Title
Mastering Difficult Intubations Using the Glidescope Videolaryngoscope; A Pilot Study with Anesthesiology Residents

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Publication Date
2016
Mastering Difficult Intubations Using the Glidescope Videolaryngoscope; A Pilot Study with Anesthesiology Residents.

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INTRODUCTION
Assistance with ventilation and blood oxygenation by endotracheal intubation is often indicated in patients who are unable to maintain a patent airway. For many years, the first line choice for intubation has been direct laryngoscopy, which done using a Macintosh laryngoscope (Figure 1).

The operator inserts the laryngoscope blade into the patient’s mouth and lifts the handle above the patient to move the patient's tongue and jaw out of the way in order to visualize the vocal cords. A tube with a stylet is inserted in the trachea under direct vision. The stylet is removed after intubation. A cuff is inflated in the trachea to seal the airway.

Outside of the Operating Room (OR), anesthesiologists respond to critically ill patients who need emergent airway assistance. However, anesthesiologists are not present during off hours in 55% of VA hospitals. In those scenarios, practitioners with lesser airway management skills, who have not received formal training with a difficult airway, will have to perform endotracheal intubation. These trainees are unlikely to reach the >99% expert success level that anesthesiologists and nurse anesthetists achieve by performing hundreds of patient laryngoscopies in the operating room.

In 2012, the Veterans Health Administration Directive 2012-032 was released and addressed the need to train non-anesthesiologists in “out of OR airway management” (OORAM) for urgent and emergent situations. Urgent airway management is used in patients whose respiratory status is deteriorating and eventual intervention is anticipated. In contrast, emergent management includes patients who need immediate intervention. The directive says that respiratory therapists, intensive care nurses, pulmonologists, emergency medicine physicians and critical care physicians may be appropriate to respond to airway issues outside of the OR. In addition, it suggests that video laryngoscopy be used as a first-line method for patients with known or suspected difficult airway because intubation skills are more easily acquired than with direct laryngoscopy. The Glidescope videolaryngoscope improves visualization of the vocal cords and raises the performance level of novices. It consists of a handle and a curved laryngoscope blade attached to a video monitor. Figure 2 shows the Glidescope.
A camera chip captures the view at the end of the blade and transmits a continuous video stream through a cable inside the blade and handle back to the monitor. A fiberoptic light bundle runs with the cable and provides light at the end of the blade. The curve on the blade, roughly 70 degrees, is designed to swing around the tongue aiming the camera chip at the vocal cords. Unlike standard direct laryngoscopy, there is no need to compress or slide the tongue out of the way or straighten out the angles between the mouth, the throat and the vocal cords. Once the vocal cords are in view, the operator maneuvers the endotracheal tube through the oral pharynx, then vocal cords and into the trachea as seen in Figure 3A and 3B. A curved stylet molds the tube into the same shape as the blade so that it can follow the same path as the blade around the tongue to reach the trachea.

Among medical personnel untrained in endotracheal intubation, videolaryngoscopy using a Glidescope leads to a 93% rate of successful intubation as compared with 51% with direct laryngoscopy. According to a study in 2009, where emergency medicine residents and attending physicians used simulation mannequins with normal and difficult airways, it was found that the Glidescope provided a better view of the cords in less time, it increased intubation success, and decreased time for intubation in difficult airways.

The problem is that despite the many benefits of the Glidescope, a novice with limited experience presented with an urgent and difficult airway can fail to intubate. Recent studies places the success rate for emergent videolaryngoscopy around 70-80%, even if the provider has moderate degree of experience. Failure to intubate, even with an optimal view of the vocal cords can occur for several reasons, which will be discussed below.

Figure 3A, 3B. View of the video laryngoscope when inserted into the mouth. Figures display the oropharynx, mid-pharynx and trachea. Figures provided by Randolph Hastings PhD, MD from UCSD Department of Anesthesia.

Figure 3B show the path of the vocal cords lying at a cross angle to the trachea, meaning the endotracheal tube normally approaches at a lower angle to the glottis opening, rather than aiming down the barrel of the tracheal lumen. Therefore, as seen in figure 4B, the tube regularly wedges on the cuneiform cartilage in front of the vocal cords, blocking successful intubation. These problems can be solved with specialized maneuvers and formal training of OOROM providers.
The solution is to implement a training module, using reliable techniques developed by two UCSD anesthesiologists, Dr. Randolph Hastings and Dr. Ching Rong Cheng to teach practitioners how to successfully perform endotracheal intubation with the Glidescope in a difficult airway. An advantage of our training program is the availability of a task trainer named Parametrically Adjustable Airway Mannequin (PAAM), developed by the UCSD engineering department. It can mimic conditions causing difficult laryngoscopy; no other commercial mannequin can realistically simulate a scenario where the vocal cords can be viewed but the trachea cannot be intubated. A TruCorp AirSim mannequin will also be used, which accounts for 90% of the market in the United States for airway task trainer. The TruCorp AirSim has an inflatable tongue with real life size and texture, a mobile head and an airway that was developed from the MRI of actual patients. Both mannequins are shown in Figure 5. Prior to implementing the training program on OORAM trainees, a pilot study including anesthesiology residents was planned. Dr. Hastings planned to use feedback from the participants to make necessary changes with the goal of improving the training program prior to teaching the OORAM trainees. The goal of the Independent Student Project (ISP) was to determine whether Glidescope training would benefit the residents who already have some skill in airway management rapidly intubate an easy and tough airway. The results of this pilot study are discussed below.

**METHODS**

I contacted and recruited subjects via email. The email contained a general description of the study, without mention of the attending physicians involved. Subjects were assured their participation would have no bearing on their employment status and no supervisors or authority figures would be informed of their decision to participate or not. Subjects were recruited regardless of gender, ethnicity, age or socioeconomic status. We were most interested in clinical anesthesia year 1 residents (CA1), as their airway management expertise most closely resembles respiratory therapists, intensive care nurses, pulmonologists, emergency medicine physicians and clinical care physicians. Fifteen CA1, five clinical anesthesia year 2 residents (CA2) and two clinical anesthesia year 3 residents (CA3) were consented, a total of 22
The training lasted about 45 minutes to an hour depending on the participant, only working with only one person at a time. It followed a checklist to ensure that instruction was uniform across all subjects. At the beginning of the training session, subjects completed a questionnaire about their experience with airway management, videolaryngoscope and regular direct laryngoscope. This was followed by a detailed presentation given by Dr. Hastings about the Glidescope and how it facilitates a view of the laryngeal inlet followed by a demonstration of a Glidescope intubation under normal conditions without difficulty. Participants also learned why it might be difficult in some conditions to intubate the trachea even though the Glidescope has provided a good view of the vocal cords. The initial instruction was followed pre-training tests measuring the time to intubate using the Glidescope on the easy Trucorp AirSim mannequin and PAAM set to a difficult configuration. The different configurations used are shown in Table 2. The primary measure was intubation success or failure. Success was measured as the ability to intubate both the easy and difficult mannequin in 30 seconds or less, measured from the time the blade was inserted in the mouth to the time the cuff on the tube enters the trachea. Secondary measures were recorded using the Likert scale assessment of skills made by expert observers using an evaluation score based on different skills, as seen in Table 1. These measures were included in evaluation forms that were completed by Dr. Hastings and a second anesthesiologist during each timed intubation, before and after the training.

After the pre-training timed intubations, Dr. Hastings demonstrated 8 steps to aid in successful intubation while using PAAM, set to the easy and tough training configuration seen in Figure 6. Participants then practiced these skills on PAAM. Of note, the tough training configuration was different than the one used in the tests prior to and after training. Table 2 shows the adjustable features on PAAM, which included face height, mouth size, jaw size, jaw tension, spine tension, larynx height, and pillow height. The difficulty of the intubation depended on the configuration. The participant then performed the post-training tests on both the AirSim trainer and PAAM in the difficult pre-training configuration. In addition, a checklist was used to ensure all steps in the training protocol were completed in the same sequence with all subjects. At the end of the training, each subject completed a survey questionnaire and provided recommendations on how to improve the training. Finally, twenty-one residents repeated the timed intubations as tests of skill retention 1-2 months after the training to measure whether they retained most of the skills learned.

Table 1. Evaluator Score Sheet

<table>
<thead>
<tr>
<th>QUESTIONS ASKED OF THE OBSERVERS</th>
<th>POSSIBLE RESPONSES FOR ALL QUESTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>The ease of inserting the blade into the mouth.</td>
<td>1</td>
</tr>
<tr>
<td>The ease of positioning the blade tip at the glottis opening.</td>
<td>Failed</td>
</tr>
<tr>
<td>The ease of exposing the glottis.</td>
<td></td>
</tr>
<tr>
<td>The ease of positioning the tube tip at the glottis opening.</td>
<td></td>
</tr>
<tr>
<td>The ease of passing the tube into the trachea.</td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Attending anesthesiologists chose one of the following when observing the subjects during timed intubations.

Figure 6. Key aspects of the training protocol included:
Insertion of the Glidescope blade on the left side of the mouth, instead of the center of the mouth, maximizing the space available.

Positioning the blade proximal to the vallecula, minimizing pressure on the larynx.

Lifting enough for a minimal view of the cords, again minimizing pressure.

Introducing the tube on the right side of the mouth aimed toward the cords.

Gripping high on the tube and moving it like a stick shift, maximizing maneuverability.

Pulling back the stylet once the endotracheal tube enters the glottic opening.

Advancing the tube into the trachea with a clockwise corkscrew rotation.

Table 2. The various PAAM settings used. In the easy training configuration all the settings are set to allow for the easiest intubation. The tough configuration during the pre and post-tests is different than the tough configuration used while practicing the 8 techniques.

<table>
<thead>
<tr>
<th>Setting</th>
<th>Mouth Spring</th>
<th>Prognath</th>
<th>Teeth</th>
<th>Face</th>
<th>Spine Stiffness</th>
<th>Pillow Height</th>
<th>Anterior Larynx</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hard Assessment (Tough Pre and Post test)</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>5.25 (3/4 Max stiffness)</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Easy Training Configuration</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Hard Training Configuration</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>7 (Max)</td>
<td>6</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 1.

Mouth spring setting: 3(Maximum jaw stiffness), 2(Moderate jaw stiffness), 1(Minor jaw stiffness)
Prognath: 0(No lower jaw protrusion or prognathion), 1(Lower jaw protrusion or prognathion),
Teeth: 1(Greatest interincisor gap), 2(Reduced interincisor gap)
Face: 1(Shortest maxilla length), 2( Longer maxilla)
Spine Stiffness: Depended on the maximum tension, 0(No tension)
Pillow Height: 3 (Standard height), 6 (Maximum Height)
Anterior Larynx: 0 (Normal larynx, not anterior), 1 (anterior larynx by placing a 6”8 block behind the trachea)

STATISTIC AND DATA ANALYSIS

Students’ pre and post training intubation tests were compared by paired t-test using the Statistical Package for the Social Sciences (SPSS). Data is expressed as mean±SEM and significance was accepted for P < 0.05. Multiple response data was collected with the survey completed by the participants after the training.

RESULTS

The time to intubate is shown on the Y-axis in figure 7A and 7B for the three tests. Line segments connect points belonging to the same subjects. Table 3A and 3B display results of all timed intubations for CA1, CA2 and CA3 residents.

According to figure 7A, endotracheal intubation on the Airsim Trucorp took an average of 39 +/- 4.9 seconds prior to training and was reduced to 15 +/- 1.4 seconds immediately after training (p=0.001). The average retention test intubation time was 20 +/- 2.1 seconds compared to 39 +/- 4.9 seconds before training (p=0.001). Participants’ average intubation time after training was 15 seconds, but increased to 20 +/- 2.1 seconds in the retention tests (p=0.109).

Endotracheal intubation on PAAM took an average of 66 +/- 13.1 seconds prior to training and was reduced to 23 +/- 1.9 seconds immediately after training (p=0.003), while the average retention test was 32 +/- 5.7 seconds compared to
66 +/- 13.1 seconds before training (p=0.033). In the tough configuration, subjects took an average of 32 seconds in their retention tests, longer than 23 seconds immediately post training (p=0.066).

Table 3A. Results for Timed Intubations.

<table>
<thead>
<tr>
<th></th>
<th>Easy pre-test</th>
<th>Easy post-test</th>
<th>Easy retention test</th>
<th>Tough pre-test</th>
<th>Tough post-test</th>
<th>Tough retention test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average in seconds (avg)</td>
<td>39</td>
<td>15</td>
<td>20</td>
<td>66</td>
<td>23</td>
<td>32</td>
</tr>
<tr>
<td>Standard Error (se)</td>
<td>4.9</td>
<td>1.4</td>
<td>2.1</td>
<td>13.1</td>
<td>1.9</td>
<td>5.7</td>
</tr>
<tr>
<td>Number of subjects (n)</td>
<td>22</td>
<td>22</td>
<td>20</td>
<td>22</td>
<td>22</td>
<td>21</td>
</tr>
<tr>
<td>Median</td>
<td>30.4</td>
<td>13.8</td>
<td>18.0</td>
<td>36.8</td>
<td>19.9</td>
<td>21.0</td>
</tr>
<tr>
<td>25th percentile</td>
<td>23.4</td>
<td>10.8</td>
<td>13.0</td>
<td>26.0</td>
<td>17.8</td>
<td>16.0</td>
</tr>
<tr>
<td>75th percentile</td>
<td>49.8</td>
<td>17.4</td>
<td>22.1</td>
<td>70.8</td>
<td>26.2</td>
<td>44.4</td>
</tr>
</tbody>
</table>

Table 3B. Results for timed intubations comparing CA1 residents and the advanced group (CA2, CA3 residents).

<table>
<thead>
<tr>
<th></th>
<th>Easy Pretest</th>
<th>Easy Post-Test</th>
<th>Tough Pretest</th>
<th>Tough Post-Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA1 Residents</td>
<td>Average in seconds (avg)</td>
<td>45.1</td>
<td>13.2</td>
<td>74.3</td>
</tr>
<tr>
<td></td>
<td>Standard Error (se)</td>
<td>6.3</td>
<td>0.8</td>
<td>16.3</td>
</tr>
<tr>
<td></td>
<td>Number of Subjects (n)</td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Median</td>
<td>40.1</td>
<td>12.0</td>
<td>38.5</td>
</tr>
<tr>
<td></td>
<td>25th percentile</td>
<td>27.9</td>
<td>10.5</td>
<td>31.1</td>
</tr>
<tr>
<td></td>
<td>75th percentile</td>
<td>62.5</td>
<td>16.0</td>
<td>112.0</td>
</tr>
<tr>
<td>Advanced Group: CA2, CA3 Residents</td>
<td>Average in seconds (avg)</td>
<td>25.2</td>
<td>20.0</td>
<td>48.8</td>
</tr>
<tr>
<td></td>
<td>Standard Error (se)</td>
<td>4.5</td>
<td>3.5</td>
<td>21.9</td>
</tr>
<tr>
<td></td>
<td>Number of Subjects (n)</td>
<td>7</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Median</td>
<td>23.0</td>
<td>17.7</td>
<td>26.0</td>
</tr>
<tr>
<td></td>
<td>25th percentile</td>
<td>19.0</td>
<td>14.7</td>
<td>23.9</td>
</tr>
<tr>
<td></td>
<td>75th percentile</td>
<td>28.9</td>
<td>23.0</td>
<td>32.9</td>
</tr>
</tbody>
</table>
Figure 7A. Easy Glidescope Intubation Times Before the Training, Immediately After and Within 1-2 months.

Figure 7B. Tough Glidescope Intubation Times Before the Training, Immediately After and Within 1-2 months.

Figure 8A and 8B demonstrate that the advanced participants performed better than the CA1 resident before training, suggesting that a shorter intubation time is a measure of expertise. A regression analysis was done to evaluate the affect that Glidescope experience would have on the intubation times. The data demonstrated that having patient Glidescope experience had a favorable effect on the subject’s performance with easy airway intubations (p=0.009) for all participants. Mannequin Glidescope intubation experience was shown to be beneficial with the easy intubations (p=0.034). Having previous mannequin Glidescope experience had no significant effect on the participant’s performance with tough intubations (p=0.672). In addition, having patient Glidescope experience had no affect on the subject’s performance when intubating PAAM in the difficult airway configuration, but this was not statistically significant (p=0.258).
Figures 9 and 10 show the number of CA1, CA2 and CA3 residents who performed better at their post-training and retention tests compared to their pre-training tests. The figures also show the number of subjects who were successful at intubation when done within 30 seconds or less on both the AirSim and PAAM, set to a post-training difficult intubation. Figure 9A shows 93% of the CA1 residents performed better on their post-test and 92% improved during their retention tests, when compared to their pre-training intubation times. Also, Figure 9A shows that CA1 residents improved to a 100% intubation success rate after the training from 33% before training and 85% succeeded during the retention tests. Figure 9B shows that when using PAAM, 80% and 85% performed better during their post-test and retention test, respectively, when compared to their pre-training intubation times. The graph also demonstrates that CA1 resident’s intubation success improved to 80% after training compared to 33% before training and 77% during their retention tests, when using PAAM.

Figure 10A shows that 71% and 50% of the advanced group using the AirSim mannequin performed better during the post training tests and retention test respectively, when compared to their intubation times before training. Figure 10A also shows an 86% intubation success rate before and immediately after training. Also, Figure 10A demonstrated a 100% intubation success rate for the retention test, however one subject was lost to follow up and did not perform the retention test.
Figure 10B shows a 71% success rate for the advanced groups before training, which improved to 86% immediately after and for the retention test, using PAAM. In addition, 85% and 57% did better on their post-training tests and retention tests, respectively, when compared to pre-training intubation times.

Figure 11 displays the responses the residents could choose from on the x-axis to the statements listed within the graph’s legend. On the y-axis, the number of subjects who chose the given response to each statement is shown. According to the graph, 68% of participants strongly agreed they would have a better chance of success with difficult
Glidescope intubation because of this training program. Less than half of the subjects (41%) strongly agreed the easy training manikin TruCorp realistically modeled an easy Glidescope intubation, while 60% strongly agreed that PAAM, in the difficult configuration accurately modeled a difficult Glidescope intubation. Seventy two percent strongly agreed the training exercises taught them how to successfully perform a difficult Glidescope intubation.

![Post-Trial Survey](image)

Figure 11. Survey completed by each participant at the end of the study. The X axis shows the responses each subject had to choose from when answering the questions seen in the legend.

**DISCUSSION**

Anesthesia providers are not present during after hours in about 55% of VA hospitals and OORAM will be the responsibility of non-anesthesiologists, such as respiratory therapists, emergency medicine physicians, intensive care nurses, pulmonologists and critical care trained physicians. Unfortunately, intubation is not 100% successful when using the Glidescope videolaryngoscope, especially when encountering a challenging airway in the hands of a novice, even when seeing an optimal view of the vocal cords. We proposed that our simulation-based training program using specific techniques to successfully intubate challenging airways would help such practitioners. Such training would improve the safety of OORAM at the VA, given that such programs are currently unavailable. This pilot study with anesthesia residents proved that our training program decreased the resident’s intubation times on both easy and difficult task trainers. The data also demonstrates the residents retained the skills learned, as evidenced by their faster intubation times 1-2 months after the training, when compared to times before training. One limitation of our pilot study is the small sample size and although most subjects were first year anesthesia residents, it might not adequately represent a novice population. The data shows that the CA1 residents improved the most after our training program, as evidence by their shorter intubation times during their post-training and retention tests. This program appears to be most beneficial for practitioners with limited intubation experience and not as beneficial for advanced professionals. However, one can claim that because most subjects were inexperience residents (CA1), there was only room for improvement after training. Although CA1 residents returned for their retention tests exactly 1 month later, the CA2 and CA3 residents returned up to 2 months later, which might have contributed to the fact that only 57% performed better on their retention tests, compared to 86% immediately after training. Eighty six percent of the advanced group had successful intubations before and immediately after training when using the AirSim, indicating no additional improvement was seen. This could be attributed to their past experience with easy intubations, given those are more common, therefore the more advanced providers would more likely benefit from training on the difficult mannequins only. Some of the changes that will be made to improve the training program will be to ensure both mannequins are well lubricated before use to better mimic a patient’s mouth. In addition, ensuring the subjects are comfortable when intubating, therefore proving a stepping stool when necessary as some felt they had to stand on their tows to reach.

Figure 11, which show that most of the advanced residents compared to CA1s, intubated both easy and difficult mannequins much quicker prior to the training. This proves that a fast intubation time is a measure of expertise, which is
why it was, used a primary measure. However, the advanced group was a small sample size, including only included five CA2s and two CA3s. The data demonstrated that prior patient and mannequin Glidescope experience was beneficial for all subjects with the easy and tough intubations. Therefore, a mannequin-training program for OORAM practitioners is feasible and could be beneficial in improving their ability to intubate patients with the Glidescope.

CONCLUSION

Intubating the trachea with the Glidescope has been proven to be difficult even though the cords are easily visualized. Therefore, it is imperative to have a training program that allows participants to practice intubating on an adjustable mannequin that can most closely mimic a challenging airway. The effectiveness of the training protocol was supported by improvement in trainee’s performances and retained skills weeks after the program. Overall, there was less improvement seen in the advanced group when intubating an easy airway, but was seen when intubating a difficult airway. Therefore, even the more advance participants would benefit from training on PAAM set to a difficult configuration. Considering that most improvement was seen in the CA1s, which most closely resemble novice and non-anesthesiologists given their limited skills and training experience, the training program could be beneficial in training OORAM providers in both easy and difficult intubation.

REFERENCES

6) Nathan J. Delson. Associate teaching professor at the Mechanical and Aerospace Engineering Department at University of California, San Diego.