

# Laryngoscopy via Macintosh Blade versus GlideScope

## Success Rate and Time for Endotracheal Intubation in Untrained Medical Personnel

Parichehr Nouruzi-Sedeh,\* Mark Schumann,† Harald Groeben, M.D.‡

**Background:** Tracheal intubation is the preferred technique to secure the airway and apply mechanical ventilation. However, when performed by untrained medical personnel, tracheal intubation *via* direct laryngoscopy has a high rate of failure. The GlideScope (Verathon Medical Europe, IJsselstein, Netherlands) technique improves the success rate for difficult tracheal intubation performed by experienced physicians; whether this technique improves the success rate for normal intubations when performed by inexperienced personnel as well is unknown. Therefore, the authors compared the success rate of direct laryngoscopy *versus* the GlideScope technique performed by personnel inexperienced in tracheal intubations.

**Methods:** Twenty volunteers, who had had only manikin training for tracheal intubation, attempted 5 intubations with either technique in patients scheduled for general anesthesia within a time limit of 120 s.

**Results:** Two hundred patients were divided into 2 groups for intubation *via* direct laryngoscopy ( $n = 100$ ) or the GlideScope technique ( $n = 100$ ). Between groups, there was neither a clinically relevant difference in the anthropometric data nor in the medication used for anesthesia. The overall success rate was 93% for the GlideScope technique *versus* 51% for direct laryngoscopy ( $P < 0.01$ ). Time for intubation was  $89 \pm 35$  s for direct laryngoscopy *versus*  $63 \pm 30$  s for GlideScope technique ( $P < 0.01$ ).

**Conclusion:** Tracheal intubation is the preferred technique to secure the airways in patients with a high risk of aspiration and is important in emergency medicine. Direct laryngoscopy with the Macintosh blade has a success rate of only 51% in our subjects. Using the GlideScope technique, a success rate of more than 90% within 120 s can be achieved after the first attempt, even in personnel untrained in intubation.

TRACHEAL intubation is still the preferred technique to secure the airway and apply mechanical ventilation when advanced airway management is required. However, standard tracheal intubation *via* direct laryngoscopy, performed by untrained medical personnel and personnel who perform tracheal intubation only occasionally, bears a high risk of failure. In several studies looking at the success rate of tracheal intubation *via* direct laryngoscopy performed by medical support staff, medical students, and novice anesthesia residents, the

initial success rate varied between 35 and 65%.<sup>1-8</sup> According to the studies of Mulcaster *et al.*<sup>9</sup> and Konrad *et al.*<sup>10</sup>, an improvement of the success rate up to a rate of 90% and higher requires about 47 to 56 intubations.

Therefore, alternative strategies have been evaluated and demonstrated higher success rates. In particular, the initial placement of a laryngeal mask airway and secondary tracheal intubation, as well as the use of video-assisted techniques, have been shown to be highly effective.<sup>1-3,6-8</sup>

Video-assisted techniques offer the advantage of abandoning the need for alignment of the optical axis in the pharynx and mouth to visualize the entrance of the larynx.<sup>11,12</sup> Therefore, video laryngoscopy is more effective, but can be more time-consuming.<sup>13-16</sup> Lim *et al.*<sup>15,16</sup> demonstrated in a study of inexperienced medical students and in a study of experienced anesthesiologists that intubation with the GlideScope (Verathon Medical Europe, IJsselstein, Netherlands) takes significantly longer in a manikin with easy intubation conditions. However, in case of difficult tracheal intubations, inexperienced students as well as experienced physicians were significantly faster, and their success rate was improved when the GlideScope technique was used.<sup>15,16</sup> Whether the poor success rate for standard tracheal intubation performed by medical personnel who have no routine in tracheal intubation can be significantly improved with the GlideScope technique as well is unknown.

Therefore, the aim of this study was to compare the success rate of and the time requirements for tracheal intubations using direct laryngoscopy *versus* the GlideScope technique performed by inexperienced personnel. We enrolled 200 patients who were scheduled for intubation under general anesthesia by 20 subjects who were untrained in intubation, within a time limit of 120 s.

## Materials and Methods

### Subjects and Patients

After approval by the ethics committee of the University of Essen in Essen, Germany, 20 subjects and 202 patients gave their informed written consent to participate in this study. Eight of the subjects were in final training to become a paramedic, 4 were first-year residents, 4 were nurses, and 4 were medical students; all of them had not yet intubated a patient.

Patients were included who were older than 18 yr, had to undergo elective surgery under general anesthesia

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with tracheal intubation, and were classified as American Society of Anesthesiologists physical Status I or II. The patients had a Mallampati score of I or II, at least 4 cm of mouth opening, no history of or physiognomical hint for a difficult intubation (such as retrognathia or macroglossia), and no increased risk of regurgitation.<sup>17</sup>

The patients were enrolled into the study and gave their consent at the preoperative evaluation center to anesthesiologists who were not informed of the status of the alternating sequence of the 2 techniques. These anesthesiologists set a fixed order of patients. The subjects and their attending anesthesiologist in the operating room had no influence on or choice of which patient would be next on their alternating list; *i.e.*, they received a fixed order of patients and had no influence on which patient had to be intubated with which technique. This way, we are convinced that on one hand the alternating sequence guarantees that no randomized order can influence the learning curve with each technique, and on the other hand that the subjects had no influence on the choice of technique for a specific patient, although the sequence of patients was not formally randomized.

#### Protocol

All subjects received extensive manikin training (Airway Management Trainer, Laerdal Medical AS, Stavanger, Norway) with both techniques. Before practical training, the theoretical background about technique, risks, and indications was presented. The subsequent practical training with the manikin was completed when the subjects accomplished 3 successful intubations in a row with each technique, with a time limit of 60 s for each attempt. After a demonstration of each technique on an anesthetized patient, the subjects started to perform, under close supervision of an attending anesthesiologist, in random order, direct laryngoscopy or the GlideScope technique. The subjects intubated 5 patients with each technique. After the subjects started with one technique, they alternated the technique from patient to patient.

The patients were in supine position with their head placed on a 7-cm headrest. A peripheral intravenous line was started and standard monitoring (electrocardiogram, noninvasive blood pressure measurement, fingertip for arterial oxygen saturation) was applied.

Induction of general anesthesia was standardized with propofol, remifentanyl, and mivacurium. The respective dose of the agents was administered according to the preference of the attending anesthesiologist (table 1). The attending anesthesiologist decided when to start the intubation attempt, according to common standards and his or her personal experience, and took the time for the procedure. The attending anesthesiologist neither gave any advice or recommendation, nor did he or she assist the subject unless he or she was asked to perform manipulations of the larynx like the "backward, upward, and rightward maneuver." The attending anesthesiologist

**Table 1. Anthropometric Data and Dose of Induction Agents of 200 Patients Scheduled for Direct Laryngoscopy or GlideScope Technique**

|                                     | Direct Laryngoscopy (n = 100) | GlideScope (n = 100) | P Value |
|-------------------------------------|-------------------------------|----------------------|---------|
| Height, cm                          | 172 ± 9                       | 171 ± 9              | 0.45    |
| Weight, kg                          | 75.8 ± 15.1                   | 78.1 ± 14.9          | 0.28    |
| Age, y                              | 54.3 ± 16.1                   | 51.8 ± 16.5          | 0.27    |
| Sex, m/f                            | 52/48                         | 47/53                | 0.48    |
| ASA Classification, I/II            | 31/69                         | 36/64                | 0.42    |
| Propofol, mg · kg <sup>-1</sup>     | 3.1 ± 0.8                     | 3.6 ± 0.9            | 0.73    |
| Remifentanyl, µg · kg <sup>-1</sup> | 0.93 ± 0.22                   | 0.99 ± 1.04          | 0.09    |
| Mivacurium, mg                      | 16.2 ± 5.3                    | 15.1 ± 5.0           | 0.13    |
| Mallampati Score, I/II              | 68/32                         | 52/48                | 0.02    |
| Cormack and Lehane                  | 32/18/37/13                   | 66/26/5/3            | < 0.01  |

Data are mean ± SD.

ASA Classification = American Society of Anesthesiologists physical status classification.

gist observed the intubation to prevent any potential harm to the patient and to take over the intubation when time was running out.

The time for an attempt was measured from the opening of the patient's mouth until the cuff of the tube was blocked. The attempt was stopped and the investigator took over the intubation when the attempt exceeded 120 s, oxygen saturation decreased below 95%, hemodynamic instability occurred (more than 30% decrease in mean arterial blood pressure from baseline), or airway trauma (*i.e.*, blood stain on the laryngoscope blade) was suspected. If the investigator took over the intubation attempt and found a laryngoscopic view of Cormack and Lehane (C&L) Grade III or IV, the patient was excluded from the study and the attempt was repeated with another patient. The patients randomized for laryngoscopy were orally intubated with an endotracheal tube (7.0 mm to 8.0 mm inner diameter) using a laryngoscope with a Macintosh blade, size 3 or 4. Patients randomized for the GlideScope technique were orally intubated with the same endotracheal tubes. The subjects described their view on the laryngeal entrance according to the classification of C&L.<sup>18</sup>

On the first postoperative day the patients were asked about pain as a result of tracheal intubation. The degree of pain was noted according to the visual analog scale, and the patients were asked how long they felt this pain. If the pain persisted at the time of the visit, the patients were revisited until the pain vanished.

#### Data Analysis

Data are presented as mean ± standard deviation. The following *a priori* null hypotheses were tested: First, the success rate for tracheal intubation is not different for the 2 techniques. Second, the time for tracheal intubation using the GlideScope technique was significantly longer than the time for using direct laryngoscopy.

Third, the difference in time for intubation between the 2 techniques in each subject did not change during the series of 5 attempts. The major outcome was defined as the success rate for both techniques.

Sample size was calculated based on an alpha error of 0.05 and a beta error of 0.1, with a minimal difference of 20% in terms of the success rate. The resulting minimal number of patients was 73 per group. We rounded the number to 100 for each group.

The success rate was analyzed for each attempt, and the accumulated attempts by chi-square tests. Confidence intervals for the success rate (95%) were calculated according to the method of Clopper and Pearson.<sup>19</sup>

For the analysis of intubation time, failed intubations were set to 120 s to avoid a negative bias towards one of the techniques. Less skilled subjects who failed with 1 technique and succeeded with a "slow" attempt with the other technique would increase the mean time for this technique without influencing the mean time for the other in which they failed. Therefore, failed attempts were included for the time analysis with a time limit of 120 s. The time was analyzed by a 2-way analysis of variance for repeated measurements from attempt to attempt, and for the 2 techniques. The difference for the intubation time between the techniques during the series of 5 attempts was tested by a one-way analysis of variance for repeated measurements. Differences were considered significant for  $P < 0.05$ .

Because of concerns about normality in the distribution of the data of intubation time and the anthropometric data, nonparametric tests were also applied (results not shown) and did not lead to any other conclusions or interpretation of the data. Anthropometric data and medication doses were tested by Student *t* tests for continuous data, and chi-square test for categorical data.

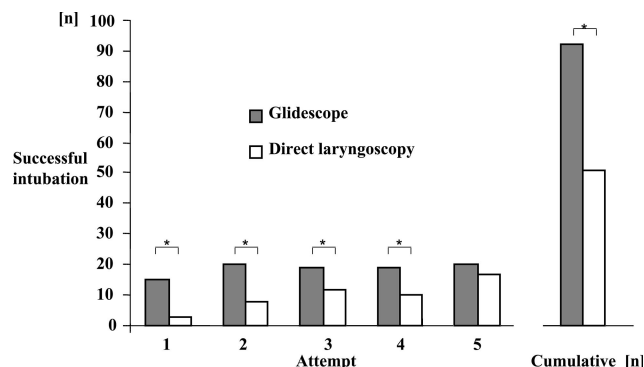
With the small number of patients with pain after tracheal intubation, the statistical power of this analysis is limited.

## Results

The subjects completed their 10 intubation attempts within 10 working days.

### Success Rate

Overall, 202 attempts at tracheal intubation were made. Two patients scheduled for direct laryngoscopy were excluded after the investigators declared the laryngoscopic view as C&L Grade III. Of the remaining 100 patients, 51 patients (0.41, 0.61; 95% confidence interval) were intubated *via* direct laryngoscopy within the defined time limit, while 93 patients of the 100 patients (0.86, 0.97; 95% confidence interval) scheduled for the GlideScope technique were intubated successfully ( $P < 0.01$ ; fig. 1). At the second attempt, all subjects were successful with the GlideScope technique.



**Fig. 1.** Number of successful intubations in 200 patients, performed by 20 subjects with manikin training only. Successful intubations are presented for each attempt and accumulated for all attempts. Each subject attempted to intubate 5 patients *via* direct laryngoscopy and 5 patients *via* GlideScope (Verathon Medical Europe, IJsselstein, Netherlands) technique. From the second to the fifth attempts, the subjects were successful with the GlideScope technique in 19 of 20 patients for each attempt. Overall, the subjects had a significantly higher success rate using the GlideScope technique ( $n = 93$ ) as compared with direct laryngoscopy ( $n = 51$ ;  $P < 0.01$ ).

The overall view at the glottis according to the classification of C&L, judged by the view of the subjects, was 32/18/37/13 for the Macintosh technique and 66/26/5/3 for the GlideScope technique ( $P < 0.01$ ). However, the attending anesthesiologists, who took over the intubation of the patients with an airway classified as C&L III and IV after the time limit was reached, judged the view as C&L I and II (27 Grade I, 22 Grade II for Macintosh; and 4 Grade I, 3 Grade II for GlideScope) using the standard Macintosh technique for all patients ( $P = 0.91$ ).

Excess of intubation time was the only reason to stop an attempt. None of the other conditions described in the protocol occurred.

### Time for Endotracheal Intubation

Time for failed intubation attempts was set to 120 s. For both techniques time for intubation becomes significantly shorter during the series of 5 attempts ( $P < 0.01$  for both techniques, respectively). The overall time for tracheal intubation for all attempts was significantly shorter for the GlideScope technique *versus* the Macintosh technique ( $63 \pm 30$  s *vs.*  $89 \pm 35$  s;  $P < 0.01$ ). For the first up to the fourth attempt, time was significantly shorter for the GlideScope technique, while at the fifth attempt no significant difference could be detected (table 2).

The difference between the intubation times with the Macintosh technique minus the GlideScope technique for each subject at every single attempt did not change significantly during the series of 5 attempts (fig. 2).

### Pain after Tracheal Intubation

On the first postoperative day the patients were asked about pain as a result of tracheal intubation. There was a low incidence of pain that could be



**Table 2. Time for Endotracheal Intubation *via* Direct Laryngoscopy (Macintosh blade, n=20 for each attempt) or GlideScope Technique (n=20 for each attempt)**

| Attempt        | Direct Laryngoscopy (n = 20) | GlideScope (n = 20) | P Value |
|----------------|------------------------------|---------------------|---------|
| I              | 112 ± 24                     | 88 ± 28             | < 0.01  |
| II             | 102 ± 27                     | 67 ± 23             | < 0.01  |
| III            | 88 ± 31                      | 61 ± 24             | < 0.01  |
| IV             | 81 ± 35                      | 50 ± 28             | < 0.01  |
| V              | 60 ± 36                      | 45 ± 26             | 0.13    |
| Mean (n = 200) | 89 ± 35                      | 63 ± 30             | < 0.01  |

Data are mean ± SD.

related to tracheal intubation (n = 12 direct laryngoscopy *vs.* n = 5 GlideScope;  $P = 0.08$ ). The degree of pain according to the visual analog scale was not different between the techniques (visual analogue scale  $3.6 \pm 0.5$  direct laryngoscopy *vs.*  $4.3 \pm 1.0$  GlideScope;  $P = 0.09$ ), neither was the duration of pain ( $10.6 \pm 7.9$  h direct laryngoscopy *vs.*  $9.0 \pm 5.3$  h GlideScope;  $P = 0.72$ , respectively). With the small number of patients with pain after tracheal intubation, the statistical power of this analysis is limited.

#### *Anthropometric Data and Dosage of Induction Agents for General Anesthesia*

There was only a significant difference in the anthropometric data of the patients regarding the Mallampati classification, with a slightly higher Mallampati score for the patients intubated *via* the GlideScope technique (table 1). There were no differences between the 2 groups in the amount of the induction agents given (table 1).

## Discussion

In medical personnel, untrained in tracheal intubation, the GlideScope technique led to a significant higher

success rate (93%) as compared with direct laryngoscopy (51%). There was no difference in intubation time.

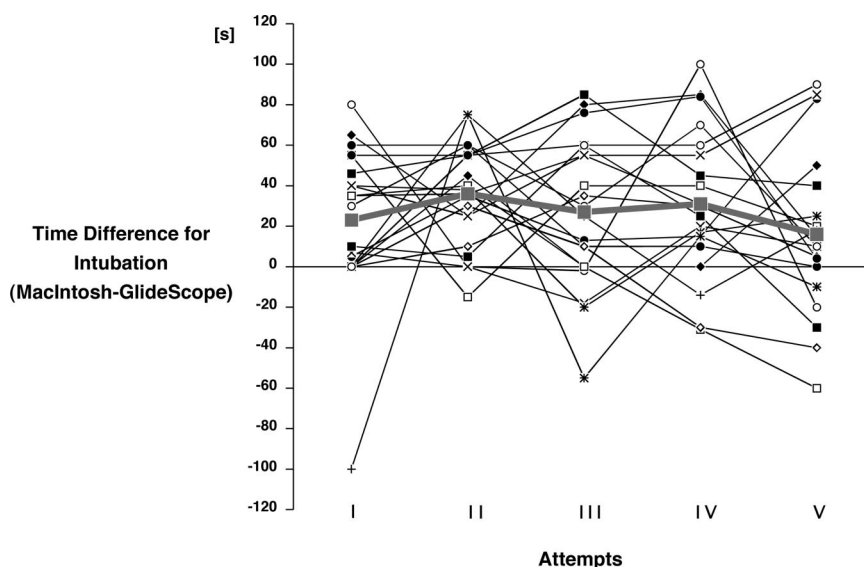
These results could have been influenced by a bias in the anthropometric data of the patients (obesity, Mallampati classification, and others), and possible differences in the depth of anesthesia. Therefore, we analyzed the anthropometric data of the patients (table 1) and found only a significant difference for the Mallampati classification of the patients (Mallampati I/II, 68/32 for Macintosh and 52/48 for GlideScope;  $P = 0.02$ ). However, this difference, albeit statistically significant, is so minimal that it clinically irrelevant. If there would have been any effect, it would have been in favor of the group for direct laryngoscopy.<sup>16</sup> Therefore, the difference in Mallampati classification did not have an effect on the results of our study.

Analyzing the doses of the induction agents, we could exclude significant differences which might have influenced the conditions for tracheal intubation (table 1). All patients received muscle relaxation for intubation.

In medical personnel untrained in tracheal intubation, the success rate of intubation *via* direct laryngoscopy ranges from 35 to 65%.<sup>1-8</sup> Our result of 51% is well within the range of these studies by various investigators. Hence, we included 5 attempts for each subject with each technique. The question occurred whether our subjects are "untrained" only until their first attempt or for the whole series of 10 attempts. Although the subjects' success rate and time for intubation improved from the first to the fifth attempt, they still cannot be called experienced after 5 attempts, and they are still beginners in terms of intubation experience.

To improve the success rate of tracheal intubation using direct laryngoscopy above 90% to an experienced level, about 47 to 56 intubations are required.<sup>9,10</sup> Neither for the training of paramedics nor for the training for emergencies of nonanesthesiologists a number of 50

**Fig. 2. The differences in time for intubation in seconds (Macintosh – GlideScope) for each subject at every single attempt. Each thin line represents the results of 1 subject. Mean differences are shown in gray with squares. There is no significant change detectable during the series of all 5 attempts (analysis of variance for repeated measurements;  $P = 0.38$ ).**



tracheal intubations or more can be guaranteed in most institutions.

Physicians and nonacademic personnel who perform tracheal intubations only occasionally, potentially in emergencies, might need even more training to achieve such a success rate.

Hence, successful intubation of only half of the patients in whom tracheal intubation was intended, is unsatisfactorily low. Therefore, alternative techniques with higher success rates are desired. The use of different variations of laryngeal masks has been shown to improve the success rate significantly.<sup>1-3,6-8</sup> Basically, tracheal intubation *via* a laryngeal mask avoids the need for visualization of the glottis or at least part of the glottis, and circumvents the need to align the oral and pharyngeal axis for a direct view of the glottis. In fact, this alignment, *i.e.*, the visualization of the glottis, posed the main difficulty for the subjects in our study when direct laryngoscopy was intended. Over the last years, video-assisted techniques have been developed to abandon the need for alignment of the optical axes and to magnify the view of the laryngeal entrance on a screen.<sup>11,12,16,20,21</sup>

The GlideScope is a laryngoscope with a blade that has an additional 60° upward angulation at the distal half of the blade. This blade is inserted along the midline of the tongue and follows the anatomical upper airway without displacement of the tongue and the need to align the optical axes. In contrast to direct laryngoscopy with a Macintosh blade, intubation with the GlideScope requires an almost U-shaped preformation of the tube with a stylet to follow the curve of the blade.<sup>11,12</sup> This unusual preformation of the endotracheal tube might explain why inexperienced medical students as well as experienced anesthesiologists need more time for normal, easy intubations, as compared with direct laryngoscopy, while in difficult intubations they intubate significantly faster and have a higher success rate with the GlideScope technique.<sup>15,16</sup> Observing our subjects, their main difficulty was to visualize the glottis. Once they had a view of C&L Grade I or II, they had no difficulty placing the endotracheal tube. All subjects who achieved a visualization of the glottis within 120 s were successful in placing the endotracheal tube. The visualization of the glottis was achieved much faster with the GlideScope technique. Therefore, they are more successful and faster with the GlideScope technique, as compared with direct laryngoscopy.

On average, our subjects needed  $63 \pm 30$  s for intubations with the GlideScope technique, and  $89 \pm 35$  s for the conventional Macintosh technique.

As compared with other studies on the same topic, our results of the conventional technique are within the time range of previous studies (34 to 206 s).<sup>2,3,6-8</sup>

Overall, we found a significant improvement in intubation time with both techniques. However, the difference between the techniques persisted until the fifth attempt, and did not change significantly with the in-

creasing number of attempts (fig. 2). Remembering that the learning curve to reach a success rate of 90% requires 47 to 56 intubations, a significant improvement during only 5 attempts might appear surprisingly fast.<sup>9,10</sup> However, our study design limited all intubation attempts to patients with an expected easy intubation. In fact, the only 2 unexpected slightly difficult intubations were excluded and replaced by 2 additional attempts. Moreover, the studies by Mulcaster *et al.* and Konrad *et al.* not only looked at successful intubation or failure, they also took into account whether the performance was good or bad and whether they needed some assistance by an attending anesthesiologist, which might explain in part the fairly high number of intubations necessary.<sup>9,10</sup> Finally, the first 5 intubations for each technique probably represent the steepest part of the learning curve. In addition, each subject had 10 attempts for intubation, and we cannot exclude that the video-assisted technique might have improved or accelerated the learning curve with the Macintosh blade.

In conclusion, in subjects with no or only minimal experience in tracheal intubation, the success rate of intubation can be significantly increased with a video-assisted technique (GlideScope) and does not require more time than direct laryngoscopy. With a success rate of 95 to 100%, already after the second attempt the portable GlideScope system might be a significant improvement for standard tracheal intubation performed by medical personnel who learn how to intubate or perform tracheal intubations only occasionally.

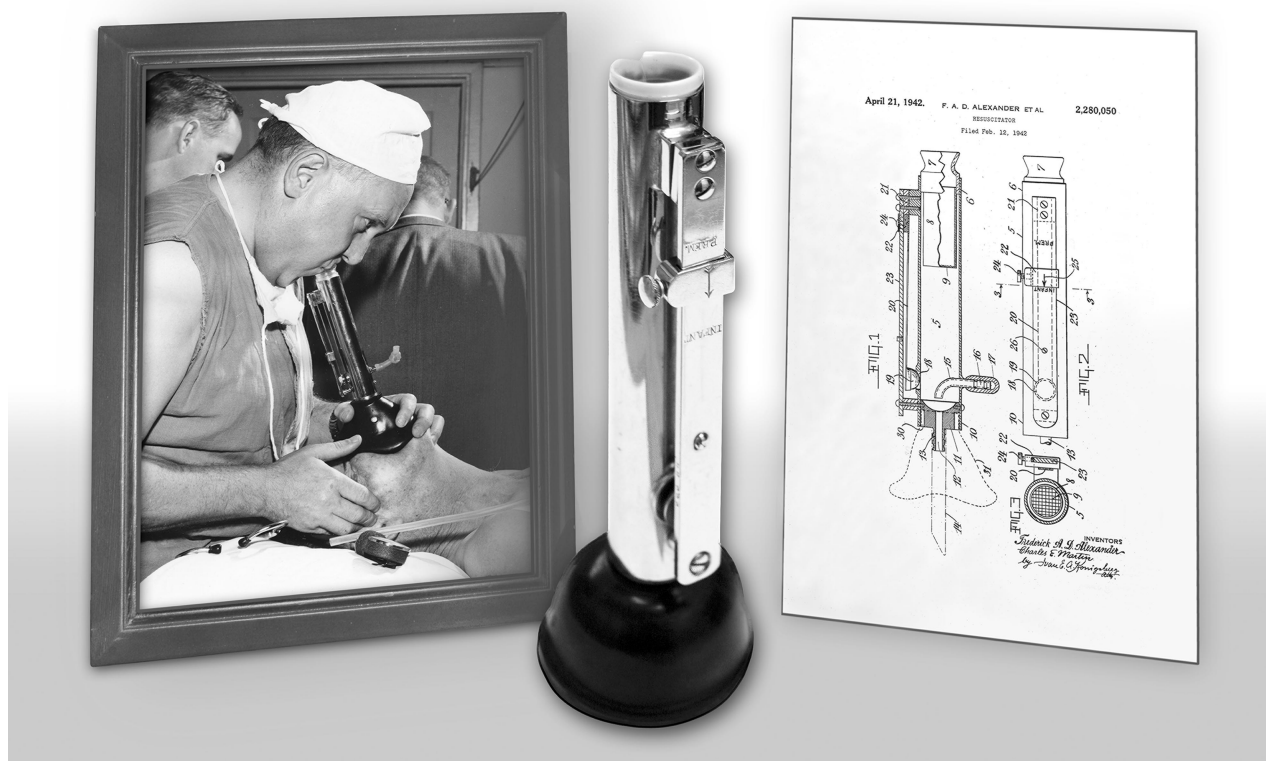
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## ■ ANESTHESIOLOGY REFLECTIONS

### Alexander "Bazooka" Insufflator



Born and educated in Ontario, Canada, F. A. Duncan Alexander, M.D. (1908–1983), trained under Drs. Ralph Waters and Emory Rovenstine before directing anesthesia services at New York's Albany Hospital. There in 1942, Alexander (pictured) and colleague Charles Martin received a US patent less than 3 months after filing for their "Bazooka" exhaled-air resuscitator. As sold for \$35 by Foregger, the "Alexander Mouth to Mouth Insufflator" featured a gauze-filtered mouthpiece for the rescuer, a nipple for supplementary oxygen, and both a sliding relief valve and a mask adaptor for safely adjusting "PREM[ature]," "INFANT," or adult inspiratory pressures and mask fit. Alexander served as American Society of Anesthesiologists (ASA) vice-president before joining the US Army Air Corps in 1942 and pioneering thoracic anesthesia techniques at evacuation hospitals in wartime England. After World War II, Alexander served his fellow war veterans back in Texas and was hailed by Dr. John Bonica as an independent founder in 1947 of multidisciplinary pain management. (Courtesy of the F. A. Duncan Alexander Collection, WLM Archives Collection No. MMS 51. This image appears in the *Anesthesiology Reflections* online collection available at [www.anesthesiology.org](http://www.anesthesiology.org).)

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