. The OSCE test form gathered data as shown in Table 1. Paired Student's t-tests were used to assess the difference in performance between baseline and postintervention scenarios. A p-value of <0.05 was considered statistically significant.

Table 1
EM Physician Performance at Baseline, One-week After, and 8 Months After the Educational Intervention With p-values

OSCE Task	Baseline, % success	One Week post, % success (p-value)	Eight Months Post, % Success (p-value)
Powers on ventilator	77%	100% (0.0170)	100% (0.0170)
Connects oxygen source	32%	95% (<0.0001)	100% (<0.0001)
Sets proper ventilator mode (volume or pressure control acceptable)	68%	95% (0.0186)	100% (0.0186)
Sets proper rate: 12–20 lung-protective strategy (every case other than obstructive cases), 6–10 obstructive strategy (asthma/COPD)	32%	86% (<0.0001)	100% (<0.0001)
Sets proper tidal volume: 6–8 mL/kg IBW (if PC using pressure to deliver appropriate volume by IBW)	9%	86% (<0.0001)	86% (<0.0001)
Sets proper PEEP: 5–10 cm H_2O initially for lung-protective, 0–5 cm H_2O for obstructive	32%	100% (<0.0001)	100% (<0.0001)
Sets proper pressure support (assure proper volume (by IBW) delivered if using pressure control, if using volume correctly give full credit)	14%	86% (<0.0001)	100% (<0.0001)
Sets proper FiO_2 (once intubated should titrate down to 30%–50% and titrate based on FiO_2)	36%	95% (<0.0001)	100% (<0.0001)
Connects patient to the circuit (actually hooking up the ventilator to the patient/test lung)	36%	100% (<0.0001)	100% (<0.0001)
Adequately troubleshoots alarms	0%	82% (<0.0001)	69% (<0.0001)

This table illustrates the performance of our EM physicians on the OSCE at baseline, 1 week after, and 8 months after the in situ simulation educational intervention.
COPD = chronic obstructive pulmonary disease; IBW = ideal body weight; OSCE = observed standard clinical examination; PC = pressure controlled; PEEP = positive end expiratory pressure.

RESULTS

The baseline, postintervention, and 8-month retention performance of the EM residents demonstrating practical ventilator management proficiency is summarized in Table 1. The baseline OSCE test results were compared to the postintervention and the 8-month retention scores using paired Student's t-tests. Of note, there was statistically significant improvement in all markers of checklist success, ranging from improvement of 23% to 82%, with an average improvement of 57%. The improvement in performance persisted 8 months later and remained statistically significant (retention OSCE compared to baseline performance). There were no statistically significant differences between the 1-week postintervention and the 8-month postintervention OSCE scores.

DISCUSSION

The ability to initiate and manage a ventilator in a critically ill or injured patient is a mission critical skill for practicing EPs. While many academic EM residency curriculums have embraced traditional simulation, we question whether the simulation experience adequately prepares our residents to enact changes on the mechanical ventilator at the patient's bedside. It was quite telling that in our study only a third of our residents could, at baseline, connect a patient to a ventilator circuit despite having previously undergone a combination of didactic lecture, traditional simulation laboratory training, and asynchronous education. Our resident conference attendance is generally around 75% (which is the mandatory level). Thus, even if a quarter of the residents missed the initial educational components, less than half of those in attendance were capable of ventilator management at baseline. This in situ simulation study demonstrated effectiveness in significantly improving the checklist scoring of ventilator management in simulated critically ill patients by EM residents. In addition, this improved score persisted 8 months after the educational intervention. Some potential biases include that there is the possibility that the EM residents simply improved their score through repeated testing (repeat testing bias). This brings up a potential alternate model in which our residents actually improved in ventilator management, Ericsson's theory of deliberate practice with feedback. According to Ericsson et al.,[9] improvements in performance are most likely 1) in tasks with a well-defined goal, 2) among those motivated to improve, 3) among those who are then provided feedback, 4) and among those given multiple opportunities for repetition. Our study met these criteria. Indeed, Ericsson's model of deliberate practice

with feedback may have been the chief intervention that made the difference in our residents' competency. Other biases include that the data collection form evaluator was involved in the study, introducing a possibility of measurement bias (i.e., giving higher scores on retesting). Nonetheless, the degree of improvement and the retention of that improvement suggest that in situ simulation particularly if combined with deliberate practice with feedback may be an effective mechanism through which to teach ventilator management in EM. While further study is required, in situ simulation may serve as a bridge between the classroom and the bedside for the practical application of critical care skills.

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