Teaching basic fiberoptic intubation skills in a simulator: initial learning and skills decay

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Abstract

Purpose Generally, novices are taught fiberoptic intubation on patients by attending anesthesiologists; however, this approach raises patient safety concerns. Patient safety should improve if novice learners are trained for basic skills on simulators. In this educational study, we assessed the time and number of attempts required to train novices in fiberoptic bronchoscopy and fiberoptic intubation on simulators. Because decay in skills is inevitable, we also assessed fiberoptic bronchoscopy and fiberoptic intubation skill decay and the amount of effort required to regain fiberoptic bronchoscopy skill.

Methods First, we established attempt- and duration-based quantitative norms for reaching skill proficiency for fiberoptic bronchoscopy and fiberoptic intubation by experienced anesthesiologists (n = 8) and prepared an 11-step checklist and a 5-point global rating scale for assessment. Novice learners (n = 15) were trained to reach the established skill proficiency in a Virtual Reality simulator for fiberoptic bronchoscopy skills and a Human Airway Anatomy Simulator for fiberoptic intubation skills. Two months later, novices were reassessed to determine decay in learned skills and the required time to retrain them to fiberoptic bronchoscopy proficiency level.

Results Proficiency in fiberoptic bronchoscopy skill level was achieved with 11 ± 5 attempts and after 658 ± 351 s. After 2 months without practice, the time taken by the novices to successful fiberoptic bronchoscopy on the Virtual Reality simulator increased from 41 ± 8 to 68 ± 31 s (P = 0.0138). Time and attempts required to retrain them were 424 ± 230 s and 9.1 ± 4.6 attempts, respectively.

Conclusion Novices were successfully trained to proficiency skill level. Although fiberoptic bronchoscopy skills started to decay within 2 months, the re-training time was shorter.

Keywords Intubation · Patient simulation · Skill decay · Education

Introduction

Failure to appropriately manage difficult airways remains the most common cause of anesthesia-related morbidity and mortality [1]. In patients with either a recognized or unrecognized difficult airway, the importance of fiberoptic intubation to secure the airway cannot be overemphasized. Since anesthesia residents are spending less time in the operating room during training [2], combined with the increasing use of video laryngoscopes for management of difficult airways [3], it becomes concerning that trainees may not be exposed to an adequate number of challenging airway cases that require...
fiberoptic intubation. To become proficient in fiberoptic intubation, the operator must understand the equipment and have a skill set to maneuver the bronchoscope appropriately through the nose or mouth into the trachea. Traditionally, residents receive fiberoptic intubation training while caring for patients under the guidance of an attending anesthesiologist, but this approach may lead to hypoxia, hypercarbia and hemodynamic compromise [4]. If novices can be initially trained on simulators and become proficient in basic fiberoptic intubation skills, these complications may be reduced. Previous investigators have demonstrated how to teach fiberoptic bronchoscopy and fiberoptic intubation to novices [5, 6]. However, the decay in skill set of fiberoptic bronchoscopy and intubation is under investigated and clinically meaningful.

Skill decay refers to the loss of acquired skills, knowledge or training after a period of non-use [7]. Previous investigators have reported a significant decay in chest compression skills in cardiopulmonary resuscitation research after 30 days of no practice [8], and also in temporary hemodialysis catheter insertion skills among nephrology fellows after 1 year of no practice [9]. In the present study, we hypothesized that fiberoptic bronchoscopy and fiberoptic intubation skills will decay over time without practice, and that novices can regain the previously achieved level of quickness and accuracy in fiberoptic bronchoscopy and fiberoptic intubation. Additionally, we aimed to assess how much more effort is required to retrain the novices to the same basic proficiency skill level in fiberoptic bronchoscopy.

Materials and methods

With approval from the Human Studies Committee of the University of Louisville, this study was conducted in the Paris Simulation Center at the University of Louisville, School of Medicine, and in the Paris Satellite Simulation Center at the University of Louisville Hospital, Louisville, Kentucky. All subjects provided written informed consent prior to their participation.

Subjects

Proficient group (n = 8)

Eight anesthesiologists, who are a part of the difficult airway management and teaching group, were recruited to establish the basic proficiency skills. Established proficiency was used as the standard level to be reached when training the novices.

Novice group

Fifteen (15) fourth-year medical students from the Anesthesia Interest Group of our institute, who were previously trained in endotracheal intubation on a simulator but with no previous experience in fiberoptic bronchoscopy or fiberoptic intubation, were recruited as the novice group.

Simulators description

Simulators

We utilized two different types of simulators in this research (detailed descriptions are reported in Appendix A)

1. The AccuTouch® Bronchoscopy Simulator is a computerized Virtual Reality simulator that can be used to learn fiberoptic bronchoscopy, but this simulator cannot be used for intubation. The computer records time for fiberoptic bronchoscopy and ‘red out’ (time viewing only mucosa at contact range).

2. The Human Anatomy Airway Simulator (HAAS) consists of a manikin-like face, head, neck, and upper chest and can be intubated with a fiberoptic scope.

Protocol

Establishing the proficiency level—proficient group organization and planning

Each subject from the proficient group performed one fiberoptic bronchoscopy on the Virtual Reality simulator. The procedure included passing the simulated fiberoptic bronchoscope from the nostril through the cords until the carina was visualized. The data were collected from the Virtual Reality computer to record the time required to complete the procedure and the amount of time spent in ‘red-out’ (viewing the mucosa). Data from all eight subjects were pooled and used as the training benchmark for the basic proficiency skill level for testing the novices.

Next, each subject from the proficient group performed one oral and one nasal fiberoptic intubation on the HAAS and their performances were video recorded. To conceal their identity from the raters for subsequent rating of their performance, all participants donned gowns, gloves, masks and caps before performing fiberoptic intubation. The recorded video was copied to a video disc and assigned a random number.

The recorded videos were evaluated with a previously used (a) checklist and (b) Global Rating Scale (GRS) with permission [6] (Appendices B and C). The details related to developing local consensus with the checklist and GRS and
the training of two anesthesia faculty members in their use can be found in Appendix D.

Novice group—organization and planning

Baseline performance evaluation Initially, all the novices received a standard 15-min didactic lecture from the same investigator. The instructions included how to hold the fiberoptic scope and how to operate the tip by using the thumb control lever. Then, functions of the Virtual Reality AccuTouch® Bronchoscopy Simulator were shown. Subsequently, all novices performed one fiberoptic bronchoscopy on the Virtual Reality simulator for fiberoptic bronchoscopy testing, and their performance was computer recorded (as for the proficient group mentioned above). Before HAAS testing, all novices received standard training from the same instructor including how to load an endotracheal tube on to the bronchoscope, steer the bronchoscope through the upper airway into the trachea, advance the endotracheal tube over the bronchoscope into the trachea, and confirm correct placement by visualization of the carina. Subsequently, novices performed one oral and one nasal fiberoptic intubation on the HAAS, and their performances were video recorded as detailed above. The raters who scored these performances were blinded to the identity and level of experience of the subjects.

Simulation-based training and post-training testing Training on the Virtual Reality simulator included performing multiple fiberoptic bronchoscopies for fiberoptic bronchoscopy acquisition under direct supervision by an expert. Training ceased once the subject demonstrated two consecutive successful performances equal to the previously established proficient performance parameters. The total number of bronchoscopy attempts and total time required to achieve the proficient level of skill were recorded from the Virtual Reality computer. Finally, after training, the novices were tested on the Virtual Reality simulator and their performance data for time and ‘red-out’ was recorded as mentioned above.

On HAAS-based training, all novices received standardized training by watching a 10-min teaching video (provided by the investigator, RL), which included a background commentary on the preparation and performance of fiberoptic intubation on the HAAS. Subsequently, novices performed a total of ten practice intubations, five nasal fiberoptic intubations and five oral fiberoptic intubations, again under direct supervision of the same faculty physician. After concealing their identity with gown, cap, mask, and gloves, the sixth nasal and sixth oral performances were videotaped and assigned a randomization code as per the pretraining performance. Supervising physicians neither corrected nor guided the novices during the recording session. We selected five oral and five nasal intubation attempts as the criteria for training because this is the minimum number of procedures required by the American Board of Internal Medicine during residency training for similar procedures [10]. From each video, the blinded rater documented the total time and numbers of attempts required to achieve a successful oral and nasal fiberoptic intubation.

Skill decay testing and retraining The goal of this stage of the study was to determine (a) whether any fiberoptic bronchoscopy and fiberoptic intubation skill decay had occurred during the 2 months without practice and (b) how much retraining would be required to regain our defined basic proficient fiberoptic bronchoscopy skill level. We selected 2 months of no use for skill decay as residents usually spend 1–2 months in each clinical rotation before moving to the next.

The twelve returning novices were tested on the Virtual Reality simulator and HAAS and their performance on HAAS was video recorded as detailed above. During this visit, novices neither received didactic training nor watched the fiberoptic intubation video. They only underwent retraining in the Virtual Reality simulator to achieve previous proficient fiberoptic bronchoscopy performance level as summarized above. The same adult scenario was used in the Virtual Reality simulator throughout the study. The number of attempts and time required to achieve this proficiency level was recorded from Virtual Reality computer. As mentioned above, the recorded videos were evaluated with a previously used (a) checklist, and (b) GRS (Appendices B and C). Details related to developing local consensus with the checklist and GRS and the training of two anesthesia faculty members in their use can be found in Appendix D.

Data analysis

Data were analyzed using SAS, and are presented as mean (standard deviation) in Tables 1 and 2. Owing to multiple paired samples for t-tests performed to assess pretraining and post-training times of novices and 2-month follow-up, a Bonferroni correction was used and statistical significance was set at \( P < 0.0125 \). For all other analyses, statistical significance was set by convention at \( P < 0.05 \). For continuous data, such as time required to complete the procedure and time on ‘red-out’, a two-sample \( t \) test was used to test the hypothesis that the performance of the pretraining novice group (sample size, \( n_1 = 15 \)) and the proficient group (\( n_2 = 8 \)) were different. Similarly, a two-sample \( t \) test was used to test the performance difference between the post-training novice group (\( n_1 = 15 \)) and the proficient group (\( n_2 = 8 \)). A paired \( t \) test was used to compare the performance between the
pretraining and post-training for the novice group, with sample size \( n_1 = 15 \) for pretraining and post-training.

As the checklist performance scores (Appendix B) follow a binomial distribution, a two-sample proportion \( z \)-test was used to carry out the testing procedure. Finally, we assumed that the mean of the data from the five-point GRS (Appendix C) followed a normal distribution by applying the central limit theorem (CLT). Hence, a paired \( t \)-test was used for novice pretraining and post-training data, a two-sample \( t \)-test was used for post-training novice and proficient data, and a paired \( t \)-test was used for post-training and 2-month follow-up data (\( n_1 = 12 \)). The statistical methods used for data analysis in this study have been reported previously, using some of the data from this study as an example of data analysis [11].

## Results

Total training time for novices took approximately 90 min, including orientation with the equipment, watching the training video, performing training intubations, and final performance assessment. The duration of post-decay testing and retraining period (at 2 months) with the Virtual Reality simulator was approximately 30 min per novice.

On the Virtual Reality simulator, there was no difference in fiberoptic bronchoscopy performance between the proficient and novice groups after training (Table 1). Initial training time for novices was 658 ± 351 s, and the number of attempts required was 11.0 ± 5.5.

Of the 15 novices, 12 returned after two months for decay assessment and retraining. On the Virtual Reality simulator, the novices showed statistically significant skill decay after 2 months of no practice in duration of time to visualize the carina, but the difference in ‘red-out’ skill was not statistically significant (Table 1). However, they showed significant retention of fiberoptic bronchoscopy skill as they tested better at the 2-month evaluation compared with pretraining performance (Table 1). When compared with their initial training time, they required less time (initial training time 658 ± 351 s vs 2 months 424 ± 230 s; \( P = 0.0288 \)) and fewer attempts (initial training attempts 11.0 ± 5.5 vs at 2 months 9.1 ± 4.6; \( P = 0.1715 \)) to retrain.

### Table 1: Comparison of fiberoptic skill in the adult Virtual Reality simulator in proficients and novices

<table>
<thead>
<tr>
<th></th>
<th>Proficients (( N = 8 ))</th>
<th>Novices (( N = 12 ))</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pretraining (( N = 15 ))</td>
<td>Immediate post-training (( N = 15 ))</td>
</tr>
<tr>
<td>Time to visualize carina (s)</td>
<td>44 ± 14</td>
<td>116 ± 59&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Time in ‘red-out’ (s)</td>
<td>3 ± 2</td>
<td>16 ± 21</td>
</tr>
</tbody>
</table>

Data are expressed as mean ± SD

*<sup>a</sup> P < 0.001 comparing pretraining in proficients and novices
*<sup>b</sup> P < 0.001 comparing pretraining and post-training in novices
*<sup>c</sup> P < 0.012 comparing post-training and pretraining 2 months later in novices (decay of skill)
*<sup>d</sup> P = 0.0138 comparing pretraining and pretraining 2 month later in novices (retention of skill)

### Table 2: Comparison of fiberoptic intubation in the human airway anatomy simulator between proficients and novices

<table>
<thead>
<tr>
<th></th>
<th>Proficients (( N = 8 ))</th>
<th>Novices (( N = 12 ))</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pretraining (( N = 15 ))</td>
<td>Immediately post-training (( N = 15 ))</td>
</tr>
<tr>
<td>Checklist (11 points for performance)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>9.88 ± 2.3</td>
<td>2.8 ± 2.6&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Global rating score (5 points for performance)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.81 ± 1.0</td>
<td>1.7 ± 0.8&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Time to perform FOI oral route (s)</td>
<td>48 ± 22</td>
<td>261 ± 13&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Time to perform FOI nasal route (s)</td>
<td>50 ± 21</td>
<td>112 ± 58&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Data are expressed as mean ± SD

*<sup>a</sup> Scored as ‘done correctly’ or ‘done incorrectly’ (maximum score 11)
*<sup>b</sup> Scored as ‘very poor’ to ‘clearly superior’ (maximum score 5)
*<sup>c</sup> P < 0.001 comparing pretraining in proficients and novices
*<sup>d</sup> P < 0.001 comparing pretraining and post-training in novices
On the HAAS, there were no differences in performance between novices and proficient in any of the measures tested after the novices completed the simulation-based training (Table 2). On the HAAS, the 12 returning novices showed no skill decay after 2 months of no practice (Table 2). We observed excellent inter-rater reliability for the total score of the 11 checklist questions (ICC = 0.86, \(P < 0.01\)) and GRS score (ICC = 0.88, \(P < 0.01\)) between evaluators.

**Discussion**

Simulators can be used to teach fiberoptic intubation [5, 6, 12]; however, several questions remain about their validity such as how much time and how many attempts are required to train novice learners to basic proficiency skill level, does fiberoptic bronchoscopy and fiberoptic intubation skills decay occur among novices after a short lapse without any practice, and (3) how much effort is required to retrain them? In this study, we established the proficiency level from our department’s airway experts and demonstrated that simulation can be used to train novices to the basic proficiency level in fiberoptic bronchoscopy and fiberoptic intubation skills. Among newly trained novices, fiberoptic bronchoscopy skill began to decay after a short period of two months without any practice.

Skill decay refers to decay or loss of acquired skill, knowledge or training after a period of non-use. The decay starts to occur immediately after training and the longer the period of non-practice or non-use, the greater the decay [7]. Speed/duration (time to complete the task) and accuracy (numbers of errors) are two established criteria which have been used as main outcome variables to assess skill decay [7]. The ‘mastering’ or ‘overtraining’ is the first and ‘complexity of the task’ is the second most important determinant of skill and knowledge retention (i.e., decay) [7]. Previous investigators have reported a significant decay starting after 30 days of no practice in chest compression skills in cardiopulmonary resuscitation research [13], and after 1 year of no practice in hemodialysis catheter insertion skills of nephrology fellows [9]. We used 2 months for the duration of our lapse period as residents usually spend 1–2 months in each clinical rotation before moving to the next. We observed decay in the fiberoptic time only with the Virtual Reality simulator after 2 months of no practice. Therefore, some additional training is necessary to return to proficiency level with the Virtual Reality simulator, but this may not be necessary for the HAAS. If we had used a longer lapse period, the decay might have been worse, but this is another hypothesis that requires testing.

There are various limitations to our study. This study was performed in human anatomy simulators, not in real patients. We acknowledge that the performance in human anatomy simulators does not necessarily reflect the experience in patients with difficult airways. Anatomy simulators do not have altered or distorted airway anatomy and there are no airway protective reflexes or secretions or blood in the airway to complicate the procedure to make it more challenging. However, the reproducibility of the skills acquired on simulators to real patients is established in the literature repeatedly [6, 14–17]. On the other hand, if we had performed this study in patients, the assessment would face many other limitations, such as (a) the time between completion of training to performance of fiberoptic bronchoscopy and fiberoptic intubation would be different in each trainee, which would make the comparison difficult; (b) testing conditions could not be standardized because each patient’s anatomy is different; and (c) the assessment of dexterity decay after a fixed lapse of time in fiberoptic bronchoscopy and fiberoptic intubation would have been impossible on live patients for similar reasons to ‘a’.

The other limitation of our study is that this was a basic skill proficiency training study, which could not provide the opportunity to assess the complete management of fiberoptic intubation in a real patient. Awake fiberoptic intubation involves preparation of the airway with local anesthesia, management of hemodynamics, and ventilation/oxygenation during the intubation process. Our study concentrated only on the bronchoscopy skills and intubation process, and did not focus on the novice’s management of the patient as a whole. The aim of our study was to investigate basic fiberoptic bronchoscopy and fiberoptic intubation skills and not the complete clinical management of a patient with a difficult airway requiring fiberoptic intubation.

On the Virtual Reality simulator, the novices showed skill decay after 2 months in the time taken to visualize carina, but no major skill decay was observed in the HAAS. The computerized Virtual Reality simulator coughs like a real patient when the tip of the bronchoscope rubs against mucosa. A small deterioration in skill can lead to more frequent coughing and fogging of the fiberoptic bronchoscope view. In summary, a small decay in skill can lead to increased procedural time recorded by the Virtual Reality computer. On the other hand, the HAAS neither has an electronic assessor nor a computerized scorer. Therefore, rough maneuvers by novices during intubation of the HAAS do not result in any penalties such as increased procedural time.

To rate a participant’s fiberoptic intubation performance technique, we used a slightly modified version of a previously used checklist [6], the GRS, and procedure time as our outcome parameters. The checklist and GRS use a broad, multimodal approach to evaluate technical skills and accuracy of performance, while the time or speed of performance only measures one variable of a complex,
practical skill. The checklists are shown to reward thoroughness rather than expertise [18], and may have favored the novices after the training. Thus, they may not have achieved proficiency in fiberoptic bronchoscopy and fiberoptic intubation skills, as our measurements would indicate. This may be why their skill decayed after only 2 months.

**Conclusion**

In conclusion, the results of this study show that novices can be successfully trained, tested, and retrained on the basic psychomotor skills of fiberoptic bronchoscopy and fiberoptic intubation equal to a proficiency level established by performances of airway experts on the same simulators. In the absence of practice, fiberoptic bronchoscopy skill began to decay within 2 months after training. Additionally, the total time to retrain after 2 months was shorter compared to the initial training duration. Future research should focus on investigating the impact of fiberoptic intubation skill decay with no practice over a period of time in real patients and how many fiberoptic intubations should be performed over a certain period of time to stay proficient in this skill. How this approach can be used to reduce airway-related morbidity and mortality also needs further investigation.

**Appendix A**

*Simulators.* We utilized two different types of simulators in this research:

1. The computerized AccuTouch® Bronchoscopy Simulator (Immersion Medical, Gaithersburg, MD, USA) is a Virtual Reality partial-task trainer consisting of a proxy flexible bronchoscope, a robotic interface device, a computer, a monitor, and simulation software. The monitor of the Virtual Reality computer generates anatomical 3-D images. This simulator can be used to learn fiberoptic bronchoscopy but not fiberoptic intubation because the actual placement of the endotracheal tube into the trachea cannot be simulated. The bronchoscope part of the simulator can be steered and maneuvered through the Virtual Reality simulator nose into the trachea. During fiberoptic bronchoscopy, the Virtual Reality computer records a variety of data, such as the total duration of the procedure and time spent in ‘red out’ (viewing only mucosa at contact range). At the end of the simulated procedure, these data can be saved and printed for analysis of performance and for teaching purposes.

2. The Human Anatomy Airway Simulator (HAAS—Medical Plastic Laboratory, Gatesville, TX, USA) consists of a manikin-like face, head, neck, and upper chest. Inside the mouth is a simulated pharynx and larynx that lead to a simulated trachea and bronchi. The HAAS is not electronic or computerized in any way. When used for training purposes, the learner’s performance must be assessed by a trained observer.

**Appendix B: Checklist for fiberoptic intubation performance**

<table>
<thead>
<tr>
<th></th>
<th>Done correctly</th>
<th>Done incorrectly</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hold control section correctly in one hand with thumb position for flexion and extension control, and index finger for suction</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Focus scope using appropriate external object</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Control tip of scope with other hand</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Hold the fiberoptic scope firmly and straight</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Introduce bronchoscope into mouth/nose centered</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Maneuvers bronchoscope through nasopharynx/oropharynx and visualizes cords</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Passes cords</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Continues insertion of bronchoscope until visualization of carina</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Passes endotracheal tube</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Reconfirms vision of carina after ETT in situ</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Removes bronchoscope smoothly</td>
<td></td>
</tr>
</tbody>
</table>
Appendix C: Five-point global rating scale (GRS) of fiberoptic intubation performance

Please circle the number corresponding to the candidate’s performance in each category

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very poor</td>
<td>Competent</td>
<td>Clearly superior</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Repeatedly makes tentative or awkward moves with bronchoscope by inappropriate use of scope</td>
<td>Competent use of instruments but occasionally appears stiff and awkward</td>
<td>Fluid manipulation of bronchoscope and no awkwardness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hesitant or jerky attempts to progress</td>
<td>General progression, occasional hesitancy</td>
<td>Progresses smoothly between sequential landmarks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Image not oriented</td>
<td>Image usually oriented</td>
<td>Maintains orientation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loses view and hits mucosa frequently</td>
<td>Occasionally loses view and collides with mucosa</td>
<td>Maintains view in center of air space</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hit-and-miss approach to navigation</td>
<td>Generally purposeful; some inaccuracy with initial movement</td>
<td>Initial movement is desired movement, i.e., purposeful and accurate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Misses targets outside field of view</td>
<td>Achieves most targets</td>
<td>Achieves targets</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Appendix D: Development of video assessment tools and training of raters

Video assessment tools

Once the study data collection was complete, recorded videos were reviewed to confirm their blinded codes without any identifiers.

1. HAAS assessment tool development:
   (a) Checklist. Prior to recruitment of study subjects, we assigned two attending anesthesiologists from our fiberoptic intubation training team to serve as a panel to select and develop research instruments to rate each participant’s fiberoptic intubation performance on the HAAS. They adopted a previously used 10-item binary scoring checklist [6] (with permission), added one essential item (#4: holds the fiberoptic scope firmly and straight) to create an 11-item scoring fiberoptic intubation scoring checklist (Appendix B). For each item, a score of ‘1’ meant ‘done correctly’ and ‘0’ meant ‘done incorrectly’. Thus the maximum score was 11 if every item was performed correctly.

   (b) Global rating scale (GRS). To give raters more flexibility, the panel added a previously used 6-item Global Rating Scale (GRS) to assess subject hand movements and image maintenance on a 5-point Likert scale (with permission) [6] with a maximum score of 30 points (Appendix C). The panel of experts reviewed and agreed on each item to ensure construct and face validity in a method modified by Lynn [19].

   (c) Definition of successful fiberoptic intubation. To achieve a successful fiberoptic intubation the participant must move the tip of the bronchoscope from the nostril or lips to the carina, advance the endotracheal tube over the bronchoscope into the trachea, and the position of the tube is confirmed by relative positioning to the carina. The total time required to complete a successful fiberoptic intubation was measured from the recorded video clips.

Training the raters

We recruited two more anesthesia faculty members to serve as blinded raters and trained them in the use of the Video Assessment Tools by showing them the fiberoptic intubation instructional video (author originated) developed for teaching novices. During this session, they were trained in what constitute ‘done correctly’ and ‘done incorrectly’ elements of the checklist scoring instrument and quality of fiberoptic intubation process using the five-point GRS (Likert scale, anchored 1 to 5 with 5 being ‘clearly superior’). In order to minimize bias, we selected raters who were experienced anesthesiology faculty members but not involved in the creation of the rating instrument or in the recruitment or training of subjects. All items on the fiberoptic intubation scoring checklist and GRS were explained to the raters and their questions answered. All the video clips were rated independently by the two blinded raters using Video Assessment Tools.

References