Initial validation of a modified suction task training system

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BACKGROUND: Trainees rarely have the opportunity to practice suctioning copious or bloody secretions from the airways of patients in respiratory distress. The act of suctioning is frequently overlooked during the training of personnel in airway management and, thus, there is a dearth of simulated suction devices that can reproduce the fidelity of this process.

OBJECTIVE: The authors describe their experience developing and obtaining initial validation of a modified suction task training system.

METHODS: Senior-level students and faculty participated in the validation of this simulator. All participants used the modified Yankauer suction device in a simulated ‘mini’ scenario that required the use of suction. The panel of experts consisted of faculty from respiratory therapy, nursing and emergency medical services. After completion of the scenario, participants were asked to anonymously complete a survey.

RESULTS: More than 94% (n=36) of students agreed or strongly agreed that the simulated oropharyngeal suction was an important component in their learning experience. The expert panel (n=11) strongly agreed that the modified Yankauer suctioning of oral secretions was an important component of student training and also strongly agreed that this apparatus would improve their students’ suctioning skills (82% for both questions). Similar to the students, 90% of the faculty believed strongly that the simulator worked well.

DISCUSSION: The authors describe their experience developing and obtaining initial validation of a modified suction task training system that has both structural and functional fidelity, offering learners an opportunity to practice appropriate and effective suctioning in patients.

Key Words: Airway training; EMS training; Nurse training; Respiratory therapy training; Simulator validation; Suction training

Suctioning is a procedure used to remove substances from the nose, mouth, pharynx or trachea, either through a natural orifice (nose or mouth) or artificial tubing (endotracheal tube, tracheostomy tube, nasal or oral airway). Respiratory therapists, paramedics, nurses and physicians use suctioning to promote secretion clearance (pulmonary hygiene) and/or maintain a patent airway. This technique is used in patients along the continuum of care, from acutely ill individuals in the community to chronically ill patients requiring long-term airway support. Controversy remains regarding the optimum technique for this procedure, which is not without its risks to patients (1-4). These risks include, but are not limited to, hypoxia, hypotension, mucosal hemorrhage and airway edema (5,6).

Unfortunately, students rarely have the opportunity to practice suctioning copious or bloody secretions from the airways of patients in respiratory distress. Simulated encounters may provide an important opportunity to fill this gap. However, the act of suctioning is frequently overlooked during the training of personnel in airway management and, thus, there is a dearth of simulated suction devices that can reproduce the fidelity of this process. We sought to create and validate a suction task training system that is able to recreate the look and feel of suctioning secretions from an actual patient, with the overarching goal of creating a trainer that was inexpensive and easy to replicate.

In the present study, we describe our experience developing and obtaining initial validation of the fidelity of a modified suction task training system. This system includes a Yankauer suction tip, tubing, suction canister and small-diameter end-tidal CO₂ sampling tubing (also known as ‘CO₂ tubing’) that allows the infusion of simulated oropharyngeal secretions into the system. When modified as described in the present study, it results in a task trainer that has both structural and functional fidelity, offering learners an opportunity to practice appropriate and effective suctioning in patients requiring advanced airway support (7).
A novel suction task training system was developed for the training of students from various disciplines. The following basic supplies were used: suction unit, suction tube with Yankauer, small-diameter tubing (preferably CO₂ tubing), scissors, caulking, foaming soap and red or yellow food colouring. This method of simulated suction was used in the training of health care staff through scenarios involving suction of vomitus and bilious secretion in intestinal obstruction, frothy secretion in congestive heart failure, bloody secretion in esophageal varices, tenacious sputum in chest infections and excessive sputum secretions.

To begin, the Yankauer suction catheter was attached to one end of the suction tubing and set aside (Figure 1A). The adapter was cut off one end of the CO₂ tubing and discarded (Figure 1B). The connection was also pulled off (not cut) from the suction tubing (opposite end from the Yankauer). The end of the small CO₂ tubing was lubricated where the adapter was cut. The internal diameter area of the suction tubing was also lubricated. This made it easier to push the CO₂ tubing through the suction tubing. The small CO₂ tubing was slid through the end of the suction tubing where the connection was removed (Figure 1C). The CO₂ tubing was pushed through the suction tubing toward the Yankauer catheter. There was approximately 6 inches (15.24 cm) of small CO₂ tubing protruding from both ends. Visible to the left (Figure 1D) is the Yankauer end and visible to the right (Figure 2A) is the suction tubing end from which the suction connection was removed. There was a 1 inch (2.54 cm) cut made in the suction tubing (Figure 2B) where the connection was removed.

After the small tube was slid through the cut in the suction tube (Figure 2C), the connection was glued back onto the suction tubing with cyanoacrylate glue (Figure 2D). The small CO₂ tubing at the end of the Yankauer catheter was cut so that it was flush with the end of the tube (Figure 3A). Silicone waterproof caulk was used to seal the small tube in place just below the connection cap (Figure 3B). The bag of simulated blood was spiked and hung. The use of a pressure bag was used to hasten the fluid expulsion process from the CO₂ tubing (Figure 3C). The end of the intravenous (IV) tubing was cut off and attached to the small CO₂ tubing (Figure 3D). Suction was hooked up...
Emergency oropharyngeal suction is an important skill to practice. Pulmonary edema requiring advanced airway treatment/manoeuvres necessitated the placement of the suction Yankauer orally for a patient with flash pulmonary edema (USA) or advanced airway head situated to appear as a full-body simulation task training system, and either a full-size patient simulator (Laerdal, Norway) or advanced airway manikin will improve my students suctioning skills

The study was conducted at both the Summa Akron City Hospital Simulation Center (North Canton, Ohio, USA) and at the Stark State College Simulation Center (North Canton, Ohio, USA). Virtual Care Simulation Laboratory (Akron, Ohio, USA) and at the Summa Health System Simulation Lab (Akron, Ohio, USA). The study was considered exempt by the institutional review board because it did not meet the definition of human subject research. The survey design consisted of five questions for the students and five questions for the faculty using a 1 to 5 Likert scale (Tables 1 and 2). The survey was adopted from a similar survey design for the students and five questions for the faculty. The responses of simulation participants are provided in Table 1. Of the students surveyed, 25% (nine of 36) agreed that the simulated suction catheter resembled a normal part of the equipment and the remaining 75% (27 of 36) of students strongly agreed with this question. More than 94% (34 of 36) of students agreed or strongly agreed that the simulated oropharyngeal suction with modified Yankauer was an important component in my learning experience. A complete schematic of the entire system is presented in Figure 4.

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| Question                                                                 | Strongly disagree | Disagree | Neutral | Agree | Strongly agree |
|-------------------------------------------------------------------------|-------------------|----------|---------|-------|----------------|
| The simulated suction catheter looked like it was a normal part of the simulation equipment | 0 (0/36)          | 0 (0/36) | 0 (0/36) | 25 (9/36) | 75 (27/36)     |
| The simulated Yankauer worked well during my simulation session | 0 (0/36)          | 0 (0/36) | 0 (0/36) | 14 (5/36) | 86 (31/36)     |
| I liked having the chance to practice oropharyngeal suction            | 0 (0/36)          | 0 (0/36) | 0 (0/36) | 30 (11/36) | 69 (25/36)     |
| The simulated oropharyngeal suction by Yankauer was an important component in my learning experience | 0 (0/36)          | 0 (0/36) | 5 (2/36) | 28 (10/36) | 66 (24/36)     |

Data presented as % (n/n)

| Question                                                                 | Strongly disagree | Disagree | Neutral | Agree | Strongly agree |
|-------------------------------------------------------------------------|-------------------|----------|---------|-------|----------------|
| Emergency oropharyngeal suction is an important skill to practice during simulated resuscitation | 0 (0/11)          | 0 (0/11) | 0 (0/11) | 0 (0/11) | 100 (11/11)    |
| The simulated oropharyngeal suction with modified Yankauer should be a part of any simulator | 0 (0/11)          | 0 (0/11) | 9 (1/11) | 18 (2/11) | 72 (8/11)      |
| The simulated oropharyngeal suction with modified Yankauer works well | 0 (0/11)          | 0 (0/11) | 9 (1/11) | 0 (0/11) | 90 (10/11)     |
| The simulated oropharyngeal suction with modified Yankauer was an important component in training my students | 0 (0/11)          | 0 (0/11) | 18 (2/11) | 0 (0/11) | 82 (9/11)      |
| Practice of oropharyngeal suction with a modified Yankauer on a mannequin will improve my students suctioning skills | 0 (0/11)          | 0 (0/11) | 0 (0/11) | 18 (2/11) | 82 (9/11)      |

Data presented as % (n/n)

Participants
Senior respiratory therapy students, senior paramedic students and senior nursing students participated in the validation of this simulator (convenience sample of 36 students). All participants used the modified Yankauer suction device in a training session that required the use of suction. The group of experts consisted of seasoned respiratory therapy faculty, nursing faculty and emergency medical services (EMS) faculty. All experts were provided an opportunity to use the simulator and observe their students use the simulator before completing the survey evaluation of the simulator (convenience sample of 11 faculty).

Setting
The study was conducted at both the Summa Akron City Hospital Virtual Care Simulation Laboratory (Akron, Ohio, USA) and at the Stark State College Simulation Center (North Canton, Ohio, USA). The simulation resuscitation bays were equipped with a vital signs monitor, basic and advanced airway equipment, the modified suction catheter with a suction Yankauer and back into the suction unit through the suction tubing. The confederate turned off the IV bag when the student suctioned the simulated patient's mouth. Simultaneously, a confederate or faculty member turned on the IV bag that was filled with the expulsions fluid. Fluids suctioned from the mouth of the simulator appeared to be coming from the patient and filled the suction canister with whatever fluid was in the IV bag (Figure 4). In reality, the fluid was flowing through the CO2 tubing from the IV bag and being suctioned from the end of the Yankauer catheter and back into the suction unit through the suction tubing. The confederate turned off the IV bag when the student suctioned from the mouth of the simulated patient to simulate flash pulmonary edema at the initiation of the scenarios. Several millilitres of frothy soap water was placed in the mouth of thesimulators to simulate flash pulmonary edema at the initiation of the scenarios.

Training sessions
Faculty and students participated in the training sessions. Both groups were briefed on the objectives of the study and were provided an opportunity to not participate. The participants were divided into small groups of five or fewer. Each group was assigned to a station where the simulated oropharyngeal suctioning was set up for education and demonstration. A scenario was given to each student in which he/ she had the opportunity to use the modified suction task training system. After completion of the scenario, the students and faculty were asked to anonymously complete a survey regarding their experiences with the task trainer.

Survey design
Face and content validity of the structural and functional aspects of this task trainer was assessed using a survey. Each survey consisted of four questions for the students and five questions for the faculty using a 1 to 5 Likert scale (Tables 1 and 2). The survey was adopted from a similar simulation device validation study (8). Each question related to the effectiveness or fidelity of the new modified suction task training system. The two most senior faculty who developed the survey are both board-certified physicians who completed fellowships in medical simulation. The survey was pilot tested by one EMS, one respiratory therapy and one nursing faculty member before executing the study. Feedback was incorporated into the final survey before utilization in the present study.

RESULTS
The responses of simulation participants are provided in Table 1. Of the students surveyed, 25% (nine of 36) agreed that the simulated suction catheter resembled a normal part of the equipment and the remaining 75% (27 of 36) of students strongly agreed with this question. More than 94% (34 of 36) of students agreed or strongly agreed that the simulated oropharyngeal suction with modified Yankauer was an important component in my learning experience. A complete schematic of the entire system is presented in Figure 4.
agreed that the simulated oropharyngeal suction was an important component in their learning experience.

The responses of the faculty are provided in Table 2. The faculty unanimously (11 of 11) strongly agreed that oropharyngeal suction is an important skill to practice during simulated resuscitation scenarios. Similar to the students, 90% (10 of 11) of the faculty believed strongly that the simulator worked well. The faculty strongly agreed (nine of 11 [82%]) that the modified Yankauer suctioning of oral secretions was an important component of student training and also strongly agreed (nine of 11 [82%]) that this apparatus would improve their students’ suctioning skills. Approximately 72% (eight of 11) of the faculty strongly agreed that the modified suction task training system should be used during all simulated airway training sessions.

**DISCUSSION**

Airway management is a fundamental skill in the care of patients. Respiratory therapists, paramedics, nurses and physicians are all trained in airway management; however, few are explicitly trained on how to manage secretions or debris in the airway. Inability to clear secretions is multifactorial, but can be a result of an increase in the volume or viscosity of secretions, ineffective cough, closed head injury and cardiovascular dysfunction, among others (2,9-11).

Our task trainer stimulated rich conversations during debriefing with the students, who confirmed our supposition that there was a relative gap in their comfort both in setting up and using suction in acute scenarios. Many students voiced concern that the use of suction and suction catheters on acutely ill and intubated patients was an area in which they still felt apprehension as they transitioned into their formal roles. Students from all three programs believed that this skill was repeatedly overlooked and/or covered superficially. During our debriefing, it also became clear that the students were not clear on the potential complications of suctioning and the potential conditions that use of suctioning that may endanger the patient or cause harm.

Croup and epiglottitis represent serious relative contraindications to suctioning (12). Some additional relative contraindications to suctioning include bleeding disorders, acute facial/head/neck injuries, angioedema and laryngospasm (2,4). This information may be unfamiliar or underemphasized to senior-level students such as those in the present study. There are several complications that can occur as a result of suctioning, both orally and through an endotracheal tube in an intubated patient that include, but are not limited to, hypoxemia, atelectasis, mucosal trauma, pulmonary hemorrhage, cardiac dysrhythmia, hypotension and worsening airway edema (5,6,13-15). If the patient is unable to protect their own airway, health care professionals are trained to remove these secretions simultaneously setting up and providing a temporary or definite airway. One of the first methods used by providers to remove these secretions is suctioning. The methods for suctioning performed can vary widely (17,18). Previously, this was practiced on patients in clinical settings, placing these patients at risk for the aforementioned adverse effects. Enabling students to practice the use of suctioning equipment and techniques in various scenarios before encountering these situations in patients is imperative.

Often, airway curriculum involves discussion of intubation techniques, airway adjunct/rescue devices and troubleshooting strategies. The setup, approach and potential complications of suctioning and a review of this suction equipment are rarely emphasized for nursing and physician residents, and are not consistent across specialties (17-21). This is despite the relative frequency in which acutely decompensating patients present requiring orotracheal suctioning before intubation. To date, very few studies have investigated evidence-based approaches to several suctioning procedures, curriculum and application of training techniques (16,17,20-22).

In previous simulations, we observed students being too aggressive with suctioning (applying too much force to the oropharynx of the simulator), leaving the catheter in too long (suctioning >10 s each time the catheter is introduced) causing hypoxemia, suctioning too frequently, being too passive or demonstrating completely inappropriate technique to clear the airway (eg, not placing the patient in the ‘sniffing’ position when attempting to clear secretions and blindly sticking the catheter into the patient) during simulations. We have also identified students using too much negative pressure, potentially causing injury to underlying tissue. For this and several other reasons, we have identified this as a gap in the training of our students, which needed to be addressed via simulation.

The results from our pilot study demonstrate that our modified suction task training system provides a realistic means to deliver effective training in this particular aspect of airway management (initial face and content validity). Most mannequins do not provide secretions and bleeding in a manner that allows learners to manage the suction equipment in a high-fidelity scenario. Additionally, many modifications that can be made place the simulators at risk for damage from liquids, and could void the manufacturer’s warranty. Our proposed modified suction task training system provides a safe, inexpensive, reusable and reliable means of adding functional and structural realism of simulated body fluids and debris without exposing costly mannequins to potentially harmful substances.

Future research should further investigate the application and utility of this trainer in scenarios of increasing complexity to determine whether there is a transfer of skills and troubleshooting strategies into their practice pattern. A simple modification of this described task trainer can also be used to train students on how to perform suctioning of patients with an endotracheal tube in place. Training for suctioning via artificial airways within critical care environment scenarios may also be considered for further investigation. A limitation of our study was that the task training system was evaluated after use in only one scenario. Further utilization in several cases may provide additional validation of this system. Additionally, this system was only evaluated by a small sample size of senior-level students and their faculty. Additional groups of trainees (ie, emergency medicine physicians, residents, critical care nurses, etc) would also provide valuable insight. Finally, based on the design of the present study, there was no way to determine how performance in the simulated environment may translate to actual behaviour in the clinical environment. We conclude that our modified suction task training system provides trainees a simple yet valuable means to train and use suction apparatus during high-fidelity scenarios that they may not otherwise have the opportunity to experience before actual clinical exposure.

This system provides an effective training device for educators to stimulate discussion and reinforce important concepts from the student’s respective curricula, including, but not limited to, the indications, contraindications and risks associated with suctioning before clinical practice. This system provides an important and frequently overlooked component in advanced airway training.

**DISCLOSURES:** The authors have no financial disclosures or conflicts of interest to declare.
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