Use of the GlideScope Ranger Video Laryngoscope for Emergency Intubation in the Prehospital Setting: A Randomized Control Trial

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Objectives: We sought to assess whether the GlideScope Ranger video laryngoscope may be a reliable alternative to direct laryngoscopy in the prehospital setting.

Design: Multicenter, prospective, randomized, control trial with patient recruitment over 18 months.

Setting: Four study centers operating physician-staffed rescue helicopters or ground units in Austria and Norway.

Patients: Adult emergency patients requiring endotracheal intubation.

Interventions: Airway management strictly following a prehospital algorithm. First and second intubation attempt employing GlideScope or direct laryngoscopy as randomized; third attempt crossover. After three failed intubation attempts, immediate use of an extraglottic airway device.

Measurements and Main Results: A total of 326 patients were enrolled. Success rate with the GlideScope ($n = 168$) versus direct laryngoscopy ($n = 158$) group was 61.9% (104/168) versus 96.2% (152/158), respectively ($p < 0.001$). The main reasons for failed GlideScope intubation were failure to advance the tube into the larynx or trachea (26/168 vs 0/158; $p < 0.001$) and/or impaired sight due to blood or fluids (21/168 vs 3/158; $p < 0.001$). When GlideScope intubation failed, direct laryngoscopy was successful in 61 of 64 patients (95.3%), whereas GlideScope enabled intubation in four of six cases (66.7%) where direct laryngoscopy failed ($p = 0.055$). In addition, GlideScope was prone to impaired visualization of the monitor because of ambient light (29/168; 17.3%). There was no correlation between success rates and body mass index, age, indication for airway management, or experience of the physicians, respectively.

Conclusions: Video laryngoscopy is an established tool in difficult airway management, but our results shed light on the specific problems in the emergency medical service setting. Prehospital use of the GlideScope was associated with some major problems, thus resulting in a lower intubation success rate when compared with direct laryngoscopy. (*Crit Care Med* 2016; XX:00–00)

Key Words: airway management; direct laryngoscopy; emergency care; prehospital endotracheal intubation; randomized control trial; video laryngoscopy

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Supported, in part, by Sanova Medical Systems, Vienna, Austria, providing the GlideScope Ranger and single-use blades for the study.

Dr. Voelckel disclosed other support from Sanova Medical Systems, Vienna, Austria, providing the GlideScope Ranger and single-use blades for the study. The remaining authors have disclosed that they do not have any potential conflicts of interest.

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DOI: 10.1097/CCM.0000000000001669

Appropriate airway management is key in emergency medicine in order to assure oxygenation and ventilation and to minimize potential risks (1, 2). Given the fact that the absolute number of patients requiring intubation is low (3) but circumstances are often difficult (4), the impact on outcome is presumably more determined by the operator's proficiency than by the tools employed (5). Nevertheless, devices or techniques developed to facilitate endotracheal intubation merit consideration and evaluation in the prehospital setting. Presently, video laryngoscopy is considered to be the most effective alternative to direct laryngoscopy when a difficult airway is recognized (6).

In-hospital studies demonstrated that the use of the GlideScope video laryngoscope (Verathon, Bothell, WA) enabled visualization of the glottis and subsequently intubation in both expected and unexpected difficult airway scenarios when direct laryngoscopy failed (7). In the hands of

inexperienced airway providers, namely, critical care fellows, primary success rates were 74% with the GlideScope (Verathon) versus 40% with direct laryngoscopy (8). Despite improved glottic visualization, there was no difference between GlideScope (Verathon) and direct laryngoscopy in the time needed to correctly position the endotracheal tube when first- to third-year nonanesthesiology residents were in charge (9). This may, in part, be explained by the fact that visualization of the glottis as judged by the Cormack-Lehane score is significantly better during video laryngoscopy versus direct laryngoscopy, but manipulation of the endotracheal tube can be challenging (10–12). Finally, in a review comprising 17 studies enrolling 1,998 patients, the advantage of video laryngoscopy was even more pronounced when the airway was defined as difficult or when operators were less qualified (13).

In the prehospital setting, helicopter emergency medical service (HEMS) physicians successfully managed failed direct laryngoscopy with the GlideScope (Verathon) (14) or the video laryngoscope (C-Mac, Karl Storz, Tuttlingen, Germany) (15, 16). However, randomized prehospital control trials addressing video laryngoscopy versus direct laryngoscopy are spare and limited to a single study in cardiac arrest patients. Interestingly, Arima et al (17) found the Pentax Airway Scope (AWS; Pentax Corporation, Tokyo, Japan) not to be superior to direct laryngoscopy in relation to the first or ultimate success rates or difficult level intubation. To our knowledge, the GlideScope Ranger video laryngoscope (Verathon), which has been designed for field use, has not been evaluated in the prehospital environment.

Thus, we sought to perform a prospective randomized control trial comparing the GlideScope Ranger (Verathon) with direct laryngoscopy in emergency patients requiring emergency endotracheal intubation in the field. The hypothesis of this multicenter study was that in the hands of experienced EMS physicians, GlideScope (Verathon) success rates should be equal or higher when compared with conventional direct laryngoscopy intubation.

METHODS

Following the approval of the Ethics Committee of the State of Lower Austria, this prospective randomized controlled multicenter trial was performed from April 2011 to September 2012 in three different, physician-staffed EMS systems operating either a rapid response car (Mistelbach, Austria), a rescue helicopter (Ålesund, Norway), or both (Wiener Neustadt, Austria). Average experience of EMS physicians in anesthesiology was 7 years (0.5–24 yr) after finalizing 3 years of basic postgraduate medical education. Thus, minimum clinical experience was 3.5 years. Prior to the study, physicians underwent a 2 hours of GlideScope (Verathon) training program comprising a basic lecture, technical instruction, and manikin training in various EMS relevant scenarios, such as floor positioning. This was followed by supervised GlideScope (Verathon)–guided intubations (average, five cases) in the operating room. During the entire study period, standard airway management manikins were accessible at the HEMS and ground unit base, and EMS personnel could elect to participate in ongoing manikin training. Training was judged sufficient when GlideScope manikin intubation was successful in five consecutive attempts, and clinical supervisors noted correct handling in patients.

Emergency patients more than 18 years old requiring prehospital airway management were enrolled and randomly subjected to endotracheal intubation employing the GlideScope Ranger single use video laryngoscope (Verathon) or conventional direct laryngoscopy (**Fig. 1**). Strict adherence to an airway management algorithm was mandatory. In order to guarantee the safety of study patients, preoxygenation employing the bag mask valve (AMBU, Bad Nauheim, Germany) was compulsory, and EMS technicians monitored oxygen saturation (Spo_2) and prompted disruption of airway manipulation when Spo_2 levels neared 90%. As outlined in the algorithm, only two attempts were allowed with the randomized technique. Accordingly, if the second GlideScope intubation attempt was not successful or had to be disrupted, airway providers had to perform one direct laryngoscopy attempt after ensuring appropriate oxygenation of the patient. Vice versa, failure of direct laryngoscopy prompted one GlideScope (Verathon) attempt. When the endotracheal airway could not be established after the third attempt, a Fastrach laryngeal mask (Teleflex Medical Europe, Athlone, Republic of Ireland) had to be employed according to our EMS difficult airway algorithm. In cardiopulmonary resuscitation (CPR) patients, intubation was attempted without sedative drugs; in all other cases, anesthesia was induced with etomidate or ketamine and supplemented with fentanil and midazolam as needed. For muscle relaxation, succinylchloride was administered as appropriate by choice of the physicians. Patients had an equal probability of assignment to the groups in both ground EMS and HEMS. The randomization code was developed using a computer random number generator. After identification of a patient at need for intubation, an envelope was opened by the emergency medical technician and physicians subsequently performed airway management as herein randomly defined. The primary endpoint was successful establishment of an endotracheal airway. Secondary endpoints were the time elapsed between opening of the mouth until successful glottis passage of the tube and time until first end-tidal Co_2 measurement.

Based on the assumption that endotracheal intubation success rate in the field should be 95% with direct laryngoscopy (18) and on literature suggesting some 78% success with the GlideScope video laryngoscope (Verathon) (19, 20), we calculated the sample size with a dropout of 20% of events for any reason in order to detect a significant difference between groups by chi-square test with a significance level of p value equal to 0.01 and a power of 90%. This resulted in 154 patients per group. Besides descriptive statistics, statistical analysis was performed using SPSS (release 20.0, 2011; Chicago). Normal distribution of all linear data has been proven by Kolmogorov-Smirnov test. Mann-Whitney U test, chi-square test, and Fisher exact test were used to detect significant differences among groups investigating primary and secondary endpoints, as appropriate. Correlation between body mass index, intubation times, and number of intubation attempts was performed by Pearson correlation test. The association of the success rate and intubation times with influencing factors (body mass index and age) was assessed using logistic regression analysis. Linear regression analysis has

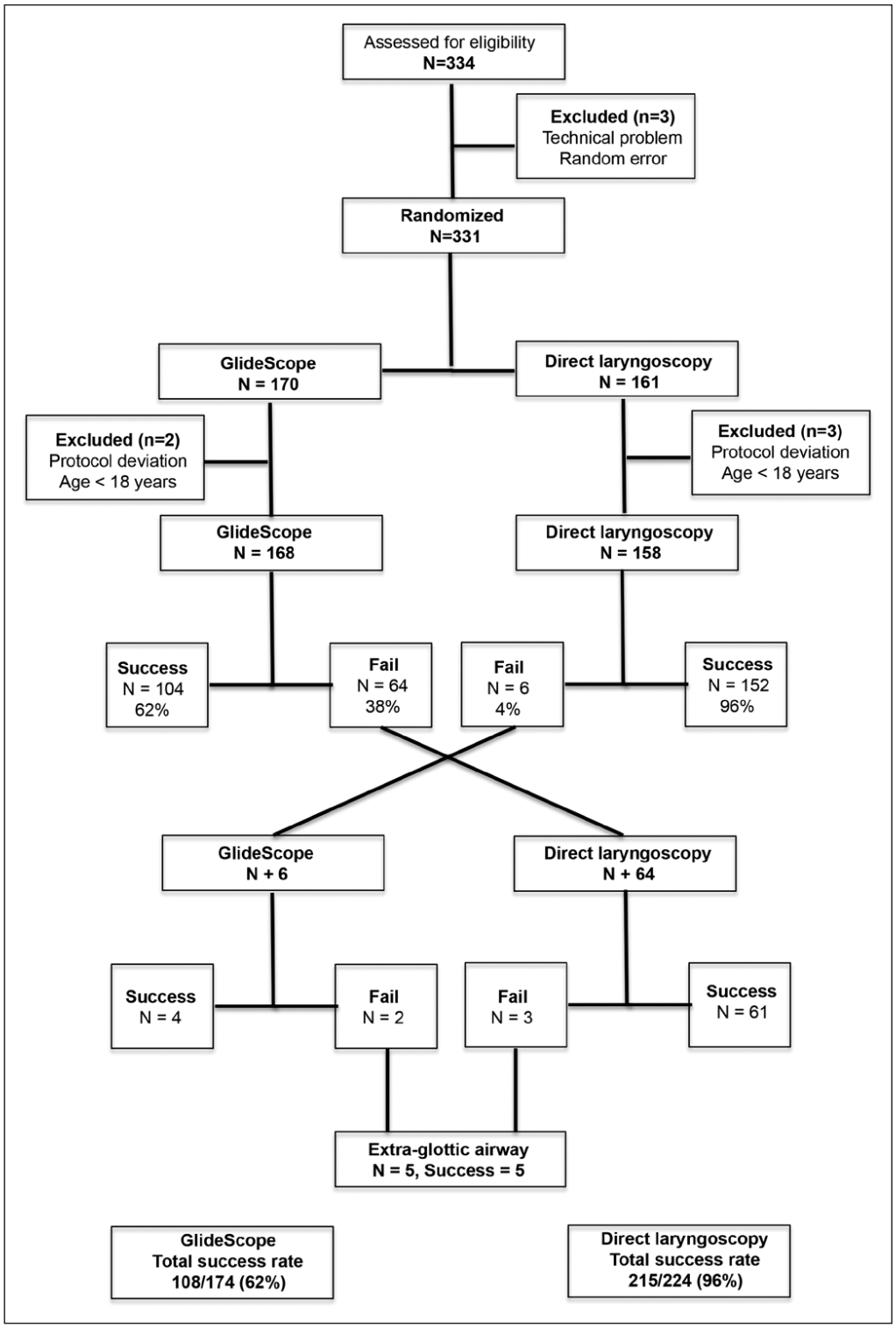

Figure 1. Enrollment and flow of the study.

been used for evaluating the association of intubation times with potential influencing factors. A p value of 0.01 was deemed to be statistically significant throughout the study.

RESULTS

A total of 331 patients were enrolled in the study (**Fig. 2**). Five patients had to be excluded because of a protocol deviation or the false assumption that patients were more than 18 years old. No differences in the demographic variables, National Advisory Committee for Aeronautics score, Glasgow Coma Scale, and indication for endotracheal intubation were observed between groups (**Table 1**). The primary success rate of endotracheal intubation with the GlideScope Ranger (Verathon) versus direct laryngoscopy was 104 of 168 (61.9%) versus 152 of 158 (96.2%), respectively ($p < 0.001$). There was no correlation between success rates and body mass index, age, or indication for airway management, respectively. In 61 of 64 patients (95.3%) with failed GlideScope intubation, direct laryngoscopy intubation was successful. In all three cases of failed direct laryngoscopy, the airway could be secured by insertion of the Fastrach (Teleflex Medical Europe) (Fig. 1). GlideScope (Verathon) was successful in 4 of 6 cases (66.7%) after failed direct laryngoscopy. The remaining two patients underwent successful airway management with the Fastrach (Teleflex Medical Europe). Problems noted during airway management are outlined in **Table 2**.

Median times until endotracheal intubation tended to be longer in patients intubated with the GlideScope (Verathon) (21 vs 14 s; $p = 0.015$) (**Table 3**). Because of the 10-fold higher change rate from GlideScope (Verathon) to direct laryngoscopy (66 vs 6), the mean number of GlideScope (Verathon) versus direct laryngoscopy attempts was also higher (1.5 ± 0.6 vs 1.2 ± 0.5; $p < 0.001$) (Table 3). Interestingly, visualization of the glottis according to Cormack and Lehane employing the GlideScope (Verathon) was judged not to be as good as in direct laryngoscopy attempts (2.0 ± 1.7 vs 1.5 ± 0.9; $p = 0.2$) The reasons for failed GlideScope intubation prompting the change to direct laryngoscopy according

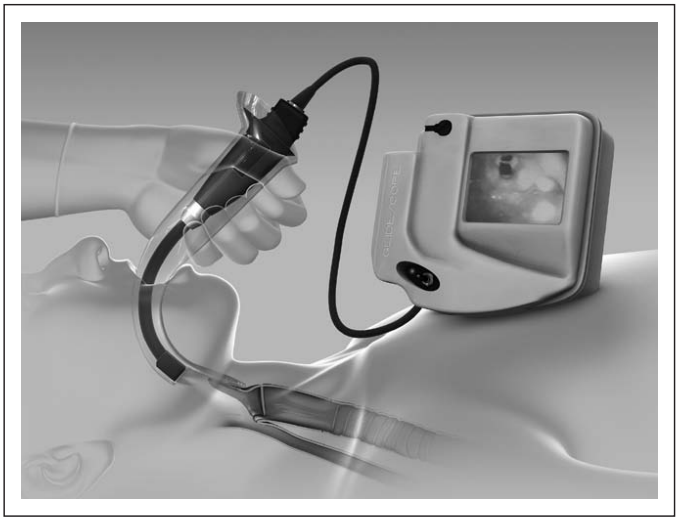

Figure 2. Schematic drawing of the GlideScope intubation technique.

to protocol are further outlined in **Table 4**. The major problems were related to tube manipulation and impaired visualization of the anatomic structure because of fluids or blood and impaired reading of the monitor in bright ambient light. In two of six direct laryngoscopy patients (33.3%), blood and fluids were also reported in combination with anatomic problems. However, after suctioning, GlideScope intubation was successful. Interestingly, because ambient light was judged to be one of the major obstacles for GlideScope intubation success, this phenomenon was not reported at the Norwegian study site enrolling 12 GlideScope (Verathon, Bothell, WA) and 16 direct laryngoscopy cases with an outdoor airway management occurrence rate of 14.3% (4/28). This may be because of the fact that Norwegian numbers were small and airway management was predominantly indoor. The overall incidence of GlideScope (Verathon) versus direct laryngoscopy field intubation was 24.4% (41/168) versus 22.8% (36/158), respectively. Bright ambient was not reported to limit direct laryngoscopy success.

DISCUSSION

In this prospective randomized multicenter control trial, prehospital endotracheal intubation employing the GlideScope Ranger (Verathon) was less successful when compared with direct laryngoscopy (61.9% vs 96.2%; $p < 0.001$). Two major problems were identified to negatively affect GlideScope intubation success: first, failure to advance the tube toward the larynx and trachea despite adequate visualization of the airway; and second, insufficient delineation of the anatomic structures when blood or fluids were an issue or when bright ambient light impaired the view on the screen. Thus, despite prestudy manikin and additional operating room training, emergency physicians were not able to take advantage of video laryngoscopy under EMS conditions.

Airway management in the field is a major challenge, and multiple publications shed light on shortcomings associated with out-of-hospital endotracheal intubation (2). It is recognized that repeated intubation attempts may contribute to patient morbidity. Mort (1) noted a significant increase in the rate of airway-related complications when more than two attempts were needed, causing hypoxemia, aspiration of gastric contents, and cardiac failure. Thus, the primary task of the paramedic supporting the physician in our study was to command immediate interruption of the intubation attempt in favor of bag mask valve oxygenation when Spo_2 declined to 90%. In CPR patients with insufficient Spo_2 reading, the time allowed for the first intubation attempt was limited to 30 seconds. In addition, not more than two attempts were tolerated with either technique (GlideScope vs direct laryngoscopy). With this approach, 99.7% (325/326 patients) of all patients

TABLE 1. Demographic Data and Indication for Endotracheal Intubation

Patients' Characteristics	Direct Laryngoscopy *n* = 158	GlideScope *n* = 168	*p*
Age (yr)	64 (18–100)	68 (18–93)	0.33
Body mass index (kg/m^2)	26.2 (18–51)	26.3 (17–55)	0.69
Gender (male/female)	104/54	106/62	0.64
National Advisory Committee for Aeronautics score[a]	6 (4–7)	6 (4–7)	0.58
Glasgow Coma Scale	3 (3–15)	3 (3–15)	0.77
Cardiopulmonary resuscitation	102	104	0.65
Impaired consciousness	26	17	0.10
Respiratory insufficiency	10	7	0.46
Brain trauma	11	18	0.25
Multiple trauma	8	19	0.05
Other trauma	1	3	0.62

[a]National Advisory Committee for Aeronautics Scoring System for severity of emergencies (0 = no injury; 7 = lethal injury).
Data are presented as median and range or numbers.

TABLE 2. Problems Occurring During Airway Management

	Direct Laryngoscopy *n* = 158	GlideScope *n* = 168	*p*
No. of patients with intubation problems	48	98	< 0.0001
Impaired mouth opening	6	4	0.531
Narrow pharynx	4	5	1.00
Impaired sight due to blood or fluids	39	34	0.406
Impaired sight due to fogged camera	0	9	0.0036
Impaired monitor visibility (ambient light)	0	29	< 0.0001
Advancing the tube to the larynx	3	31	< 0.0001
Advancing the tube into the trachea	3	16	0.0036
Esophageal intubation	4	3	0.716
Total observed problems[a]	59	131	< 0.0001

[a]Multiple observations per patient possible.
Data are presented as numbers.

TABLE 3. Median and Range Time Intervals (Seconds) From Mouth Opening to Correct Tube Positioning and First End-Tidal Co_2 Reading

	Direct Laryngoscopy *n* = 158	GlideScope *n* = 168	*p*
Time until tube positioning (s)	14 (3–250)	21 (3–360)	0.015
Time until first end-tidal CO_2 reading (s)	120.3 ± 243	96.9 ± 79	0.72
No. of attempts	1.2 ± 1	1.5 ± 1	0.001

TABLE 4. Reasons to Change From the Randomized Technique After the Second Failed Attempt

	Direct Laryngoscopy *n* = 158	GlideScope *n* = 168	*p*
No. of patients requiring crossover	6	64	< 0.0001
Impaired mouth opening	4	4	1.0
Narrow pharynx	3	3	1.0
Impaired sight due to blood or fluids	3	21	0.0002
Impaired sight due to fogged camera	0	6	0.030
Impaired monitor visibility (ambient light)	0	22	< 0.0001
Advancing the tube to the larynx	0	18	< 0.0001
Advancing the tube into the trachea	0	8	0.007
Esophageal intubation	2	2	1.0
Total observed problems[a]	12	84	< 0.0001

[a]Multiple observations per patient possible.
Data are presented as numbers.

were successfully intubated after the third attempt, and severe complications, such as unrecognized esophageal intubation or cardiac events, were not observed.

Nevertheless, the likelihood of difficult intubation outside the hospital is considerably high and considered to be around 13% (21). In our trial, first attempt direct laryngoscopy intubation also failed in 13.9% (22/158), which is comparable with some 14.5% observed in an international multicenter observational study (22). We speculate that two main reasons may account for this observation: first, the airway providers

proficiency; and second, typical prehospital airway management problems, such as unexpected anatomic findings, blood or fluids in the upper airway, and specific environmental issues (4). In a Cochrane review by Lecky et al (5), the skill level of the operator was judged to be key in determining efficacy of endotracheal intubation. Depending on the EMS program, the necessity of advanced airway management might be as low as 3% (3). Even in physician-based ground and air rescue systems, airway interventions do not exceed 8–16% of all missions (22, 23), a number still too low for adequate training and maintenance of intubation skills. Accordingly, the search for devices, which may facilitate endotracheal intubation even for the inexperienced provider, is ongoing. In this regard, video laryngoscopes were found to provide a great visualization of the glottis (10) and to improve endotracheal intubation success rates (24).

The GlideScope video laryngoscope (Verathon) has been evaluated in manikin studies (19,20,25), the operating room (7, 26, 27), emergency departments (28), and ICUs (9, 18). There is evidence that especially subjects at higher risk of a difficult airway benefit from GlideScope-assisted intubation (26, 29, 30). Unfortunately, randomized prehospital control trials evaluating the potential benefits of video laryngoscopy in the prehospital setting are still spare, and our results underscore that extrapolation of putative convincing manikin or in-hospital findings into the EMS world is difficult. Employing a similar study design, we recently found that intubation success rates with the Airtraq (Prodol Meditec, Vizcaya, Spain), a fiber optic-like intubation device, were unacceptably low when used by EMS physicians (31). The main reasons for the Airtraq shortcoming were handling failures, impaired visibility because of fluids, and technical problems associated with endotracheal tube manipulation. The same major problems account for the limited GlideScope (Verathon) success rate of 61.9%. Interestingly, visualization of the glottis according to Cormack and Lehane was scored worse in the GlideScope (Verathon) group when compared with direct laryngoscopy (2.0 ± 1.7 vs 1.5 ± 0.9; not significant). This observation is confirmed by the findings from an analysis of more than 2,000 GlideScope intubations, documenting an overall GlideScope intubation success rate of 97%. When GlideScope (Verathon) failed in 60 of 2,004 cases as primary or rescue technique, visualization of the glottis was insufficient in 65%. Further predictors of failed GlideScope intubation were neck anatomy, thyromental distance less than 6 cm, impaired cervical motion, and the clinical institution participating in the trial (7). In our study, physicians had problems to direct and advance the tube, which was armed with a rigid stylus, toward the larynx or trachea in 27% (47/168). This phenomenon is well known and described as a typical GlideScope intubation problem, which may be overcome with improved handling, such as shifting the blade to the left, backing up, holding the tube more proximally, and retracting the stylet as soon as the vocal cords are passed (12). Accordingly, there is strong evidence that expertise in video laryngoscopy requires prolonged training and practice, and a minimum of 76 attempts are considered necessary to achieve proficiency (32, 33). The disappointing GlideScope (Verathon) performance in our study is a clear indicator that the learning process has just begun. Unfortunately, manikin training suggested competence in video laryngoscopy, which was not fortified with sufficient clinical experience. In addition, literature suggesting that the GlideScope (Verathon) might be a helpful tool to improve success rates of inexperienced providers must be interpreted with caution (34). By contrast, the 96% success rate of direct laryngoscopy in our EMS setting is a clear indicator for rigorous training, comprising at least 80 supervised endotracheal intubations in the operating room per year. In addition, in patients successfully intubated with the GlideScope (Verathon), time until correct endotracheal tube placement tended to be longer when compared with direct laryngoscopy (21 vs 14 s; $p = 0.015$). This confirms the findings by Yeatts et al (35) evaluating video laryngoscopy–guided airway management in the emergency room of an urban hospital. In the latter study, median intubation time in GlideScope-intubated patients was significantly longer when compared with direct laryngoscopy and a greater incidence of low oxygen saturation ($Sa{O_2}$ < 80%) had to be noted. We did not observe this higher incidence of $Sa{O_2}$ with the video laryngoscope (Karl Storz), probably because of our rigorous $Sp{O_2}$ monitoring and subsequent limitation of the time granted for intubation.

Interestingly, impaired visualization of the monitor because of ambient light was an issue forcing to quit the GlideScope intubation attempt in 17.3% (29/168). This is in part surprising because direct laryngoscopy in a sunny environment is known to be difficult and must frequently be solved by pulling a blanket over the rescuer and the patient. However, there might be room for technical improvement. Finally, fluids and blood in the oral cavity or larynx require immediate suctioning in order to enable visualization of the anatomic structures in both video and direct laryngoscopy. This is a recognized limitation of video-assisted intubation devices and noted in 21 cases (12.5%) in our study as is fogging of the camera, which occurred in an additional six cases. Occurrence of the latter problem should be minimized by the inbuilt Reveal (Verathon) "antifogging" feature with a rapid heating profile (36) but was still observed in our study.

Some limitations of the study should be noted. Our findings reflect, in part, the present skill level of the EMS personnel involved. Nevertheless, our observations may be of value even for paramedic-based systems because the handling of devices and intubation skills are questions of the individual ability, which is strongly determined by training. Although emergency physicians and anesthesiologists taking part in the study felt comfortable with the used device, prestudy training must be considered inappropriate. Thus, with better experience, the results might have been different. In addition, without the strict limitation of the time granted for laryngoscopy, success rates might have been higher. This is an important aspect when comparing our results with data derived from different studies. To our conviction, limitation of intubation time and/or attempts is compulsive. Finally, because the primary target was to evaluate intubation success rates, outcome data of the patients requiring advanced airway management in the field were not assessed. Thus, we are not able to contribute to the discussion about the potential impact of advanced airway management on outcome, which is ongoing and controversial (37–39). In conclusion, video laryngoscopy is

a state of the art tool in difficult airway management, but our results shed light on the specific problems in the EMS setting. Prehospital use of the GlideScope Ranger video laryngoscope (Verathon) was associated with some major problems, thus resulting in a lower intubation success rate when compared with direct laryngoscopy. In order to improve success rates, comprehensive and ongoing training is mandatory.

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