Enhancing the Safety of Ventilator Use by Improved Understanding of the Interaction Between Ventilators and Patient Pulmonary Physiology in a Simulated Environment

Murray WB, Schneider AJL, Henry J, Marine R, Rudy S
Simulation Development and Cognitive Science Laboratory,
Pennsylvania State University College of Medicine, Hershey, PA

Introduction

Present-day ventilatory equipment is increasing in complexity as more capabilities are added necessitated by advancing age and illness severity of our patient population. There is an increasing potential for errors as the interactions between ventilators and the abnormal patient physiology become more complex. Residents need to understand these interactions, diagnose the problems as originating in the equipment or in the patient, and, under time pressure, institute treatment in a timely fashion. We report the use of Objective Structured Clinical Examination (OSCE) stations in an Education Laboratory using multiple types of simulators as a platform for residents to practice key points while working in a limited time period.

Methods

We developed 15 stations demonstrating several aspects of ventilator function as influenced by the patient's pulmonary physiology and pathology. The residents (n=34) were divided into groups of 2-3 while the medical students (n=5) on anesthesia rotation were combined in a single group. Each station had simple, clear, written instructions for the trainees to follow. Six instructors were available to reset each station during change-over of the groups as well as answer any questions related to the stations. One instructor acted as the time keeper giving a one minute warning and then indicating the six minute point for change of stations. After all groups had completed each station, the participants gathered for a debriefing session. Using an interactive question and answer format, the learning points from each station were emphasized.

Results

The groups completed the stations in the allotted time (90 min.) The debriefing session (30 min) was extremely lively. The residents reported that they had encountered many of the problems high-lighted in the session, but had not found satisfactory answers until this session.

Discussion

The principles of OSCE stations include the provision of a brief clinically relevant problem which trainees have to resolve. The station should ideally be developed such that a non-specialist (e.g. a "secretary") could objectively evaluate the performance of trainees in a yes/no (or pass/fail) format. We used the principle of the brief exposure but used self-evaluation of the trainees as a stimulus to learn. Based on the feedback from the residents, they found this hands-on learning experience much more of a challenge and a stimulus compared to a lecture.

Conclusion

We believe this is a suitable method to enable a large group of trainees to experience hands-on learning in an Education Laboratory setting using a variety of simulators.

Table 1
Examples of Stations

Ventilator and Simulator	Pulmonary Physiology	Teaching Points
Bear ICU ventilator, 5 mm and 8 mm endotracheal tubes with reservoir bag as the "lung"	Work of breathing	Effects of resistance and compliance on work
Bird ventilator, endotracheal tube and reservoir bag	Broncho-pleural fistula	Pressure limited versus volume limited ventilation
Draeger IIB, Michigan Instruments pediatric simulator	Pediatric parameters	Overpressure dangers – high fresh gas flow, oxygen flush
Ohmeda 7900 ventilator, Michigan Instruments adult lung simulator	Changes in compliance	Safe switching between volume controlled and pressure controlled ventilation
Siemens 9000, Residents' self experience at breathing	CPAP, Synchronized and non-synchronized ventilation	Comfort/sensation of various settings of the ventilator
Generic ventilator, "Body" flat screen simulator	Compliance and resistance, pressure-volume (P-V) loops	Effects of compliance and resistance on P-V loops
Hand ventilation, Endotracheal tube and reservoir bag with CO_2 flow meter (200 ml/min)	Rebreathing of carbon dioxide, inspiratory carbon dioxide	Influence of fresh gas flow on Mapleson C system
Draeger IIB, METI full human simulator	Missing one-way valve in an anesthesia circle system	Recognition of abnormalities in capnographic patterns