A Mannequin Study of Intubation with the AP Advance and GlideScope Ranger Videolaryngoscopes and the Macintosh Laryngoscope

Jack A. R. Hodd, MA, MB, Bchir,* D. John Doyle, MD, PhD,† Shipra Gupta, BS,* Jarrod E. Dalton, MA,*‡ Juan P. Cata, MD,* Edward J. Brewer, BS, MA, EMSI,§ Monyulona James, BS,§ and Daniel I. Sessler, MD*  

BACKGROUND: The AP Advance (APA) is a videolaryngoscope with interchangeable blades: intubators can choose standard Macintosh blades or a difficult-airway blade with increased curvature and a channel to guide the tube to the larynx. The APA may therefore be comparably effective in both normal and difficult airways. We tested the hypotheses that intubation with the APA is no slower than Macintosh laryngoscopy for normal mannequin airways, and that it is no slower than videolaryngoscopy using a GlideScope Ranger in difficult mannequin airways.  

METHODS: Medical professionals whose roles potentially include tracheal intubation were trained with each device. Participants intubated simulated (Laerdal SimMan) normal and difficult airways with the APA, GlideScope, and a conventional Macintosh blade. Speed of intubation was compared using Cox proportional hazards regression, with a hazard ratio >0.8 considered noninferior. We also compared laryngeal visualization, failures, and participant preferences.  

RESULTS: Unadjusted intubation times in the normal airway with the APA and Macintosh were virtually identical (median, 22 vs 23 seconds); after adjustment for effects of experience, order, and period, the hazard ratio (95% confidence interval) comparing APA with Macintosh laryngoscopy was 0.87 (0.65, 1.17), which was not significantly more than our predefined noninferiority boundary of 0.8 (P = 0.26). Intubation with the APA was faster than with the GlideScope in difficult airways (hazard ratio = 7.6 [5.0, 11.3], P < 0.001; median, 20 vs 59 seconds). All participants intubated the difficult airway mannequin with the APA, whereas 33% and 37% failed with the GlideScope and Macintosh, respectively. In the difficult airway, 99% of participants achieved a Cormack and Lehane grade I to II view with the APA, versus 85% and 33% with the GlideScope and Macintosh, respectively. When asked to choose 1 device overall, 82% chose the APA.  

CONCLUSIONS: Intubation times were similar with the APA and Macintosh laryngoscopes in mannequins with normal airways. However, intubation with the APA was significantly faster than with the GlideScope in the difficult mannequin simulation. (Anesth Analg 2011;113:791–800)
The AP Advance (Fig. 1C) is a videolaryngoscope that is designed to be esthetically and functionally similar to current Macintosh laryngoscopes. As a result, clinicians use an intubation technique similar to that used with a Macintosh laryngoscope. The AP Advance may be fitted with interchangeable blades (Fig. 2). The choice includes a difficult airways blade and 2 standard Macintosh blades, therefore potentially offering greater versatility. The difficult airways blade delivers the tube using a channel that follows the increased curvature of the blade; consequently, the tube needs only be manipulated under direct vision and a stylet is unnecessary.

Videolaryngoscopy is often reserved for anticipated difficult airways; for a videolaryngoscope to be acceptable to clinicians for all forms of practice, it should offer advantages in difficult intubations while not imposing a penalty when intubating normal airways. The interchangeable blades of the AP Advance may satisfy this requirement. We therefore tested the hypothesis that the intubation rate of the AP Advance is as good as or better (noninferior) than the GlideScope Ranger in difficult intubations, while simultaneously noninferior to the Macintosh blade in normal intubations.

The GlideScope was selected as the reference videolaryngoscope because it has proven efficacy and is frequently used in our institution; the Macintosh laryngoscope was chosen because it is ubiquitous and highly effective in normal airways.

As secondary outcomes, we compared the laryngeal views obtained, how quickly they were obtained, and how quickly the tube could be delivered once a view was obtained. We recorded incidents and causes of failures to intubate, along with objective and subjective damage to the larynx. Lastly, we sought the preferences of clinicians for devices and aspects of device design.

METHODS
The project was approved by the Cleveland Clinic IRB, with written consent waived. Clinicians who might intubate the airway during their clinical practice were eligible. Clinicians were split into 3 groups depending on prior experience with the devices: (1) medical students and clinicians with...
Airway damage was compared subjectively and objectively. Participants were asked to compare, on a 10-cm-long visual analog scale, the potential for laryngeal damage with each device. Objectively, potential damage to laryngeal structure was assessed by comparing the number of misdirected advances of the endotracheal tube into the structures surrounding the laryngeal opening.

Participants were asked to recommend a device for use in normal airways, a device for difficult airways, and a single device to use for all intubations. Finally, participants were asked to rate the 2 videolaryngoscopes on portability, light source, picture quality, and position of the screen.

Statistical Analysis
Stratified Cox regression modeling was used to accommodate incomplete observations corresponding to failed intubations (as defined above) while also making appropriate adjustments for potential correlation exhibited by multiple time-to-intubation measurements made for a given participant under the 6 experimental scenarios. Failed intubations were censored at 120 seconds.

Analysis of crossover designs requires consideration of potential order, period, and differential carryover effects confounding the relationships of interest, in addition to varying participant characteristics. We randomized the order of devices for each participant and for each mannequin, but nonetheless adjusted for this as a factor in our stratified Cox models. A factor describing period effects (e.g., a “learning curve”) was also adjusted for. Differential carryover effects (i.e., if a device disproportionately affects the intubation rate of subsequent devices) were evaluated by testing the period-by-laryngoscope interaction term, and if there were differential carryover effects, only the first period would be used for analysis. Finally, we adjusted for our defined categories of practitioner experience.

Power Analysis
Accurate estimates of sample size were precluded by the fact that this is the first assessment of the AP Advance; furthermore, large variability for intubation times with Macintosh and videolaryngoscopes are reported. We therefore enrolled 90 participants, which is 50% more than previous similar studies.

Primary Hypothesis
We evaluated noninferiority of the AP Advance as compared with the reference laryngoscope for each airway. The Macintosh and GlideScope Ranger were used as the reference laryngoscopes in the normal and difficult airways, respectively. Noninferiority was predefined as an AP Advance intubation rate not more than 20% slower than the reference technique.

To evaluate the primary research hypothesis, a Cox model was developed for each airway. Noninferiority of the AP Advance to the relevant reference device was declared if the ratio of intubation rates between AP Advance and the reference (the hazard ratio [HR]) was significantly >0.8 (i.e., an HR of 0.8 implies the rate of intubations for the AP Advance is equal to 80% of the rate for the reference device, or equivalently, 20% slower than the reference device). One-sided Wald tests were used for
the noninferiority testing. The Bonferroni correction was used to control the overall type I error rate at 5% for this primary analysis.

Secondary Hypotheses

The secondary end point comparing the AP Advance with the reference laryngoscope within levels of practitioner experience (no intubation experience; experience with Macintosh only; and experience with both Macintosh and GlideScope) was evaluated as per the primary analysis, having added an interaction between experience and laryngoscope to the stratified Cox models. The Bonferroni correction was applied to the significance criterion.

Quality of view obtained, as represented by C & L grades, was analyzed using a repeated-measures proportional odds logistic regression model33 to compare AP Advance with Macintosh direct laryngoscopy in the normal airway. For the difficult airway, we instead used a simpler generalized estimating equation logistic model to evaluate the relative odds between the AP Advance and GlideScope Ranger of obtaining a full view of the glottis versus obtaining a poorer-quality view (C & L grade >1), because 97% of the scores were <3 for these 2 laryngoscopes. Both of these models incorporated a compound symmetric covariance structure to account for potential intrasubject correlation among the repeated measures and also adjusted for order, period, and practitioner experience. Two-sided hypothesis tests, with adjusted significance criterion of \( P < 0.025 \), were used in these models. Other outcomes were summarized using standard univariable summary statistics.

RESULTS

Ninety participants were recruited between December 18, 2009 and February 11, 2010 and grouped according to experience: 28 (31%) had no intubation experience, 32 (36%) had experience with the Macintosh but not GlideScope, and 30 (33%) had experience with both the Macintosh and GlideScope (Table 1).

Tests for differential carryover effects in our stratified Cox models were not statistically significant (\( P = 0.39 \) for the normal mannequin, \( P = 0.69 \) for the difficult mannequin); thus, data from all 3 phases were used for analysis. Primary outcomes and main secondary outcomes are summarized below; results for all measurements are detailed in Figure 3 and the tables.

Primary Analysis: Comparison of the AP Advance to the Macintosh Laryngoscope in the Normal Airway and the GlideScope Ranger in the Difficult Airway

In the normal-airway mannequin, unadjusted intubation times were slightly longer with the GlideScope Ranger than with the other 2 devices. In the difficult mannequin airway, by contrast, the AP Advance required the least time to intubate, followed by the GlideScope Ranger then the Macintosh (Fig. 3).

In our primary analysis for the normal airway, the adjusted HR (95% confidence interval) comparing the AP Advance to Macintosh in normal airways was 0.87 (0.65, 1.17), which was not significantly more than our predefined boundary of 0.8 (\( P = 0.26 \), Wald test). Median intubation times were 22 seconds for the AP Advance and 23 seconds for the Macintosh.

In the difficult airway, after adjustment, intubation with the AP Advance was faster than with the GlideScope Ranger (HR = 8.6 [6.0, 12.3], \( P < 0.001 \)). Median time to intubation was 20 s versus 59 s, respectively.

Secondary Analyses

Time to Intubation Analyses Within Subgroups of Different Prior Experience

In the normal airway, analysis did not demonstrate noninferiority of the AP Advance for any level of prior experience: \( P = 0.10 \), HR (Bonferroni-adjusted 95% confidence interval) = 1.03 (0.62, 1.72) among those with no experience; \( P = 0.55 \), HR = 0.77 (0.36, 1.65) among those with Macintosh experience but no GlideScope experience; and \( P = 0.45 \), HR = 0.82 (0.53, 1.25) among those with both Macintosh and GlideScope experience.

In the difficult airway, the superiority of the AP Advance over the GlideScope Ranger held for participants of all levels of experience: \( P < 0.001 \), HR = 7.9 (4.5, 14.0) for the nonexperienced group; \( P < 0.001 \), HR = 8.1 (4.1, 16.2) for the group with only Macintosh experience; and \( P < 0.001 \), HR = 10.1 (5.1, 19.9) for the experienced group.

Comparison of the AP Advance to the GlideScope Ranger in the Normal Airway and the Macintosh in the Difficult Airway

Comparing the AP Advance with the GlideScope Ranger in the normal airway, analysis showed the AP Advance was faster than the GlideScope Ranger (HR = 2.1 [1.5, 3.0], \( P <

---

**Table 1. Summary of Participant Characteristics and Experience**

<table>
<thead>
<tr>
<th>Category</th>
<th>Not experienced with direct or GlideScope intubation</th>
<th>Experienced with direct but not GlideScope intubation</th>
<th>Experienced with both direct and GlideScope intubation</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Senior medical staff (attendings, fellows)</td>
<td>0 (0%)</td>
<td>4 (29%)</td>
<td>10 (71%)</td>
<td>14</td>
</tr>
<tr>
<td>Junior medical (residents, interns)</td>
<td>2 (9%)</td>
<td>10 (45%)</td>
<td>10 (45%)</td>
<td>22</td>
</tr>
<tr>
<td>Medical students</td>
<td>24 (96%)</td>
<td>1 (4%)</td>
<td>0 (0%)</td>
<td>25</td>
</tr>
<tr>
<td>CRNAs</td>
<td>0 (0%)</td>
<td>1 (11%)</td>
<td>8 (89%)</td>
<td>9</td>
</tr>
<tr>
<td>Paramedical staff (RTs, EMS)</td>
<td>2 (10%)</td>
<td>16 (80%)</td>
<td>2 (10%)</td>
<td>20</td>
</tr>
<tr>
<td>Total</td>
<td>28 (31%)</td>
<td>32 (36%)</td>
<td>30 (33%)</td>
<td>90</td>
</tr>
</tbody>
</table>

Data are presented as n (% of row).

CRNA = certified registered nurse anesthetist; RT = respiratory therapist; EMS = emergency medical services paramedic.
Figure 3. Kaplan-Meier cumulative density plots of (a) time to successful intubation, (b) time to declared optimal view of the glottis, and (c) time from optimal view to deliver tube, by simulation difficulty and laryngoscope. APA = AP Advance; DL = Macintosh direct laryngoscope; GS = GlideScope Ranger.

Table 2. Details of Failed Intubations for 90 Participants with Each Device Broken Down by Failure Categories

<table>
<thead>
<tr>
<th>Failure Category</th>
<th>APA</th>
<th>GS</th>
<th>DL</th>
<th>APA</th>
<th>GS</th>
<th>DL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abandoned procedures</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>3 (3%)</td>
<td>10 (11%)</td>
</tr>
<tr>
<td>Esophageal intubations</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>2 (2%)</td>
<td>0 (0%)</td>
<td>5 (6%)</td>
<td>22 (24%)</td>
</tr>
<tr>
<td>Time &gt;120 s</td>
<td>1 (1%)</td>
<td>5 (6%)</td>
<td>1 (1%)</td>
<td>0 (0%)</td>
<td>17 (19%)</td>
<td>11 (12%)</td>
</tr>
<tr>
<td>&gt;3 attempts at intubation</td>
<td>1 (1%)</td>
<td>3 (3%)</td>
<td>1 (1%)</td>
<td>0 (0%)</td>
<td>22 (24%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Totals</td>
<td>1 (1%)</td>
<td>5 (6%)</td>
<td>3 (3%)</td>
<td>0 (0%)</td>
<td>30 (33%)</td>
<td>33 (37%)</td>
</tr>
</tbody>
</table>

Data are presented as n (% of participants).

Note that an intubation may be deemed a failure for >1 reason.

APA = AP Advance; GS = GlideScope Ranger; DL = Macintosh direct laryngoscope.
Mannequin Comparison of AP Advance and GlideScope

Comparison of Views Obtained

The view with the AP Advance was better than with the other 2 laryngoscopes in both normal and difficult airways. In the normal airway, the odds that the AP Advance produced a better view than the Macintosh were an estimated 7.1 (3.3, 15.2) \( (P < 0.001) \) times as likely than vice versa; in the difficult airway, a full view of the glottis (C & L grade = 1) was an estimated 4.0 (2.1, 7.7) times as likely for the AP Advance than for the GlideScope Ranger \( (P < 0.001) \), with 70% of intubators achieving a grade 1 view and 99% achieving a grade 1 to 2 view with the AP Advance.

Comparison of Subjective and Objective Airway Trauma

Details of intubation failures are given in Table 2. In the normal airway, the AP Advance yielded 1 failure (1%), the GlideScope Ranger 5 (6%), and the Macintosh 33 (37%; including 22 esophageal intubations and 10 abandoned procedures). In addition, fewer intubators required multiple attempts with the AP Advance than with the GlideScope Ranger.

DISCUSSION

Although we did not show noninferiority of the AP Advance to the Macintosh in our primary analysis of easy airways (because the HR was not significantly more than our predefined noninferiority boundary of 0.8), the univariate intubation times with the AP Advance were almost...
Table 4. Summary of Subject-Expressed Preferences

<table>
<thead>
<tr>
<th>Comparison of all 3 laryngoscopes</th>
<th>AP Advance</th>
<th>GlideScope Ranger</th>
<th>Macintosh direct laryngoscope</th>
</tr>
</thead>
<tbody>
<tr>
<td>Damage score (VAS)</td>
<td>1.1 (0.5, 2.8)</td>
<td>3.6 (1.9, 5.4)</td>
<td>4.8 (2.6, 7.4)</td>
</tr>
<tr>
<td>Ranking of devices</td>
<td>1 (1, 2)</td>
<td>2 (2, 3)</td>
<td>2 (1, 3)</td>
</tr>
<tr>
<td>For normal airway</td>
<td>1 (1, 1)</td>
<td>2 (2, 3)</td>
<td>3 (2, 3)</td>
</tr>
<tr>
<td>For difficult airway</td>
<td>74 (82%)</td>
<td>7 (8%)</td>
<td>9 (10%)</td>
</tr>
<tr>
<td>Participants’ choice of 1 device</td>
<td><em>Favors GlideScope Ranger</em></td>
<td><em>No preference</em></td>
<td><em>Favors AP Advance</em></td>
</tr>
<tr>
<td>Comparison of videolaryngoscopes</td>
<td>Light source</td>
<td>61 (68%)</td>
<td>21 (23%)</td>
</tr>
<tr>
<td>Portability</td>
<td>11 (12%)</td>
<td>44 (49%)</td>
<td>35 (39%)</td>
</tr>
<tr>
<td>Position of screen</td>
<td>1 (1%)</td>
<td>9 (10%)</td>
<td>80 (89%)</td>
</tr>
<tr>
<td>Position of screen</td>
<td>6 (7%)</td>
<td>4 (4%)</td>
<td>80 (89%)</td>
</tr>
</tbody>
</table>

Data are presented as n (%) or median (first quartile, third quartile). VAS = visual analog scale.

identical to the Macintosh, and the rate of intubation with the AP Advance was significantly faster than with the GlideScope Ranger. This is in agreement with previous work showing that the GlideScope is slower than the Macintosh in normal airways, and suggests that there is little time penalty for using the AP Advance.

The GlideScope was generally slower than the AP Advance and Macintosh in each of the experienced groups, with the most notable difference in the novice intubators (approximately 20 seconds’ difference). This result seems inconsistent with the theory that the GlideScope is superior for novice clinicians intubating easier airways, even though the GlideScope Ranger provided these intubators a better view of the glottis. In contrast, experienced intubators did not experience any clinically important delay in intubating the normal airway, which again contrasts with the findings of others. The overall differences in intubation times of the normal airway among all devices, although statistically significant, is not, in the authors’ opinion, clinically important. Our results thus suggest that use of the GlideScope (by competent GlideScope practitioners) or AP Advance (by any clinician) is not clinically detrimental in normal airways.

Explanation of Differences in Intubation Times and Successes

Our work suggests that it may take longer to intubate with the GlideScope because of the time required to manipulate the tube to the glottic opening (Fig. 3C): the difference in intubation rates seems to have been attributable to the time required to deliver the tube to the trachea, which took more time with the GlideScope than with the AP Advance (median tube delivery times of approximately 7 seconds with the AP Advance and Macintosh, but approximately 36 seconds with the GlideScope Ranger). This observation is consistent with previous reports and reflects the substantial dexterity required to intubate with the GlideScope Ranger, especially manipulation of the tip of the endotracheal tube under video guidance. In contrast, advancing the tube is usually easy under direct visualization or through the guide channel in the AP Advance.

Although experienced GlideScope users were able to rapidly intubate normal airways, they experienced a time penalty compared with the other devices in the difficult scenario. Therefore, even experienced GlideScope users take longer in a difficult airway; tube delivery is more difficult and independent of prior skill acquisition. In contrast, tube delivery was rapid with the AP Advance even in difficult airways (via the guide channel attached to the blade) and Macintosh (via direct visualization).

Ideally, laryngoscopes should provide a good view and then require minimal effort to introduce the tube into the trachea. Both the AP Advance and GlideScope Ranger provided better views than the Macintosh blade and decreased the time to attain that view in the difficult airway (Fig. 3B). This was clearest in the difficult mannequin, and fits with previous work comparing videolaryngoscopes with Macintosh blades in mannequins and humans, while also validating our difficult model. Compared with the AP Advance, the GlideScope Ranger was much more likely to require multiple attempts at tube delivery, particularly in the difficult airway.

The number of intubation failures and causes thereof varied among the devices and gives insight into device limitations: although the success rates for all devices were very high in the normal airway, the failure rates for the GlideScope Ranger and Macintosh were high in the difficult airway. The Macintosh was far more likely to fail because of esophageal intubation or abandoned procedures, whereas the GlideScope Ranger was more likely to fail because of the long time required or the need for multiple attempts. Therefore, in a controlled environment where intubation time is not critical, the GlideScope Ranger would provide an excellent solution for intubating difficult airways. However, both Macintosh and GlideScope Ranger compared poorly with the AP Advance (which yielded only 1 failure overall, and none in the difficult airway); this may be explained by the fact that the AP Advance offers solutions for both visualization and tube delivery. This adds to the evidence that participants find it easier to intubate with channel devices compared with the GlideScope in difficult scenarios.

However, it should also be noted from our results that some participants were able to intubate with the GlideScope in times comparable to the AP Advance; using the GlideScope was not universally, and therefore inherently, more time consuming. The GlideScope technique requires
greater dexterity and skill because of the degrees of freedom of endotracheal tube movement the intubator has, compared with channel-based videolaryngoscopes such as the AP Advance. Increased freedom may allow greater flexibility to adapt to specific airway anatomy. The GlideScope may therefore be a more difficult tool to use, but simultaneously have a wider spectrum of utility, whereas the AP Advance may be easier to use but have a more limited spectrum of utility. The wider angle of glottic view achieved with the GlideScope may also aid in airways with abnormal anatomy.

We used a difficult airway model in this study that is identified in previous work as challenging. Nonetheless, only 1 difficult mannequin airway simulation was used, which does not simulate the heterogeneity encountered in human difficult airways. It thus remains possible that the GlideScope Ranger may be comparatively advantageous with other types of difficult airways, in which the GlideScope already has proven efficacy.

The plasticity of the GlideScope technique has an advantage that it may also be used to augment other intubation modalities. The GlideScope has been used in concert with fiberoptic intubation for difficult airways. Multiple device techniques and efficacy in different types of difficult airways have yet to be demonstrated with the AP Advance. Therefore, overall, our study showed the AP Advance provided the benefit of the GlideScope Ranger in this model in attaining a good laryngeal view and maintained the ease of tube delivery of the Macintosh, whereas the GlideScope Ranger was limited by the tube delivery technique and the Macintosh was limited by the clinicians’ ability to gain an intubating view.

Further Considerations in Comparing the Devices: Complications of Use and Price
The differences in technique also have different associated potential complications. The GlideScope technique, which uses a styletted tube, has been associated with pharyngeal arch perforation and soft palate perforation. However, there is also a potential risk that passing a tube through a channel may lead to endotracheal tube cuff damage or rupture, necessitating tube exchange and associated risk. The literature-reported incidence of pharyngeal perforation is low, but it remains to be determined what the incidence is of endotracheal tube cuff rupture as a result of channel-based videolaryngoscopy.

The GlideScope Ranger, as used in this study, costs approximately $11,000 for the entire system. The GlideScope Single-Use camera module (including handle and cable) costs approximately $11,000, with each disposable blade costing about $15. The AP Advance Kit costs $7500 (JARH personal correspondence with Venner Medical, Singapore, October 2010) for the laryngoscope system (which includes the viewer module and 10 each of Macintosh 3, Macintosh 4, and Difficult Airway blades), with disposable Macintosh blades costing $6.75 per unit and disposable Difficult Airway Blades costing $45 per unit. The GlideScope Single-Use blades are currently available in a range of adult (3–4) and pediatric (1–2) sizes. The AP Advance blades are currently limited to adult usage only (Macintosh sizes 3 and 4, with 1 size option for the difficult airway blade). Therefore, although the initial capital outlay for a videolaryngoscope is high, the marginal cost (i.e., the cost of each subsequent intubation) of use of a videolaryngoscope is not prohibitive for either the GlideScope Ranger Single-Use or the AP Advance.

Limitations of This Study
We compared the AP Advance with the best devices available in our institution, but the AP Advance still needs to be compared with other available videolaryngoscopes. As with almost all other intubation studies, participants performing intubations could not be blinded to device, resulting in potential for performance or reporting bias. Although we used an advanced simulator (Laerdal SimMan 3G), mannequins fail to closely mimic the feel of human tissues, anatomical diversity of patients, and do not reproduce the fluids often encountered in real airways. Results described in this study thus require validation in patients. However, it has been argued that it is ethically preferable to validate a protocol with simulation before a human study, thereby limiting patient exposure in a trial that is methodologically unsound or unlikely to produce results. Also, comparing similar study methodologies undertaken in mannequins and patients shows that results have been similar, although there is currently a limited number of mannequin studies that have been faithfully reproduced in patients.

This study used a heterogeneous group of participants, as have other studies, to represent the variety of back-grounds and experience levels in the clinical environment. We considered prior experience with at least 10 clinical intubations to indicate the clinician was no longer a novice, although this is at the lower end of reported intubation learning curves. Furthermore, participants were able to practice until they considered themselves competent.

Failed intubations are rare in humans and mannequins. We therefore used a combination of true and surrogate failure end points, which lower the failure threshold, but which have been used previously in mannequin studies. Our choice of surrogate failure criteria (more than 3 attempts; intubation time >120 seconds) seem reasonable, because most clinicians would switch to an alternative approach under these circumstances.

CONCLUSION
The AP Advance was the fastest device for difficult airways, and nearly as fast as the Macintosh for normal airways. The AP Advance produced the best view for participants and the fewest failures, and caused the least potential airway damage. Participants in our simulation preferred it as a device to the GlideScope Ranger, with 82% of study participants preferring it as a single-device solution for all intubations. Although these results in mannequins are encouraging, efficacy of the AP Advance needs to be compared against other devices in humans.

DISCLOSURES
Name: Jack A.R. Hodd, MA, MB, Bechr.
Contribution: Study design, data analysis, conduct of study, manuscript preparation.
REFERENCES


Name: D. John Doyle, MD, PhD.
Contribution: Study design, data analysis, conduct of study, manuscript preparation.
Name: Shipra Gupta, BS.
Contribution: Study design, data analysis, conduct of study, manuscript preparation.
Name: Jarrod E. Dalton, MA.
Contribution: Study design, data analysis, conduct of study, manuscript preparation.
Name: Edward J. Brewer, BS, MA, EMSI.
Contribution: Study design, conduct of study, manuscript preparation.
Name: Monyulona James, BS.
Contribution: Conduct of study, manuscript preparation.
Name: Daniel I. Sessler, MD.
Contribution: Study design, data analysis, conduct of study, manuscript preparation.