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Use of Fiberoptic Intubation Simulation to Enhance Skill and Confidence Among Anesthesia Providers

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Abstract

Background

The purpose of this study was to describe the usefulness of a video-recorded low-fidelity Fiber Optic (FO) intubation simulation and its effect on anesthesia providers' confidence and skill in performing FO intubation.

Method

The study was conducted during the 2019 IANA Airway Workshop using a post-test only study design. All participants who volunteered to participate in the simulation were asked to watch a video-recorded instruction on FO intubation. Immediately after viewing the video, the participants completed a hands-on simulation while the researchers recorded their FO intubation times. Participants were allowed up to three recorded attempts.

Results

Fifty-eight participants completed the hands-on simulation and the post-simulation questionnaires. Results showed an improvement in skill as evidenced by faster mean FO intubation times for each of the three attempts (27.34 sec, 24.99 sec, and 16.13 sec). The FO simulation was found to be effective as demonstrated by participants rating the simulation as both useful (M = 3.73; SD = -0.77; Range = 1 to 4) and instilling a sense of confidence (M = 3.58; SD = 0.81; Range = 1 to 4).

Conclusion

The simulation enhanced anesthesia providers' skill and confidence in FO intubation and was found useful by the participants.

Key Words: Low-fidelity simulation, fiberoptic intubation, anesthesia providers, instructional video, airway workshop.

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Introduction

One of the primary responsibilities of a Certified Registered Nurse Anesthetist (CRNA) is management of a patient's airway and ensuring the maintenance of adequate gas exchange. Securing a patient's airway can involve a variety of maneuvers such as mask ventilation or the use of a laryngeal mask airway, however the insertion of an endotracheal tube remains the standard in ensuring that a patient's airway is protected.

Endotracheal intubation is a skill that is acquired throughout the clinical training of a CRNA and is most commonly performed using a laryngoscope. The laryngoscope allows the provider to displace the tongue and visualize the vocal cords, which is a key landmark in successfully advancing the endotracheal tube into its proper position. For some patients, however, a laryngoscope is not sufficient in granting the CRNA a direct view of the vocal cords. Some contributing factors may include disease processes that can alter a patient's airway anatomy (tumor, goiter, or swelling) or lack of mobility in the jaw or neck that makes it difficult for the CRNA to get the patient in optimal position for intubation (Akhtar et al., 2017).

Portable video laryngoscopes such as the GlideScope and C-MAC are frequently used alternatives to the traditional laryngoscope for intubating patients with anticipated difficult airways. The video laryngoscope (VL) utilizes a similar blade as the standard laryngoscope with a video chip at the tip of the blade that projects the view onto a video display monitor (Yumul et al., 2016). The VL is designed to provide a clear view of the vocal cords, which is accomplished with 30% to 50% less neck and jaw movement than direct laryngoscopy with a Macintosh blade

(Yumul et al., 2016). Limiting neck and jaw movement can be useful in patients with unstable cervical spine in preventing secondary spinal cord injury.

While use of VL can assist in the vast majority of difficult airway scenarios, there are some conditions that warrant the use of a flexible fiberoptic (FO) scope. The FO scope has been widely considered the “gold standard” for intubating patients with very difficult airways (Yumul et al., 2016). Cases that require a FO intubation include an unstable cervical spine in which the neck cannot be manipulated, an awake intubation on a patient with a known difficult airway, and a patient with a mouth opening too small to accommodate VL devices for a successful intubation. However, despite training on how to use a FO scope, it is a skill that is rarely performed in the clinical setting. Anesthesia providers may lack confidence in their abilities using a FO scope, which provides an opportunity for retraining via simulation. In fact, lack of experience and training has been found to be a central reason for avoiding the use of the FO scope in airway management and difficulty in learning to maneuver the flexible scope has been suggested as the hardest part of learning FO intubations (Nilsson, Russell, Ringstead, Hertz, & Kong, 2015).

The use of simulation in nursing has increased substantially in the last few decades (Leigh, Stueben, Harrington, & Hetherman, 2016). Recent comparisons of various simulator modalities found an overall improvement in performance among its users. In addition to improvements in performance, simulation allows trainees to gain confidence in their abilities. Unlike traditional remediation methods that may not increase students’ confidence, using patient simulation provides a safe place to practice skill until a specified level of proficiency is reached (Haskvitz & Koop, 2004). In the simulation environment, learning is enhanced, patient safety is optimized, and there is an increase in self-reported confidence levels (Haskvitz & Koop, 2004).

Nilsson et al. (2015) found that simulation-based training is effective when learning FO intubation. A randomized, controlled study was performed at the University of Copenhagen to compare the effect of training the motor skills of FO intubation to relate the performance levels achieved by the novices to the standard performance of experienced FO practitioners (Nilsson et al., 2015). Results from the study revealed that FO intubation is very suitable for simulation-based training. After performing 12 different intubations on manikins in less than one hour, the novices were performing at the same level as the experienced anesthesiologists (Nilsson et al., 2015). The results from the study further support the notion that simulation-based training can be an effective method in acquiring a clinical skill, such as performing FO intubation, for both novice and experienced learners.

This study aimed to examine the effectiveness of simulation among anesthesia providers in the skill of FO intubation. The following questions were addressed through the implementation of this project:

- Does participating in a low-fidelity FO intubation simulation enhance an anesthesia provider's confidence in his or her ability to complete a FO intubation in a clinical environment?
- Does participating in a low-fidelity FO intubation simulation improve skill among anesthesia providers as evidenced by a reduced time to successful intubation?
- Did participants find the investigator-developed FO simulation useful?

Theoretical Framework

The theoretical frameworks that guided this study were Paivio's Dual Coding Theory or DCT (Paivio, 1991) and the Cognitive Theory of Multimedia Learning or CTML (Mayer, 2005). The DCT explains the benefit of utilizing multimedia education. Despite language and imagery being processed at different parts of the brain, these areas are intertwined and lead to dual coding of information (Hartland, Biddle, & Fallacaro, 2008). In other words, information is more effectively retained and retrieved when it is simultaneously processed via the interconnected visual and linguistic pathways (Hartland et al., 2008).

The CTML is based on the idea that learners attempt to build meaningful connections between words and pictures, and that they learn more deeply than they otherwise would have with words or pictures alone (Gadbury-Amyot, Purk, Williams, & Van Ness, 2014; Mayer, 2003; Sorden, 2012). One of the principal aims of multimedia instruction is to encourage the learner to build a coherent mental representation from the presented material by engaging both visual/pictorial and auditory/verbal channels, then organize the information logically and dynamically (Sorden, 2012). Utilizing a multimedia presentation consisting of narration and video ensure that both knowledge retention and knowledge transfer are optimized relative to text alone.

Consequently, the DCT and CTML were selected as the theoretical framework for a low-fidelity simulation on FO intubation to encourage the active participation of anesthesia providers in their educational experience. Exposure to a multimedia presentation allowed participants to experience the enhancement of knowledge retention, retrieval, and transfer through simultaneous stimulation of the linguistic and visual pathways (Hartland et al., 2008).

Methods

Design

The study utilized a one-group posttest-only design consisting of an instructional video plus hands-on simulation. The posttest-only design was appropriate because FO intubation is a skill that most anesthesia providers have been exposed to throughout their training or in their clinical practice. Therefore, it was impossible to obtain a true "control group" that had no prior experience in performing FO intubation. Instead of comparing to a control group, the researchers measured a change in the areas of skill and confidence. In addition, the posttest-only design allowed the researchers to evaluate the effects of the simulation on the providers' skill and confidence in performing FO intubation.

Setting

The study took place at the Airway Workshop hosted by the Illinois Association of Nurse Anesthetists (IANA) on September 14th, 2019. The Airway Workshop was held in a conference room at Northwestern Memorial Hospital in Chicago, IL. Attendees progressed through eight airway-related skills stations. Inclusion criteria consisted of anesthesia providers who attended the IANA airway workshop and volunteered to participate in the FO skills station. Attendees who wished to participate in the FO skills station approached the table in groups and viewed the instructional video. After completing the video, the participants were instructed to begin the hands-on simulation while the researchers recorded the time it took them to fiber-optically intubate an airway mannequin. Once the simulation was completed, participants were instructed to fill out the simulation evaluation survey and handed the completed surveys to the researchers. Each simulation session took approximately 15 to 20 minutes.

Instruments

Instructional Video. To ensure consistent delivery of information, the researchers showed an instructional video outlining successful completion of the skill. The video content was based on *Fiberoptic Airway Management in Adults and Children* by Ramesh (2005). A video script was validated by a panel of five experts with consensus in the areas of clarity, relevance, simplicity, and consistency.

Simulation Evaluation Survey. The simulation evaluation survey consisted of a single survey with three sections. The first section provided space for participants to record their times to successful FO intubation as a measure of skill. The second section of the survey gathered demographic information from the participants. The demographic questions included the participant's gender, age, current position, years of experience as an anesthesia provider, the number of times they performed a FO intubation within the past year, and the type of anesthesia setting they primarily work in. The third section of the survey evaluated the participant's confidence and the usability of the simulation. The demographic and posttest survey were submitted to aforementioned committee members for content validity.

The third section of the survey consisted of a 10-item Likert scale with four points ranging from strongly disagree (1) to strongly agree (4). The first five statements on the survey evaluated provider confidence in performing FO intubation. Confidence evaluation was adapted from the Confidence Survey and Critical Actions Checklist by Yee et al. (2016). The reliability of the survey was examined using Cronbach's alpha. The statements used from the survey were modified in a way that pertained to the topics discussed in the FO instructional video. The statements required participants to self-evaluate their confidence levels in recognizing appropriate anatomical landmarks when performing FO intubation, their ability to perform a successful FO intubation, recognizing situations where FO intubation is appropriate, their ability to operate the FO bronchoscope, as well as their level of efficiency with the steps involved in successful FO intubation.

The remaining five statements in the survey evaluated the usability of the simulation itself. The usability evaluation was adapted from the System Usability Scale (SUS) Questionnaire by Brooke (1996). Questions pertaining to course structure and user satisfaction were modified to address the FO simulation and the topics covered in the instructional video. The SUS Questionnaire by Brooke (1996) reported a Cronbach's coefficient alpha consistently above 0.80, which indicates internal consistency of the five items in measuring usability. There was also a high level of reliability demonstrated for the survey items used in this study, with Cronbach’s alpha values for confidence and usability at 0.991 and 0.989 respectively.

Recruitment Procedures

Participation in the study was voluntary and no formal consent was required. An information sheet was provided outlining the rights of all the participants. No monetary or other incentives were offered. Participants who wished to volunteer were already attending the conference and no additional travel was necessary. All volunteers were briefed on the research objectives by the researchers prior to initiating the simulation. Subjects were given an information sheet for participation in research, including a statement that reads, “your participation in this simulation and completion of this survey is voluntary and anonymous.” Subject participation with the simulation and posttest survey was considered implied consent.

Data Collection

Following Institutional Review Board (IRB) approval from DePaul University, a convenience sample of anesthesia providers participated in the study. Participants began by watching an instructional video, followed by taking turns performing a FO intubation. To measure skill subset, the researchers recorded each participant’s time for every successful FO intubation attempt. Each attempt was recorded on the survey. Timing a successful FO intubation was defined as the time from when the scope passed the teeth to when the scope advanced to the carina. Participants were each given up to three attempts to perform a FO intubation. Once the participants completed the simulation, the participants were asked to complete the remaining demographic, confidence, and usability portions of the survey.

Data Analysis

The data was analyzed using the International Business Machines (IBM) SPSS software version 25 (IBM, 2019) to determine the impact of the low-fidelity simulation. After determining that the assumptions for parametric statistics were met, *t* test and analysis of variance (ANOVA) were performed to examine differences in mean scores between two groups and three or more groups, respectively (Kellar & Kelvin, 2013). Descriptive statistics such as frequencies, percentages, means, standard deviations, and ranges were used whenever appropriate to summarize and describe the sociodemographic characteristics of the participants as well the usability and confidence data. Cronbach's alpha coefficient was calculated to determine the reliability of the usability and confidence questionnaires in this current study (DeVellis, 2016).

Results

Demographic Features of Study Participants

A total of fifty-eight anesthesia providers participated in this study (N=58). The majority of study participants were female (n=34; 58.6%) and SRNAs (n=40; 69%) with a quarter (n=10; 25%) of them in the final year of a nurse anesthesia educational program (i.e., third year). Only a few participants were 41-50 years old (n=2; 3.4%), 51-60 years old (n=1; 1.7%), and over 61 years old (n=3; 5.2%). The demographic data is represented in Table 1.

The majority of the participants had less than 1 year of experience providing anesthesia (n=33; 56.9%) and a very small number of participants had over 10 years of experience (n=5; 8.6%). Over three fourths of study participants worked at an academic institution (n=44; 75.8%) and a minority of them worked at a community hospital (n=11; 18.9%), or an outpatient surgery center (n=3; 5.1%). More than half of the participants (n=30; 51.7%) had not performed FO intubations in the past year and only a few of them had performed over ten FO intubations (n=7; 12.1%) as outlined in Table 1.

Post-Video Hands-on Simulation Results

When performing the simulation, the mean score for the first attempt at FO intubation was 27.34 seconds, the mean score for the second attempt at FO intubation was 24.99 seconds, and the mean score for the third attempt at FO intubation was 16.13 seconds. The significance of all inferential statistics used in this study was set at the alpha level of 0.05. An independent *t*-test was used to determine the difference in mean scores based on demographic data with two groups. There were no statistically significant differences seen based on gender during the 1st (Males (M=24.61, SD=13.84); Females (M=29.27, SD=19.9); t(56)=-0.988, p=0.137), 2nd (Males (M=23.24, SD=14.23); Females (M=26.23, SD=18.71); t(56)=-0.661, p=0.157), and 3rd (Males (M=14.24, SD=6.76) and Females (M=17.67, SD=6.65); t(18)=-1.139, p=0.84) attempts.

The ANOVA test was used to compare the mean scores of FO intubation times (in seconds) among three or more socio demographic groupings. There was a statistically significant difference in mean scores of FO intubation time between age groups (≤ 30 years old and 31-40 years old) on the first attempt [F(4,53)=2.843, p = 0.03] as well as the difference in mean scores between anesthesia setting groups on the third attempt [F(2,17)=5.100, p=0.018]. Although there were five age groups, only two groups were analyzed based on the frequencies of each age group. This was done to minimize outliers resulting from the small sample size in the other three age groups.

There were no statistically significant differences found in mean scores between age groups for the second and third attempts [1st: F(4,53)=0.527, p=0.716; 2nd: F(1,18)=1.001, p=0.330], current position groups across all attempts [1st: F(2,55)=1.069, p=0.350; 2nd: F(2,55)=0.434, p=0.650; 3rd: F(2,17)=0.207, p=0.815], among three or more groups based on years of anesthesia experience across all attempts [1st: F(4,53)=0.898, p=0.472; 2nd: F(4,53)=0.662, p=0.621; 3rd:F(3,16)=0.345, p=0.793], number of FO intubations in the past year across all attempts [1st: F(4,53)=2.306, p=0.070; 2nd: F(4,53)=1.900, p=0.124; 3rd: F(3,16)=0.846, p=0.489], and anesthesia setting on the first and second attempts [1st: F(2,55)=0.296, p=0.745; 2nd: F(2,55)=0.376, p=0.689]

Survey Results

Based on the survey that participants completed following the simulation, the itemized mean scores along with an overall mean score for confidence are shown in Table 2. The highest mean score was achieved for the variable "more confident in recognizing the appropriate anatomical landmarks when performing a FO intubation," at a mean of 3.62, and the lowest mean score for the variables "more confident in my ability to perform a successful FO intubation" and "more efficient performing the steps involved in a successful FO intubation," at a mean of 3.55 for both variables.

Additionally, the itemized mean scores along with an overall mean score for usability is shown in Table 3. The highest mean score was achieved for the variable "the simulation was an effective resource for improving my performance of FO intubation," at a mean of 3.76. The lowest mean scores were achieved for the variables "objectives and procedures of the simulation were clearly communicated" and "the simulation covered critical content necessary for performing successful FO intubation," at a mean of 3.72 for both variables.

Discussion

The purpose of this study was to examine the usability of a low-fidelity FO intubation simulation and its effect on anesthesia provider confidence and skill. Provider skill was measured by the time it took a provider to perform a FO intubation. Results demonstrated an improvement in skill as evidenced by faster mean FO intubation times for each of the subsequent three attempts (27.34 sec, 24.99 sec, and 16.13 sec).

In addition to the independent samples t-test, one-way ANOVA tests were used to compare the mean scores based on demographic data with three or more groups. It is important to note that only one of the ANOVA test results demonstrated statistical significance, which was that participants working in an academic hospital were more skilled at performing FO intubation by their third attempt. The lack of statistical significance in other areas may have occurred due to the relatively small sample size (n=20). However, differences in mean overall scores based on demographic data could still be appreciated. On the first attempt, the participants greater than 61 years of age had the fastest mean score. By the second attempt, participants less than 31 years old showed the greatest improvement in their times, and further reduced their times to nearly half by the third attempt. Additionally, participants ages 31-40 years old cut their times by over half on their third attempt compared to their first attempt.

Another observation worth noting was that participants who performed more FO intubations in the past year overall had faster times across all attempts compared to participants with less experience. FO intubation is an essential skill for anesthesia providers to master during their training; however, FO intubation is an advanced technical skill that requires repetition in order to remain proficient (Samuelson et al., 2016). The participants who performed more FO intubations in the past year likely experienced the repetition necessary to maintain the skill, which could explain why they achieved faster intubation times. Similarly, the providers greater than 61 years of age were likely practicing anesthesia prior to the release of the VL, and subsequently had more experience with using the FO scope compared to those less than 31 years of age. This collective repetition over time could have explained why they achieved the fastest mean score on the first attempt.

Other factors to consider are the mean scores for confidence (3.58) and usability (3.73) among the participants. While the participants less than 31 years old did not have as much experience as the older age groups, the usability of the simulation and their enhanced confidence may have translated to the large improvement in times across each subsequent attempt. The findings are consistent with those in the qualitative study performed by Henrichs, Rule, Grady, and Ellis (2002), who gathered the perceptions of nurse anesthesia students towards a MedSim simulator as part of their educational training. Due to the realistic feel that the simulation provided, the students had an increase in their confidence levels by becoming familiar with the setting and learning how to manage a simulated patient (Henrichs et al., 2002). The students also felt that the simulator could be used to evaluate their own cognitive and psychomotor skills and improve those skills that they are weak in through practice (Henrichs et al., 2002). Students who participated in the simulations experienced improved confidence in their clinical abilities as well as development of their critical thinking and decision-making skills.

Using both video and a low-fidelity FO intubation simulation were an effective way to incorporate Paivio’s DCT and the CTML in enhancing the skill and confidence of anesthesia providers. Suitably, utilizing video and hands-on simulation for training and retraining technical skills like FO intubation forces the learner to use both verbal and nonverbal channels. The DCT and CTML both explained the benefit of using multimedia education where information is more effectively retained and retrieved when simultaneously engaged relative to if words or pictures were used alone (Paivio, 1991; Mayer, 2005).

Conclusion

Though the results of this project did not show a statistically significant improvement in overall intubation times in all three attempts, an improvement in skill across multiple FO attempts was noted. The results of the confidence and usability survey demonstrated a favorable response from the participants. Therefore, this study provides preliminary evidence for the usefulness of a low-fidelity FO intubation simulation that could be used as part of the training and re-training of anesthesia providers in this skill. The low-fidelity FO intubation simulation can be both a useful way to improve provider competence and confidence, especially for those that do not use the FO frequently. Finally, the simulation can also help to ensure that anesthesia providers are prepared in the event that a FO intubation is necessary. However, more studies are needed before it can be considered an effective means of training.

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Table 1. Demographic Characteristics of Study Participants			
		Frequency	Percentage (%)
Gender	Male	24	41.4
	Female	34	58.6
Age Group	≤ 30 years old	24	41.4
	31-40 years old	28	48.3
	41-50 years old	2	3.4
	51-60 years old	1	1.7
	> 61 years old	3	5.2
Current Position	SRNA second year	25	43.1
	SRNA third year	15	25.9
	CRNA	18	31
Years of Anesthesia experience (including clinical residency)	< 1 year	33	56.9
	1-3 years	9	15.5
	4-6 years	6	10.3
	7-10 years	5	8.6
	> 10 years	5	8.6
Number of times you performed a fiberoptic intubation in the last year	None	30	51.7
	1-3 times	14	24.1
	4-6 times	6	10.3
	7-9 times	1	1.7
	10+ times	7	12.1

Table 2. Critical Action Survey Mean Scores for Confidence in Each Item				
Item	Minimum	Maximum	Mean	SD
More confident in recognizing the appropriate anatomical landmarks when performing a FO intubation.	1	4	3.62	0.813
More confident in my ability to perform a successful FO intubation.	1	4	3.55	0.820
More efficient performing the steps involved in a successful FO intubation.	1	4	3.55	0.820
More confident in recognizing situations where FO intubation is appropriate.	1	4	3.60	0.815
More confident in my ability to operate the FO bronchoscope.	1	4	3.59	0.838
Overall Confidence Score: (M = 3.58; SD=0.81, Range = 3) Cronbach's Alpha = 0.99				

Table 3. Simulation Usability Mean Scores for Each Item				
Item	Minimum	Maximum	Mean	SD
The simulation was well organized and easy to follow.	1	4	3.74	0.785
Objectives and procedures of the simulation were clearly communicated.	1	4	3.72	0.790
The simulation covered critical content necessary for performing successful FO intubation.	1	4	3.72	0.790
The simulation was an effective resource for improving my performance of FO intubation.	1	4	3.76	0.779
Participating in the simulation made it easier for me to perform a FO intubation	1	4	3.74	0.785
Overall Usability Score: Mean = 3.73; SD=-0.77; Range = 3 Cronbach's Alpha = 0.98				