Original Article

Learning awake fiberoptic intubation: use of a computerized mannequin simulator teaching

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Background: Nasotracheal intubation is the most common method used to ventilate patients for oral maxillofacial surgeries. Fiberoptic intubation (FOI) is an essential skill for a wide range of healthcare providers, including anesthesiologists and emergency medicine physicians. However, proper programs and facilities for intubation training are insufficient.

Methods: In this single-center, prospective quality improvement study, we developed a computerized mannequin simulator teaching program to assist training healthcare providers. The program included an instructive where participants were introduced to FOI through instructive videos and handouts. Participants then practiced FOI through case studies with close guidance and timely feedback from facilitators. After the session, participants evaluated the helpfulness of the curriculum for their clinical practice.

Results: The program was completed by 33 participants and 30 participants completed the survey. All participants (n=30) agreed that the simulation was realistic enough to engage in learning. Approximately 90% of participants (n=27) felt that the simulation exercise helped improve technical skills and all participants (n=30) agreed that the simulation exercise was clinically applicable. Seventy-seven percent of the participants felt that they would change their practice as a result of the course.

Conclusions: Our program demonstrated initial success at improving anesthesia residents' and Certified Registered Nurse Anesthetists (CRNAs)' confidence level with FOI knowledge and skills. Further research is needed to prove the benefits of this teaching in real patients and optimize the program.

Keywords: Nasotracheal fiberoptic intubation; oral maxillofacial surgeries; computerized mannequin simulator

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Introduction

Background

Maintaining an open airway is critical for patients undergoing oral maxillofacial surgeries. Nasotracheal intubation is the most common method used to ventilate patients as it offers better mobility and visualization of the surgical field compared to orotracheal intubation (1). Therefore, fiberoptic intubation (FOI) is a strongly desirable skill among anesthesiologists and is essential to manage complex oral and maxillofacial surgery (OMFS) patients (2,3). Although intubation is usually performed under general anesthesia, awake FOI should be considered for patients with difficult airways, especially when

concurrent difficult ventilation is expected, as awake FOI preserves spontaneous respiration and facilitates viewing of the larynx as the vocal cords open and close during patient breaths (2-5).

Intubation can be difficult in certain patients and the consequences of intubation failure might directly cause hypoxia or endanger the patient's life (3,6). Complications from intubation include vocal cord injury, esophageal perforation, retropharyngeal abscess, bronchial intubation, and/or nerve damage such as vagus and hypoglossal nerve (7,8). Reducing the number of intubation attempts and establishing a timely operational exit mechanism minimizes the harm to the patients (9). Healthcare providers should be taught to predict difficulties and possible complications during intubation based on patients' conditions (10).

Rationale and knowledge gap

Educational programs can be used to help learners practice standardized protocols and emergency management techniques to help reduce the complication rate from intubation (6,11-14). However, the facilities for formal training in this area are limited. Only about half of anesthesiology residency programs in the United States and Canada have formal airway rotations and less than half of the faculty members were responsible for airway training (13). Furthermore, no criteria for program competence have been established and objectives of intubation practice vary among different training programs (11-17). Currently, there is no data that outlines the minimum criteria needed to assess competency and confidence in airway management (10,12). Simulation is an ideal tool for both instruction and assessment of airway education programs. Health delegates, animals, real patients, or human patient simulators have all been described in the literature (14-18). In general, higher fidelity stimulators may increase trainee confidence with difficult airway conditions as more advanced simulators can imitate multiple airway conditions and accept repeated attempts and strategies (15,17,18).

Highlight box

Key findings

- We established an educational program to help anesthesia residents and Certified Registered Nurse Anesthetists (CRNAs) learn awake fiberoptic intubation (FOI) using computerized mannequins with practice scenarios and real-time feedback.

What is known and what is new?

- Only a limited number of anesthesia residency programs currently offer formal airway rotations. Furthermore, there is no formally established educational curriculum or learning objectives for FOI.
- Our stimulation-based educational program successfully helped anesthesia residents and CRNAs improve their technical skills. Learners reported that the simulation resembled a realistic clinical environment, and the curriculum was relevant to their clinical practice.

What is the implication, and what should change now?

- We encourage other residency programs to offer similar educational opportunities for anesthesia trainees early in their training.

Objective

In this study, we established a training curriculum that provides opportunities for anesthesia residents and Certified Registered Nurse Anesthetists (CRNAs) to learn awake FOI using just-in-time teaching techniques and standardized proficiency assessment systems. We gathered feedback from learners to evaluate the effectiveness of using a computerized mannequin simulator training on provider comfort and competency in performing awake FOI.

Methods

Outcomes

The primary outcome is to evaluate the effectiveness of using a computerized mannequin simulator training on provider comfort and competency in performing awake FOI. The secondary outcomes are (I) to assess the impact of the training on provider confidence, knowledge, and skills in awake FOI, (II) to evaluate the acceptability and feasibility of the training method from the perspective of the providers.

Education curriculum

This single-center, prospective quality improvement study was conducted at Massachusetts General Hospital (MGH). Our program featured four distinct phases (see *Figure 1*). The first phase was the Instructive Phase which focused on instructive awake FOI videos, didactic handouts, and an introduction to the simulation environment. The videos focused on the overview of FOI and specifically awake FOI. The didactic handouts included materials focused on the overall steps of the procedure as well an introduction to the

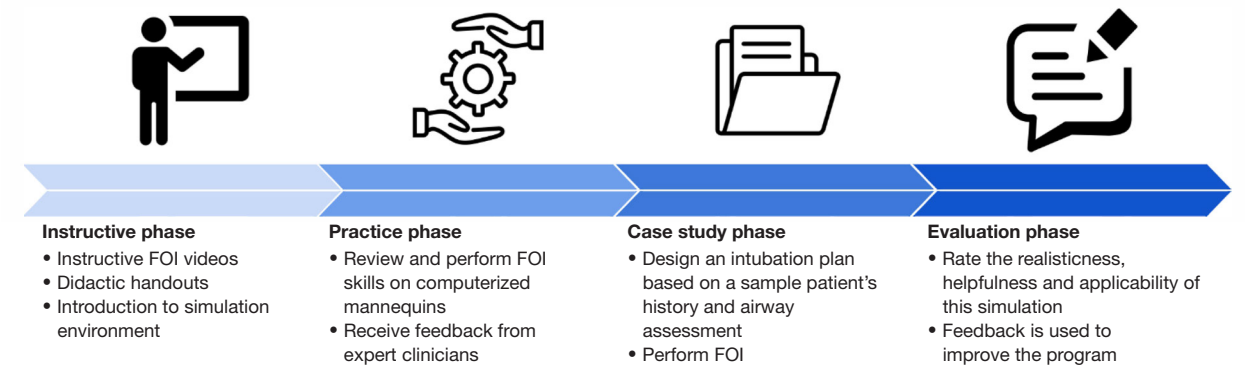

Figure 1 Overview of the simulation program. FOI, fiberoptic intubation.

Figure 2 The observation deck of the Simulation OR at MGH. This allows personnel to overlook the OR table from above. OR, operating room; MGH, Massachusetts General Hospital.

simulation environment focused on the equipment and any anticipated realism variances (limitations of the mannequin, how to call for assistance, etc.). The teaching program also includes addressing the techniques and strategies for minimizing the risk of epistaxis, such as the use of Afrin nasal spray and softening the nasal tube by emerging it in warm water before intubation.

The next phase was the Practice Phase which gave the trainees opportunities to review and practice basic skills on computerized adult mannequins. The mannequin was placed in the MGH Simulation Operating Room (see *Figure 2*) (19). The mannequin-based simulator represents actual functions of spontaneous breathing, real-time display of electronically monitored information [blood pressure (BP), electrocardiogram (ECG), and SpO_2], and vocal communication, and can be intubated through both nasal and oral techniques. These mannequins were run by simulation specialists to react to a multitude of different treatment algorithms the learners may apply. Task trainers that featured sustainable oral and nasal airway for repetitive practice were available along with instruction and guidance from expert faculty.

The third phase was the Case Study Phase where learners were provided with a detailed case scenario. Learners were required to synthesize the patient's past medical conditions and their airway assessment and design an intubation plan. The learners then discussed their approach with the mentors much as they would do with real patients in the operating room. With direct supervision, the learners performed awake FOI on the computerized adult mannequins that had been modified to feature difficult airway scenarios. These scenarios included narrowed airways (created by taping batteries circumferentially around the mannequin's airway externally) and significant anxiety (created by indicated by the simulation specialists through the mannequin's speaker). Throughout the session, we ensured that each group of learners (8 participants) had three facilitators to provide individualized instruction and feedback during the simulation-based training sessions. We also monitored the sessions closely to ensure that each learner received adequate attention and support from the facilitator.

The last phase was the Evaluation Phase where learners received feedback. We used just-in-time teaching methods to focus the teaching on content areas that learners found the most difficult after the completion of the scenario. A standardized evaluation was used at the end of the scenario to provide an objective assessment of the session (see Table S1). Prior to distributing the evaluation survey, we developed the paper survey questions based on the learning objectives and goals of the training program. We conducted

Table 1 Personnel composition of program learners

Learners	Number of participants	% of participants
CA 1	20	60.60
CA 2	3	9.10
CRNA	8	24.24
Other	2	6.06
Total	33	100.00

CA, clinical anesthesia; CRNA, Certified Registered Nurse Anesthetist.

Figure 3 Participants practicing FOI on computerized mannequins. FOI, fiberoptic intubation.

a pilot test to ensure that the questions were clear and effective. The learners rated and provided comments on the realism helpfulness to their learning, and the applicability of this stimulation to their clinical practice.

The mannequin simulator

The mannequin simulator used in our study was the Laerdal SimMan Classic (Laderal Medical, Stavanger, Norway), and the software used was Legacy software (Stavanger, Norway). We selected this mannequin simulator for its high fidelity and realistic simulation of the anatomy and physiology of the airway, which was used in the MGH Learning Lab.

Participants

The personnel composition of program learners is illustrated in *Table 1*. *Figure 3* shows participants practicing FOI during the simulation sessions.

Results

Evaluation responses

The evaluation responses from the program learners are highlighted in *Table 2*. Of those who finished the program, all participants at least somewhat agreed that the simulation was realistic enough to engage in learning and clinically applicable to their future practice. Approximately 90% of participants felt that the simulation exercise at least somewhat helped them improve technical skills and 77% felt that they would change their practice as a result of the course. Detailed evaluation comments provided by trainees are included in Table S1.

Discussion

Key findings

Awake FOI is an essential skill in anesthesiology for difficult airway management in OMFS patients. We established a training curriculum to help anesthesia residents and CRNAs at MGH improve their proficiency with awake FOI. Trainees in our program designed airway management plans and performed awake FOI based on case scenarios on computerized adult mannequins under close supervision. Based on the evaluation responses, the simulation provided a realistic clinical environment and trainees are satisfied with the effective learning of awake FOI skills. Participants noted that they felt more confident in their ability to perform the skill after completing the program and would like to have this learning opportunity earlier in their residency.

Strengths and limitations

Compared to other various pedagogical methods used in medical education, such as conventional lectures, instructional approaches, reversed classrooms, and the Socratic method, simulation training involves the use of high-fidelity mannequins, virtual reality, or standardized patients to simulate realistic scenarios for trainees to practice their skills and decision-making abilities. It provides hands-on experience, offers a safe and controlled environment for trainees to make mistakes and learn from them without putting real patients at risk. Its limitations include expensive to implement, limited to specific scenarios, may not provide a full understanding

Table 2 Evaluation responses of program learners

Likert scale	1. The simulation was realistic enough for me to engage in learning?		2. The simulation exercise helped me improve my technical skills?		3. The simulation exercise was clinically applicable to my practice?		4. I will change my practice as a result of this simulation exercise	
	Respondents	% of respondents	Respondents	% of respondents	Respondents	% of respondents	Respondents	% of respondents
1—Strongly disagree	0	0.00	0	0.00	0	0.00	1	3.85
2—Disagree	0	0.00	0	0.00	0	0.00	0	0.00
3—Somewhat disagree	0	0.00	1	3.34	0	0.00	0	0.00
4—Neutral	0	0.00	2	6.67	0	0.00	5	19.23
5—Somewhat agree	11	36.67	2	6.67	1	3.33	5	19.23
6—Agree	10	33.33	14	46.66	6	20.00	5	19.23
7—Strongly agree	9	30.00	11	36.66	23	76.67	10	38.46
# of responses	30	100.00	30	100.00	30	100.00	26	100.00

of patient management and care. In particular, there are still differences between performing FOI on mannequins versus on real patients. For instance, awake FOI could be a challenge in case of conditions like stenosis of the upper airways which can be difficult to realistically mimic by simulators (6). Indeed, some trainees in our program noted that it was easier to intubate on mannequins due to their dry and rigid airway structure and suggested reducing the length of the didactic phase of the program to leave more time for practicing skills and providing real-time feedback. Furthermore, some participants provided helpful suggestions to make the simulation more closely aligned with the operating room environment such as practicing medicating the patient and having other operating room personnel present. Based on participant feedback, we have modified the scenarios and simulation format to improve the learning experience.

Comparison with similar researches

As simulation-based training is increasingly being incorporated into medical and anesthesia education, many programs will need help to train healthcare providers and improve airway management skills. Based on recent studies, simulation-based learning has been shown to be effective to improve skill performance in general (14,18,20). However, the overall fidelity or realism of the airway in the simulated tools is still under investigation (18) and criticized by some of our program participants. Based on evidence from meta-analyses, simulation-based training may not be superior to non-simulation-based training mainly because the success rate of intubation completion on real patients is difficult to calculate (14). Recently, a few programs attempted innovative ways to provide training that offers higher fidelity of the real human airway. A group of researchers created a cadaveric model of a simulated parapharyngeal abscess to help residents learn how to manage difficult airways with distorted anatomy and narrow airway passages (20). Similarly, we could provide more opportunities for our trainees to better understand and learn to manage difficult airways. Another group of researchers in Germany used large animal models (swine) to help residents practice intubation, which is a safe and accessible method for novel trainees (17). Dr. Xia and colleagues developed a novel multimodal endotracheal intubation assistant device (MEIAD), which uses end-tidal carbon dioxide ($ETCO_2$) collected by sampling tubes at the tip of the endotracheal tube to guide intubation when encountering an unclear view created by secretions or sputum (21). This tool was shown to improve the FOI success rate and reduce the insertion time on mannequins among residents (21). In the future, other training programs could consider incorporating similar innovative tools that could assist residents with performing intubation such as the MEIAD (2,21-23).

Implications and actions needed

Our program demonstrated initial success at instructing

our learners with simulation-based awake FOI knowledge and skills. Our team hopes to improve our program with feedback from trainees and other simulation-based FOI training programs and balance overall realism with the resources required for this training. In the future, we hope to implement refresher courses, develop an FOI-validated assessment instrument, and further research our just-in-time teaching techniques using qualitative assessment methods. Ultimately, we would like to correlate the results of this course with actual patient encounters to see what effect this course has in real patient situations. Although we focused specifically on anesthesia residents and CRNAs training in this study, our goal with the development of this computerized mannequin simulator teaching program is to assist in the training of all healthcare providers. We are committed to continue refining our approach to ensure that our training program is accessible and effective for all healthcare professionals. We encourage other residency programs to establish similar programs to help anesthesia trainees gain proficiency with FOI.

Conclusions

In summary, our simulation-based program successfully helped anesthesia residents and CRNAs improve proficiency and confidence with awake FOI. We were able to recreate a realistic clinical environment with computerized mannequins and practice scenarios. We encourage other residency programs to incorporate simulation-based training opportunities to help residents improve FOI skills.

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Footnote

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Supplementary

Table S1 Evaluation comments from learners

1. The simulation was realistic enough for me to engage in learning?	2. The simulation exercise helped me improve my technical skills?	3. The simulation exercise was clinically applicable to my practice?	4. I will change my practice as a result of this simulation exercise	5. Comments
Good for learning how to guide fiberscope	Manipulating fiberoptic scope	I look forward to coming back!	Hope to use fiberoptic intubation more effectively	Great. Can also recommend participants to watch videos before the workshop at home—maybe more time for hands-on learning. Also maybe more realistic if do anesthetic prep/medicate patient beforehand too
The eye blinking was too real!	Would like more time to practice and less on the videos	Planning was a highlight as it makes you think about meds in additional to technique	These concepts were already part of practice—just need to get better at guiding scope!	Less video time; more play time
When the mannequins are so obvious it's hard to view it realistically. Also, pretending to have equipment or drugs not really present takes away from realistic scenarios	Working with scope itself	The hands-on portion very helpful. Experience in a team setting was helpful as well	I've had practice with this before but it was good to practice	The art of topicalizing for awake FOI is something I am less comfortable with than the actual intubating itself. Was helpful to practice nasal as I am also less able at those than oral
I think it would have been more realistic to have 1 "resident" and 1 "attending" doing this simulation instead of so many people.	Handling fiberoptic scope in sim setting (less pressure than actual clinical setting) with real time feedback from peers		Techniques for topicalization	Overall I thought it was a very educational as well as informational. Only thing that may improve would be to physically go over the steps for awake intubation
Would suggest making adverse events (i.e., apnea) in response to versed/fentanyl to throw a wrench	But mannequins have rigid and dry structures so it's almost easier to do procedures on them		Using the checklist supplied to create a systematic approach to care	Would be even more helpful to have this earlier in residency
Needed more time—scheduled for 1 hour but went over. I think we all thought we needed be keep moving fast	Use of scope		Although it is easy to make a plan, need a back up plan and to think more thoroughly about all risks and benefits of the plan	I am happy to be intubated awake by my colleagues in the future!
	FOB manipulation			Great program!
	It was good to have a few minutes with the scope to practice		Better topicalization sedation. Also now I have a better understanding of some of the difficulties like anxiety issues	Split up groups to allow focused learning. Rile play OR personnel to make it more real. Vital signs are a critical portion of our care. It will cue us to change what we are dong in a positive way
	Using FOB scope. Every time you get your hands on it, you improve! Simulation allows you to go slowly enough to get a better feel for how to handle the scope			Separate skills practice location from the case
				Early steps of learning—every repetition helps
				Just to save cost for the program, I think we can use "fake" medications instead of real ones. Thank you very much for organizing this! Please organize this more often, so helpful!
				Would like more time to practice awake nasal intubations, even though it is a skill we can rarely take advantage of
				It was a great opportunity to practice skills—since I rarely have the chance
				When starting the simulation cases, it would be more beneficial to "set the stage" prior to entering the operating room (i.e., assigning a team leader/assigning specific people to specific tasks)
				A more clear idea, now, of which meds and doses to use for awake FOIs
				Thank you—very nice exercise
				Finish on time (schedule it longer if necessary) allow a longer amount of time for the exercise. Clarify the goals of this sim
				Mannequin was too easy to intubate, so didn't find technically challenging
				Providing enough time for the tams to come up with a plan

FOI, fiberoptic intubation; FOB, fiberoptic bronchoscopy.

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