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Improvement in GlideScope® Video Laryngoscopy performance over a seven-year period in an academic emergency department

John C. Sakles · Jarrod Mosier · Asad E. Patanwala · John Dicken

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Abstract To evaluate the outcomes in first pass success (FPS) of GlideScope (GVL) intubations over a seven-year period in an academic ED. Data were prospectively collected on all patients intubated in an academic ED with a level 1 trauma center over the seven-year period from July 1, 2007 to June 30, 2014. Following each intubation, the operator completed a standardized data collection form that included information on patient, operator and procedure characteristics. The primary outcome was first pass success, defined as successful intubation with a single laryngoscope blade insertion. The secondary outcome was the Cormack–Lehane (CL) view of the airway. To adjust for important confounders, a logistic regression model was used to determine the association between academic year and first pass success. In the first year of the study, the first pass success with the GVL was 75.6 % (68/90; 95 % CI 65.4–84.0 %) and the percentage of patients with CL I/II views was 95.6 % (86/90; 95 % CI 89.0–98.8 %). By the seventh year of the study, the first pass success with the GVL increased to 92.1 % (128/139; 95 % CI 86.3–96.0 %) and the percentage of patients with CL I/II views was 94.2 % (131/139; 95 % CI 89.0–97.5 %). In the logistic regression model, first pass success improved during the seven-year period (aOR 3.1; 95 % CI 1.3–7.1; $p = 0.008$). Over the seven-year period, there was significant improvement in the first pass success of the GVL, without any change in the Cormack–Lehane view, suggesting that there was improvement in the skill of tube delivery with use of the GVL over time.

Keywords Emergency intubation · GlideScope · Video laryngoscopy · Airway management · Emergency department

J. C. Sakles (✉) · J. Mosier
Department of Emergency Medicine, University of Arizona, 1501N, Campbell Avenue, PO Box 245057, Tucson, AZ 85724, USA
e-mail: sakles@aemrc.arizona.edu

J. Mosier
e-mail: jmosier@aemrc.arizona.edu

A. E. Patanwala
Department of Pharmacy Practice and Science, University of Arizona College of Pharmacy, Tucson, USA
e-mail: patanwala@pharmacy.arizona.edu

J. Dicken
University of Arizona College of Medicine, Tucson, USA
e-mail: jdicken@email.arizona.edu

Introduction

The GlideScope® Video Laryngoscope (GVL) (Verathon Medical Inc., Bothell, WA) became available for clinical practice in 2001. Since then, its use has become increasingly common for emergency intubations [1–5]. Previous research has evaluated the performance of the GVL, comparing it to other intubation devices, including the direct laryngoscope (DL) [2, 3, 6, 7]. Some of these studies have shown very little difference in first pass success of the GVL compared to DL [6, 7]. A major limitation of these studies is that they were performed either shortly after the introduction of the GVL into clinical practice at the study institution or with minimal training of the study participants. The GVL, a novel device, was compared to DL, a familiar device that has been used for many years. It remains unknown if there is any improvement in first pass success with the GVL over time with continued use and experience. The goal of this study was to evaluate the first

pass success of the GVL over a seven-year period in an academic emergency department (ED).

Materials and methods

Study design

This was an analysis of prospectively collected data on 668 emergency intubations performed with the GVL over 7 years from July 1, 2007–June 30, 2014 at an academic ED. This project was granted exemption from informed consent requirements by the University's Institutional Review Board (IRB) prior to conducting the study.

Study setting and population

The study was conducted at an academic ED/Level 1 trauma center that currently sees 70,000 patients annually. This institution is home to a three-year emergency medicine (EM) residency training program with an average class size of 15 residents as well as a 5-year combined emergency medicine/pediatrics (EM/Peds) residency program with an average class size of three residents. This academic institution is affiliated with a second university hospital that has an EM residency program with a class size of six residents, and EM residents from this program also rotate in our ED. Residents in all three programs were categorized as EM residents, and were included in the study.

EM residents undergo formal training with the GVL, which includes both didactic and simulation laboratory experience. The residents are instructed to turn on the GlideScope at least 2 min prior to intubation to activate the anti-fog mechanism. They are strongly encouraged to use the GlideRite® rigid stylet (GlideRite) which has been shown to improve intubation success in the emergency setting [8]. The "four-step technique", recommended by the manufacturer, is taught to the residents. First, the operator looks into the patient's mouth and inserts the GVL blade in the midline. Second, the video monitor is used to navigate to and displace the epiglottis to achieve a view of the larynx, taking care not to insert the blade too deeply. Third, looking into the patient's mouth (not at the screen), the tracheal tube is inserted and advanced until the distal tip of the tube appears on the video monitor. Fourth, using the video monitor, the tube is directed to the glottic inlet. After the tube is passed beyond the vocal cords, residents are encouraged to withdraw the stylet several centimeters to facilitate advancement of the tube down the trachea [9].

For the duration of the study, this ED contained between two and four separate GVL units. The standard reusable blade is the most common and most effective GVL blade, and only intubations using this blade were included in this study [10]. Less commonly used GVL blades were excluded (GlideScope® AVL Single Use, GlideScope® Ranger, GlideScope® Direct, and GlideScope® Groove). The EM resident, in conjunction with the EM attending, made all decisions regarding the method and device used prior to each intubation.

Data were collected on all patients intubated in the ED. Only adult patients (18 years or older) intubated by EM residents using the standard GVL as the initial device were included in this study.

Study protocol

Data were collected on each intubation via continuous quality improvement (CQI) forms. EM residents completed a CQI form that included important information regarding the patient, operator, and procedure. These data included patient demographics, difficult airway characteristics (DACs), method and drugs used, device used, reason for device selection, type of stylet used, Cormack–Lehane (CL) view, number of intubation attempts and outcome of each attempt.

DACs include cervical immobility, facial or neck trauma, airway edema, small mandible, obesity, short neck, large tongue, restricted mouth opening, and blood or vomit in the airway. An intubation attempt was defined as the insertion of the GVL blade into the mouth of the patient, regardless of whether an attempt was made to pass a tracheal tube. Methods of intubation included rapid sequence intubation (RSI) in which a paralytic agent was used, awake intubation in which only a sedative agent was used (OTI SED), and intubation without the use of any pharmacologic agents (OTI No Drugs).

The primary outcome measured in this study was the first pass success of the GVL in each academic year. First pass success was defined as the successful placement of a tracheal tube on a single blade insertion. The secondary outcome measured was the Cormack–Lehane view of the airway. An additional secondary outcome was overall success which was defined as success with the GVL regardless of the number of attempts.

The senior author reviewed all data forms for completion as they were collected, and if any forms were incomplete, the EM resident was interviewed to obtain the missing information. Forms were cross referenced with professional billing records, pharmacy records and a customized intubation report in the electronic medical record to identify any intubations where a form was not received. If an intubation was identified where a form was not received, then the resident was given a form to complete.

Data analysis

Patient and intubation characteristics are presented descriptively. Continuous variables were reported as means, and categorical variables were reported as percentages. 95 % confidence intervals (CI) calculated using the "exact" method were included for categorical data. The proportion of cases with first pass success was reported as a percentage for each academic year. A logistic regression model was used to determine the association between academic year and first pass success. The model accounted for clustering by provider. The primary predictor of interest was academic year, categorized as years one through seven, and included in the model as an ordinal variable. Based on previous investigations, the following confounders were selected a priori and included in each model: reason for intubation (cardiac arrest vs. non-cardiac arrest) and number of difficult airway characteristics (included as an ordinal variable), operator level of training, and type of stylet used. [5, 10] These variables have been shown to be significantly associated with first pass success. Also, after noting imbalances in patient characteristics over time, trauma status was also included in the model. All statistical analyses were performed with STATA version 13 (College Station, Texas).

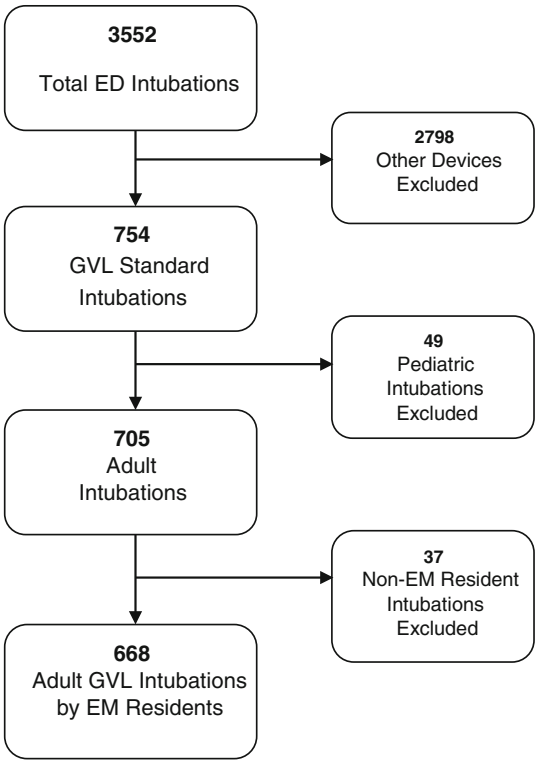

Fig. 1 Flow chart of patients in study

Results

Over the seven-year study period, 3,552 intubations were performed in the ED. After excluding intubations performed with devices other than the standard GVL, pediatric intubations, and intubations not performed by EM residents, a cohort of 668 intubations were included in our study (Fig. 1). The characteristics of the GVL intubations in year one and year seven are presented in Table 1. In year one, 77.8 % of patients intubated with the GVL were trauma patients, while 40.3 % of patients intubated with the GVL in year seven were trauma patients. Additionally, in year one, 62.2 % of operators selected the GVL because of a difficult airway, whereas in year seven, the GVL was chosen for this reason in 43.2 % of the intubations. The GlideRite stylet was used in 63.3 % of the cases in the first year of the study, and in 89.9 % of the cases in the final year. In year one, the GVL was used for 22.6 % (90/398) of all ED intubations, and in year 7, it was used for 27.2 % (139/512) of all ED intubations.

In year one, first pass success was 75.6 % (68/90; 95 % CI 65.4–84.0 %,) and in year seven, first pass success was 92.1 % (128/139; 95 % CI 86.3–96.0) (Fig. 2). In the first year of the study, the percentage of patients with CL I/II views was 95.6 % (86/90; 95 % CI 89.0–98.8 %), and in the seventh year of the study, the percentage of patients with CL I/II views was 94.2 % (131/139; 95 % CI 89.0–97.5 %) (Table 2). The overall success with the GVL increased from 84.4 % (76/90; 95 % CI 75.3–91.2 %) to 97.8 % (136/139; 95 % CI 93.8–99.6 %) between years one and seven (Table 2).

In the logistic regression model, the adjusted odds ratio (aOR) of first pass success increased over the seven-year period (aOR 3.1; 95 % CI 1.4–7.1; $p = 0.008$) (Table 3).

Discussion

Over the seven-year period that the GVL was used in our ED, first pass success improved from 75.6 % in the first academic year to 92.1 % in the seventh academic year. Interestingly, the proportion of patients in which a good CL view (I/II) was obtained with the GVL remained constant over this entire time period.

Operators using the GVL were able to consistently obtain good CL views, suggesting that they were able to visualize the glottic opening, but were unable to successfully complete the intubation because they had difficulty maneuvering the tracheal tube to the glottic inlet [11]. Prior studies have demonstrated that using the GVL results in uniformly excellent views of the glottis, but this does not necessarily correlate with intubation success [2, 12, 13]. The steep curvature of the GVL blade allows easy

Table 1 Demographics of GVL intubations Year 1 vs. Year 7

Patient characteristics	Year 1 ($n = 90$)		Year 7 ($n = 139$)	
	% (n)	95 % CI*	% (n)	95 % CI*
Age	43.7 (range 18–93)	39.8–47.5	52.6 (range 18–95)	49.3–55.8
Sex (male)	73.3 (66)	63.0–82.1	64.0 (89)	55.8–71.5
Trauma status				
Trauma	77.8 (70)	67.8–85.9	40.3 (56)	32.1–48.9
Difficult airway characteristics				
DAC = 0	16.7 (15)	9.6–26.0	29.5 (41)	22.1–37.8
DAC = 1	25.6 (23)	16.9–35.8	27.3 (38)	20.1–35.5
DAC ≥ 2	57.8 (52)	46.9–68.1	43.2 (60)	34.8–51.8
Operator PGY				
PGY-1	13.3 (12)	7.1–22.1	17.3 (24)	11.4–24.6
PGY-2	32.2 (29)	22.8–42.9	28.8 (40)	21.4–37.1
PGY-3,4,5	54.4 (49)	43.6–65.0	54.0 (75)	45.3–62.4
Reason for intubation				
Airway	62.2 (56)	51.4–72.2	58.7 (81)	49.6–66.6
Respiratory failure	15.6 (14)	8.8–24.7	18.0 (25)	12.0–25.4
Patient control	11.1 (10)	5.5–19.5	6.5 (9)	3.0–11.9
Hypoxia	2.2 (2)	0.3–7.8	0 (0)	N/A
Cardiac arrest	8.9 (8)	3.9–16.8	17.3 (24)	11.4–24.6
Reason for device				
Standard	31.1 (28)	21.8–41.7	49.6 (69)	41.1–58.2
Difficult	62.2 (56)	51.4–72.2	43.2 (60)	34.8–51.8
Education	6.7 (6)	2.5–14.0	7.2 (10)	3.5–12.8
Method/drugs				
RSI	88.9 (80)	80.5–94.5	81.3 (113)	73.8–87.4
Rocuronium	51.1 (46	40.4–61.8	41.0 (57)	32.7–49.7
Succinylcholine	37.8 (34)	27.8–48.6	40.3 (56)	32.1–48.9
Etomidate	82.2 (74)	72.7–89.5	75.5 (105)	67.5–82.5
Stylet used				
GlideRite stylet	63.3 (57)	52.5–73.3	89.9 (125)	83.7–94.4
Usage				
% of all ED intubations	22.6 (90)	18.6–27.0	27.2 (139)	23.3–31.2

* 95 % confidence intervals calculated using the "exact" method

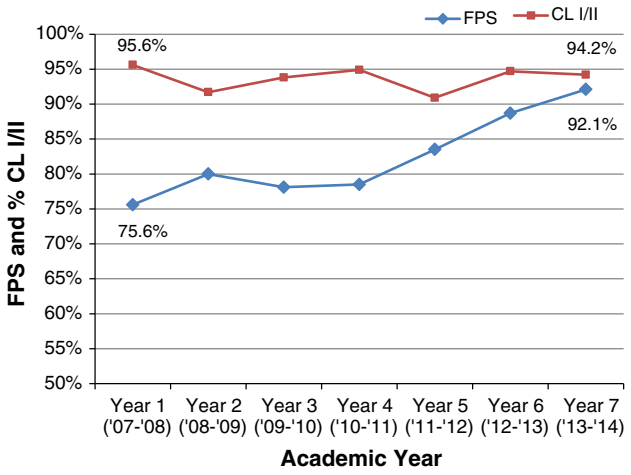

Fig. 2 GVL first pass success (FPS) and Cormack–Lehane (CL) view over 7 years

visualization of the vocal cords, but this shape requires that the operator navigate the tube along this steep curvature up toward the glottic opening (Fig. 3). This is in contrast to direct laryngoscopes where there is an essentially straight path to the airway, thus making delivery of the tube to the glottic inlet easier. The increase in first pass success over the study period with no change in the quality of the CL view suggests that operators became more skilled at delivering the tube to the glottic inlet.

Over the seven-year period, operators became better at intubation. However, these resident operators are not the same over the seven years. Different residents entered and left the program over the entire study period, so no academic year had the exact same population of residents. Therefore, the improvement in tube delivery must be secondary to institutional improvement rather than individual

Table 2 GVL performance Year 1 vs. Year 7

	Year 1 ($n = 90$)		Year 7 ($n = 139$)	
	% (n)	95 % CI	% (n)	95 % CI
First pass success	75.6 (68)	65.4–84.0	92.1 (128)	86.3–96.0
CL view I/II	95.6 (86)	89.0–98.8	94.2 (131)	89.0–97.5
Overall success	84.4 (76)	75.3–91.2	97.8 (136)	93.8–99.6

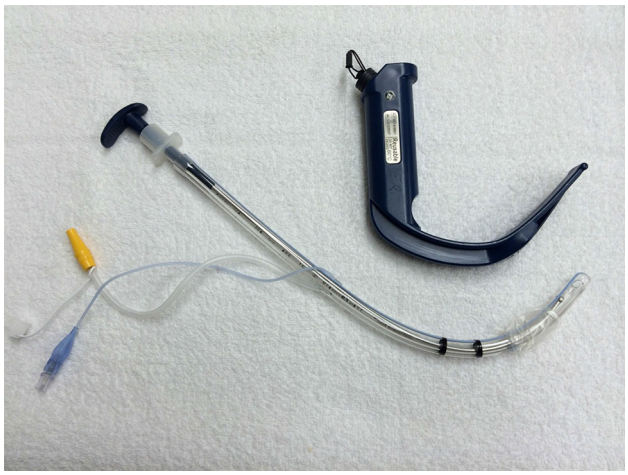

Fig. 3 GVL and tracheal tube loaded with GlideRite stylet

Table 3 Logistic-regression model for improvement in first pass success

Variable	Adjusted odds ratio (aOR)	95 % CI	P value
Reason for intubation			
Non-cardiac arrest	Reference		
Cardiac arrest	0.26	0.14–0.46	<0.001
Trauma status			
Medical	Reference		
Trauma	1.27	0.75–2.15	0.367
Difficult airway characteristics	0.74	0.63–0.87	<0.001
Stylet			
Standard	Reference		
GlideRite	2.78	1.73–4.46	<0.001
Operator PGY			
PGY 1	Reference		
PGY 2	1.96	1.13–3.39	0.016
PGY 3,4,5	3.07	1.59–5.94	0.001
Academic year	3.08[a]	1.34–7.09	0.008

Model clustered by provider

[a] aOR per 7 year change

operator improvement. It is possible that because the attending physicians who have joined the faculty most recently received extensive GVL training during their own residency, thus they are better able to train and supervise residents with the GVL. This is in contrast to the attending population at the beginning of the study, who had received minimal if any GVL training during their own residency because GVL was not widely available then. Additionally, over the study period, there has been increasing use of video laryngoscopes (VL) in our ED. For example, in 2009 the C-MAC was introduced in our ED, and has been used with increasing frequency since then. Exposure to these other video laryngoscopes may augment the overall VL skills of the residents, contributing to the increased success seen with GVL.

The first pass success of the GVL that we observed in the first year of our study is similar to that of other studies. For example, Platts-Mills et al. find the first pass success of the GVL in the ED to be 81 % [6]. This study was performed after only a brief training period with the GVL. Similarly, Yeatts et al. found the first pass success of the GVL in their trauma center to be 80 %, and this study was also conducted after limited clinical experience with the GVL [7]. In contrast, we observed in the seventh year of our study a first pass success of the GVL of 92 %. This demonstrates that with continued use and clinical experience, the first pass success of the GVL increases substantially.

There are several important differences in the procedure and patient characteristics between the first and seventh years of the study. It appears that at the beginning of the study period when the GVL was a newer device, operators often elected to use it to intubate patients with more difficult airways. By the end of the study period, operators appeared to expand the device usage to more routine airways (Table 1). This suggests that when the GVL was a newer device, it was viewed as a device to be used in difficult intubations, but over time it became more accepted for use in routine airways. This trend of expanded use could perhaps account for some of the improvement in first pass success observed over the seven-year period. It is also likely that the operator's definition of a difficult airway may have evolved over time in our ED. As they became more comfortable with video laryngoscopy, it is possible that the threshold for what they considered a difficult airway increased. For example, a patient in C-spine immobilization previously may have been considered a difficult airway when the operator had limited GVL experience, but currently might be considered a routine airway as the operators are more comfortable with the GVL. We attempted to control for these potential confounders using a multivariate logistic regression model (Table 3). After controlling for confounders, we still found that there was a

significant improvement in first pass success between years one and seven.

This study has several limitations. This was an observational study, and thus lacks the benefits of a randomized controlled trial. There could be operator bias with regard to device selection based on the predicted difficulty of the intubation or based on operator preference. Another limitation is the use of self-reported data. The operator filled out the data form after the procedure, so it is possible that information was reported inaccurately, or that certain events were underreported. Also, this study was conducted at a single institution with extensive training and experience with video laryngoscopy. Thus, these results may not be generalizable to all other ED settings.

In conclusion, over the seven-year period of the study, there was considerable improvement in the first pass success with GVL in our ED. During this time period, CL view achieved with the GVL remained constant. This suggests that over time, improvement in the skill of tube delivery was responsible for the increase in first pass success.

Conflict of interest We have no conflict of interest to report.

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