Video Laryngoscopy Versus Direct Laryngoscopy in the ICU: Don't Throw Away That MAC Blade Just Yet*

Ramon E. Abola, MD
Elliott Bennett-Guerrero, MD
Department of Anesthesiology
Stony Brook Medicine
Stony Brook, NY

As experienced anesthesiologists, when called to the ICU for an emergent intubation, there are many questions that arise. What is this patient's condition and comorbidities? How urgent is this intubation? Is there a full stomach? Is there anticipated difficulty of bag/mask ventilation and/or laryngoscopy? What should we use for induction? Are we worried enough about hypotension to select certain agents (e.g., etomidate or ketamine) or perhaps coadminister a vasopressor with the induction agent? What paralytic should be used, if any? Most recently, a new question has been what should we use to intubate the patient, which is the focus of the current study by Janz et al (1).

It has been reported that up to one third of patients in the ICU undergoing endotracheal intubation will have a complication, such as severe hypoxemia, severe hypotension, esophageal intubation, frank aspiration, or death (2). There are many risk factors that cannot be modified, such as the patient's critical condition, comorbidities, airway, and the intubation skill of the practitioner. Equipment used to intubate, however, can be modified to improve patient safety, especially in clinicians who have less experience performing tracheal intubation.

The introduction of the video laryngoscope (VL) was heralded as a possible replacement for direct laryngoscopy (DL). Previous studies have reported improved glottic visualization, improved first attempt intubation success rate, and improved success with anticipated difficult airways comparing VL to DL (3, 4). Untrained medical personnel had better success at intubation using VL versus DL (5). This fact becomes particularly of interest in the ICU setting, where intubating experience may be limited. Despite these potential benefits, there are scant data to support the routine use of VL. For example, a randomized trial in trauma patients found no improvement in patient survival when compared with DL (6).

In this issue of *Critical Care Medicine*, Janz et al (1) report a prospective randomized trial of 150 ICU patients undergoing endotracheal intubation. Patients were randomized to either DL or VL. Pulmonary and Critical Care Medicine (CCM) fellows under the supervision of CCM attendings performed all intubations. They found that there was no difference in intubation success on the first attempt between the two modes of intubation (68.9% for VL and 65.8% for DL). The one advantage of VL was a better view of the glottis. However, there was no difference in the number of complications, time to intubation, lowest oxygen saturation, ventilator days, and hospital mortality between patients who were intubated with DL versus VL. This was a factorial study design and the other intervention subjects were randomized to was apneic oxygenation versus usual care (7). Apneic oxygenation had no impact on patients making this aspect of the study irrelevant to the comparison of DL versus VL.

The study is commendable because it is one of the few randomized trials addressing this question. To reduce observation bias, independent observers (ICU nurses and physicians) were trained in the specific definitions of outcomes and were not associated with the procedure. They enrolled 90% of the intubations in their ICU during the time period of the study.

There are some aspects of the trial that may have influenced their findings. The fellows in the study had limited experience with VL compared with DL (median prior intubating experience was 10 times with VL and 47 times with DL). The limited experience with VL may have contributed to a similar rate of first attempt success to DL. In our opinion, 10 times does not seem like enough attempts to be technically proficient. It has been suggested that proficiency at DL (> 90% success) occurs after 50 attempts (8).

Another critique of this study is that there was no standardization for induction technique and use of neuromuscular blockade. The study used a pragmatic design allowing the physicians to decide all other aspects of care except the mode of intubation. However, more VL patients received rocuronium and more DL patient received succinylcholine. These drugs can have different onset times and pharmacokinetics, which may have influenced the results. Amounts of drug administered (e.g., high- vs low-dose rocuronium) and need for redosing (e.g., more relevant to succinylcholine) were not reported.

Approximately, 10% of patients were excluded if the ICU staff desired a certain airway technique. This may have effectively removed all difficult intubations from the study group where VL may have had a more pronounced difference when compared with DL. Finally, there is no formal definition in the literature of an intubation attempt. These authors defined the use of an advanced airway adjunct, such as a bougie, as a

*See also p. 1980.

Key Words: direct laryngoscopy; intensive care unit; intubation; video laryngoscopy

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difficult intubation/second attempt, but we do not agree with this definition.

The goal of this study was to determine if VL was a safer technique than DL for ICU patients. What is not captured in this study is the value of having a display monitor. A supervising physician or other clinician can observe the progress of intubation and provide assistance when appropriate. We believe that this is a tangible benefit; however, it might require a large randomized trial to prove that this aspect of VL improves outcome. Not assessed is the fellows' preference in intubating technique. More failed DL intubations converted to VL on the second attempt (11/22); fewer failed VL attempts went on to use DL (2/16).

Will VL replace DL for all intubations in the future? This study would suggest that this idea is premature. Typically, we use the VL in patients with an anticipated difficult airway (short thyromental distance, limited mouth opening, limited neck mobility) who do not warrant an awake fiberoptic intubation. VL is not without its own problems. Occasionally, the vocal cords can be visualized but the endotracheal tube cannot be positioned to the glottic opening. This can be corrected with reshaping the stylet inserted in the endotracheal tube or adjustment of the position of the VL. There are certain situations where DL is superior to VL, such as when there is blood or secretions in the airway that may limit camera visualization. Not all DL blades are the same. Many experienced anesthesiologists prefer a straight blade over a curved blade for difficult airways. Straight blades provide better visualization of the larynx, but curved blades provide better intubating conditions if visualization is satisfactory (9). A loss of the skills associated with DL would be unfortunate.

There are interesting parallels to this new technology and ultrasound. Studies comparing landmark versus ultrasound-guided placement of central lines found improved success rates and decreased frequency of minor complications with the use of ultrasound (10). Practitioners experienced with the landmark technique did not feel ultrasound was a necessary intervention, and perhaps better suited for trainees. Subsequently, ultrasound has become increasingly adopted for placement of internal jugular central lines with more safety and efficacy data. Unfortunately, in the current environment, new trainees may never gain competence with central line placement using landmarks alone, which could be an issue in an emergency if ultrasound is not available. Similarly in the field of regional anesthesia, ultrasound versus landmark/nerve stimulation technique studies did not show great efficacy or safety benefits with the newer technology (11). However, ultrasound has been adopted as the preferred method for peripheral nerve blocks in this field, and ultrasound has resulted in a larger number of anesthesiologists performing regional anesthesia.

In summary, Janz et al (1) report that there was no difference in first attempt intubation success rate or patient outcomes between DL versus VL when performed by ICU fellows. It is not known if these data are generalizable to clinicians with other levels of experience/training or to all ICU patients. Ten percentage of patients were excluded from this study based on a preference for one intubating technique. We believe that ICUs should have VLs available for trainees and for difficult airways, but that it is premature to "throw out" blades for DL.

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Randomized Trial of Video Laryngoscopy for Endotracheal Intubation of Critically Ill Adults*

David R. Janz, MD, MSc[1]; Matthew W. Semler, MD[2]; Robert J. Lentz, MD[2]; Daniel T. Matthews, MD[2]; Tufik R. Assad, MD[2]; Brett C. Norman, MD[2]; Raj D. Keriwala, MD, MPH[2]; Benjamin A. Ferrell, MD[2]; Michael J. Noto, MD, PhD[2]; Ciara M. Shaver, MD, PhD[2]; Bradley W. Richmond, MD[2]; Jeannette Zinggeler Berg, MD, PhD[2]; Todd W. Rice, MD, MSc[2]; for the Facilitating EndotracheaL intubation by Laryngoscopy technique and apneic Oxygenation Within the ICU Investigators and the Pragmatic Critical Care Research Group

***See also p. 2106**.

[1]Department of Medicine, Section of Pulmonary and Critical Care Medicine Louisiana State University School of Medicine, New Orleans, LA.

[2]Division of Allergy, Pulmonary and Critical Care Medicine, Department of Medicine, Vanderbilt University School of Medicine, Nashville, TN.

Drs. Semler, Janz, and Rice helped in study concept and design. Drs. Janz, Semler, Lentz, Matthews, Norman, Assad, Keriwala, Ferrell, Noto, Shaver, Richmond, and Zinggeler Berg helped in acquisition of the data. Drs. Janz, Semler, Lentz, Matthews, Norman, Assad, Keriwala, Ferrell, Noto, Shaver, Richmond, Zinggeler Berg, and Rice helped in data analysis and interpretation. Drs. Janz, Semler, and Rice helped in article preparation and drafting. Drs. Janz, Semler, and Rice helped in statistical methods and statistical data analysis. Drs. Janz, Semler, Lentz, Matthews, Norman, Assad, Keriwala, Ferrell, Noto, Shaver, Richmond, Zinggeler Berg, and Rice helped in article critique and review. All authors approved the article submitted. Drs. Janz, Semler, and Rice take responsibility for the integrity of the work as a whole.

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For information regarding this article, E-mail: djanz@lsuhsc.edu

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Objective: To evaluate the effect of video laryngoscopy on the rate of endotracheal intubation on first laryngoscopy attempt among critically ill adults.

Design: A randomized, parallel-group, pragmatic trial of video compared with direct laryngoscopy for 150 adults undergoing endotracheal intubation by Pulmonary and Critical Care Medicine fellows.

Setting: Medical ICU in a tertiary, academic medical center.

Patients: Critically ill patients 18 years old or older.

Interventions: Patients were randomized 1:1 to video or direct laryngoscopy for the first attempt at endotracheal intubation.

Measurements and Main Results: Patients assigned to video ($n = 74$) and direct ($n = 76$) laryngoscopy were similar at baseline. Despite better glottic visualization with video laryngoscopy, there was no difference in the primary outcome of intubation on the first laryngoscopy attempt (video 68.9% vs direct 65.8%; $p = 0.68$) in unadjusted analyses or after adjustment for the operator's previous experience with the assigned device (odds ratio for video laryngoscopy on intubation on first attempt 2.02; 95% CI, 0.82–5.02, $p = 0.12$). Secondary outcomes of time to intubation, lowest arterial oxygen saturation, complications, and in-hospital mortality were not different between video and direct laryngoscopy.

Conclusions: In critically ill adults undergoing endotracheal intubation, video laryngoscopy improves glottic visualization but does not appear to increase procedural success or decrease complications. (*Crit Care Med* 2016; 44:1980–1987)

Key Words: critical illness; intubation; laryngoscopy; respiratory failure

As many as one third of critically ill patients undergoing endotracheal intubation experience a life-threatening complication (1–4). Patient illness and instability, limited preparation time, operator inexperience, and equipment limitations all contribute to procedure-related complications (2–4).

Few of these factors are modifiable; hence, efforts to improve the safety of endotracheal intubation have focused on modifiable factors such as medications (5–8), preparation (1), positioning (9–11), preoxygenation (12–14), and equipment to improve glottic visualization (15–19).

Video laryngoscopes use a camera on the distal end of the blade oriented toward the glottis to improve visualization. Although it is logical that a better glottic view might translate into easier or more rapid endotracheal intubation, data are conflicting as to whether video laryngoscopy (VL) results in increased intubations on the first attempt, decreased complications, or improved clinical outcomes (16, 18, 20–22). Along with the need to train operators on multiple devices, these conflicting results have limited the use of VL for the intubation of critically ill patients (23).

To address this uncertainty, we conducted a prospective randomized trial comparing the effect of video versus direct laryngoscopy (DL) on the rate of intubation on first attempt among critically ill adults. We hypothesized that VL would increase the rate of intubation on first attempt, adjusting for the operator's previous experience with the intubating device at the time of intubation.

METHODS

The Facilitating EndotracheaL intubation by Laryngoscopy technique and apneic Oxygenation Within the ICU (FELLOW) study was a prospective, randomized trial of VL compared with DL during endotracheal intubation of critically ill adults by Pulmonary and Critical Care Medicine (PCCM) fellows. The study was combined in a factorial design with a comparison of apneic oxygenation versus usual care, the results of which are reported separately (24). The protocol was approved by the Vanderbilt Institutional Review Board with a waiver of informed consent; the trial was registered on www.clinicaltrials.gov (NCT02051816), and the analysis plan was published online (https://starbrite.vanderbilt.edu/rocket/page/FELLOW) prior to completion of enrollment.

Study Patients

Between February 13, 2014, and February 11, 2015, all patients (≥ 18 years old) undergoing endotracheal intubation in the Vanderbilt University Medical ICU by a PCCM fellow were enrolled unless awake intubation was planned, intubation was required so emergently that a randomization envelope could not be obtained, or the treating clinicians felt a specific approach to intraprocedural oxygenation or a specific laryngoscopy device was mandated for the safe performance of the procedure (**Fig. 1**).

Randomization and Blinding

Patients were randomly assigned in a 1:1 ratio to use of VL or DL on the first laryngoscopy attempt via random permuted blocks of 4, 8, and 12. Study assignment was concealed until after the decision had been made to intubate and the patient was enrolled in the trial. Because of the nature of the intervention, patients, clinicians, and study staff were aware of study group assignment after enrollment.

Study Interventions

Within the assigned laryngoscopy group, operators were free to select their preferred video laryngoscope (McGrath Video Laryngoscope [Medtronic, Minneapolis, MN]; GlideScope Video Laryngoscope [Verathon, Bothell, WA; or Olympus Video Bronchoscope [Olympus America Inc, Center Valley, PA]) or direct laryngoscope (curved MacIntosh or straight Miller blades). All other aspects of the procedure were at the discretion of the clinical team. All intubations were supervised by either a PCCM or an Anesthesia attending physician who could offer feedback and guidance at any time during the procedure.

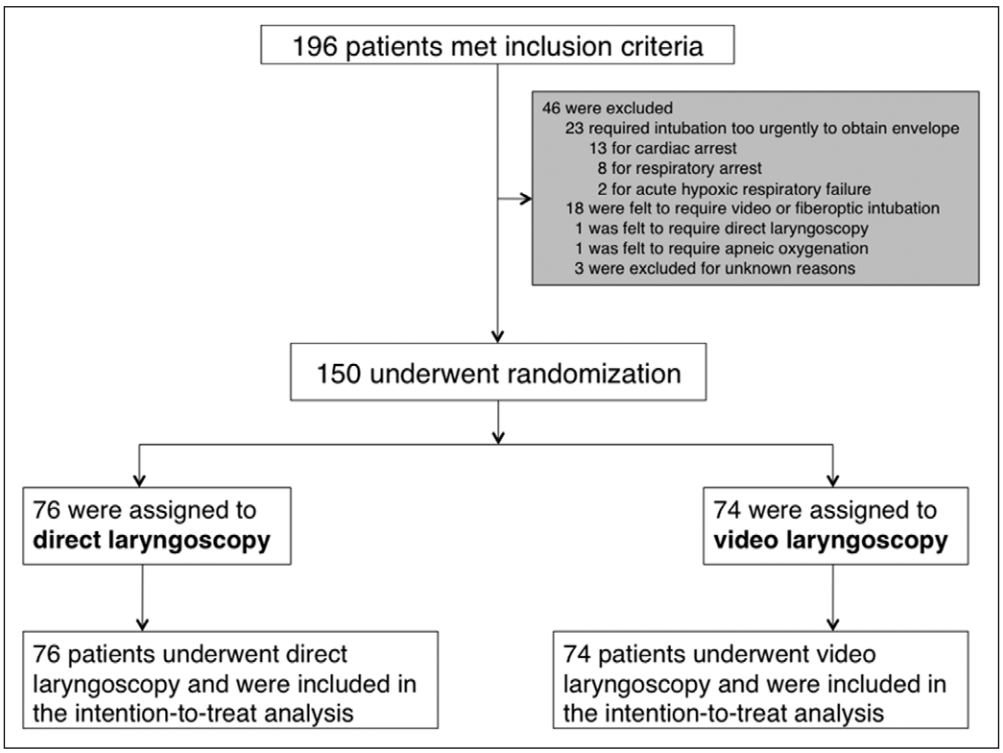


Figure 1. Patient screening, randomization, and follow-up.

Data Collection

Study endpoints were collected by independent observers (ICU nurses or physicians trained in the definitions of each outcome) who were present in the patient's room but not associated with the performance of the procedure. To confirm the accuracy of

the data collected by the independent observers, the primary investigators concurrently assessed the same endpoints for a convenience sample of 10% of study intubations.

Measurement of Outcomes

The primary outcome was the rate of intubation on first attempt, adjusted for the operator's previous experience with the intubating device at the time of the procedure. "Intubation on first attempt" was defined as successful placement of an endotracheal tube (Covidien Mallinckrodt Hi-Lo Oral/Nasal Tracheal Tube Cuffed) in the trachea during the first insertion of a laryngoscope into the oral cavity without removing the device from the mouth or using additional airway adjuncts. Adjustment for the operator's previous device experience was performed by collecting the number of times the operator had previously used a VL or DL at the time of each intubation event during the trial, such that the adjustment for prior experience with a specific device was updated constantly as the trial progressed. Suction devices and endotracheal tube stylets (Mallinckrodt Satin-Slip 14 French intubating stylet) were used routinely and not considered airway adjuncts. Secondary outcomes included time from induction to intubation, lowest arterial oxygen saturation (Sao_2) measured between medication administration and 2 minutes after endotracheal tube placement, intubation on first attempt adjusted for patient age, severity of illness, body mass index, and operator device experience, the need for additional devices or operators, Cormack-Lehane grading of the glottic view (25), procedure-related complications, and in-hospital mortality.

Statistical Analysis

A prior study of endotracheal intubation by PCCM fellows in a similar population reported a rate of intubation on first attempt of 68% with DL and an improvement of 23% with use of VL (26). To have 90% statistical power to detect a difference in rate of intubation on the first attempt of 23% between VL and DL with a type I error rate of 0.05, we calculated a sample size of 142 patients. We planned to enroll a total of 150 patients to anticipating a small number of cases in which the primary endpoint would be unavailable.

Data are expressed as median and interquartile range for continuous variables and frequencies for categorical variables. Between-group comparisons were conducted using the Wilcoxon rank-sum test for continuous variables and Fisher exact test for categorical variables. Logistic regression models were created to analyze the effect of VL on intubation on first laryngosocpy attempt while adjusting for (1) previous experience with the device at the time of the procedure and (2) previous experience with the device plus prespecified baseline confounders. IBM SPSS Statistics (version 22.0; Chicago, IL) was used for statistical analyses; a two-sided significance level of 0.05 was used for statistical inference.

RESULTS

Of 196 critically ill adults intubated by PCCM fellows during the study period, 150 were enrolled and randomized to VL or DL (Fig. 1). There was no crossover between study arms.

Baseline and Procedural Characteristics

Patients randomized to VL (n = 74) and DL (n = 76) were similar at baseline (**Table 1**). Sixteen PCCM fellows each performed a mean of 9.4 (SD ± 6.4) intubations as a part of the trial. Fellows' prior total intubating experience and duration of training was similar between the VL and DL groups (Table 1). As anticipated, fellows had fewer prior intubations with VL (median, 10; interquartile range [IQR], 5–22) compared with DL (47; IQR, 35–58) at the time of each procedure.

Postrandomization procedural characteristics including preoxygenation strategy, sedative medications, and laryngoscope blade size used were similar between groups (**eTable 1**, Supplemental Digital Content 1, http://links.lww.com/CCM/B885). Only two patients in the VL arm and three patients in the DL arm were intubated without neuromuscular blockade. In the VL group, operators chose the McGrath MAC (98.6%) and GlideScope (1.4%) video laryngoscopes for the first intubation attempt. In the DL group, 97.4% of first intubation attempts were performed with a curved blade.

Primary Outcome

There was no difference in the rate of intubation on first attempt between VL (68.9%) and DL (65.8%) (unadjusted odds ratio [OR] of intubation on first attempt with VL, 1.15; 95% CI, 0.58–2.28; p = 0.68). Results were similar in analyses adjusting for operator experience with the assigned device at the time of intubation (adjusted OR, 2.02; 95% CI, 0.82–5.02; p = 0.12) and operator experience with the assigned device, Acute Physiology and Chronic Health Evaluation II score, and body mass index (OR, 2.00; 95% CI, 0.81–5.02; p = 0.12).

When intubation on the first attempt did not occur (23 of 74 patients in the VL group and 26 of 76 patients in the DL group), addition of only an endotracheal tube introducer (SunMed Introducer Adult Bougie with Coude tip, 15F × 70 cm) allowed intubation for seven of the failed VL patients (30%) compared with four of the failed DL patients (15%; p = 0.3) (**eFig. 1**, Supplemental Digital Content 2, http://links.lww.com/CCM/B886; legend, Supplemental Digital Content 1, http://links.lww.com/CCM/B885). Of the 22 DL patients who required a second laryngoscopy attempt, half were intubated with VL and half with DL as opposed to the 16 VL patients requiring a second attempt, 14 of whom were intubated with VL and only two with DL.

Secondary Outcomes

Despite significantly improving the Cormack-Lehane grade of glottic view (**Fig. 2**), VL did not decrease time to intubation (126 s; IQR, 89–197) compared with DL (153 s; IQR, 93–253; p = 0.13) overall or in patients requiring only one attempt (105 s; IQR, 75–150 vs 112 s; IQR, 86–156; p = 0.45) (**Table 2**). There was no difference between VL and DL in lowest arterial oxygen saturation (91%; IQR, 82–98% vs 90%; IQR, 82–97%; p = 0.75) or decrease in Sao_2 from baseline (4%; IQR, 14–1% vs 4%; IQR, 11–0%; p = 0.39). In-hospital mortality (VL 41.9% vs DL 42.1%; p = 1) and procedure-related complications (aspiration, esophageal intubation, new hypoxia, new hypotension,

TABLE 1. Patient and Operator Characteristics at Baseline

Characteristic	Video Laryngoscopy (*n* = 74)	Direct Laryngoscopy (*n* = 76)
Age, median (IQR) (yr)	59 (49–68)	60 (51–67)
Men, *n* (%)	47 (63.5)	44 (57.9)
Caucasian, *n* (%)	63 (85.1)	62 (82.7)
Acute Physiology And Chronic Health Evaluation II score, median (IQR)	22 (16.7–28)	21 (15–25)
Body mass index, median (IQR) (kg/m^2)	28.5 (23.4–32.7)	28.8 (23.1–33.3)
ICU diagnoses, *n* (%)		
Sepsis	49 (66.2)	50 (65.8)
Septic shock	21 (28.4)	13 (17.1)
On vasopressors	11 (14.9)	9 (11.8)
Cardiogenic shock	2 (2.7)	1 (1.3)
Hemorrhagic shock	5 (6.8)	4 (5.3)
Delirium	34 (47.2)	34 (45.9)
Hepatic encephalopathy	8 (10.8)	12 (15.8)
Chronic obstructive lung disease exacerbation	8 (10.8)	4 (5.3)
Myocardial infarction	6 (8.1)	7 (9.2)
Drug overdose	3 (4.2)	1 (1.3)
Active comorbidities complicating intubation, *n* (%)		
Body mass index > 30 kg/m^2	20 (27)	28 (36.8)
Upper gastrointestinal bleeding	6 (8.1)	7 (9.2)
Limited neck mobility[a]	3 (4.1)	2 (2.6)
Limited mouth opening[a]	3 (4.1)	3 (3.9)
Head or neck radiation	0	1 (1.3)
Airway mass or infection	1 (1.4)	0
Witnessed aspiration	1 (1.4)	0
Indication for intubation, *n* (%)		
Hypoxic or hypercarbic respiratory failure	40 (54)	45 (59)
Altered mental status or encephalopathy	20 (27)	19 (25)
Other	14 (19)	12 (16)
Oxygen saturation at induction (%), median (IQR)	99 (95–100)	98 (93–100)
Operator characteristics, median (IQR)		
No. of times operator has previously used the assigned device at the time of intubation	10 (5–22)	47 (35–58)
No. of months of fellowship training completed at the time of the intubation	23 (15–31)	20 (14–30)
No. of total previous intubations by operators	68 (52–69)	56 (47–69)

IQR = interquartile range.
[a]As reported by the fellow performing the intubation.
Data given as median (25th percentile–75th percentile) or number (percentage) of patients.

cardiac arrest, and airway trauma) were similar between groups (Table 2). There were no differences in duration of mechanical ventilation (VL 3 d; IQR, 1–11 vs DL 3 d; IQR, 1–8; $p = 0.69$) or ICU length of stay (VL 6 d; IQR, 2–11 vs DL 4 d; IQR, 3–9; $p = 0.41$). In a 10% convenience sample, intubation on first attempt recorded concurrently by the independent observer,

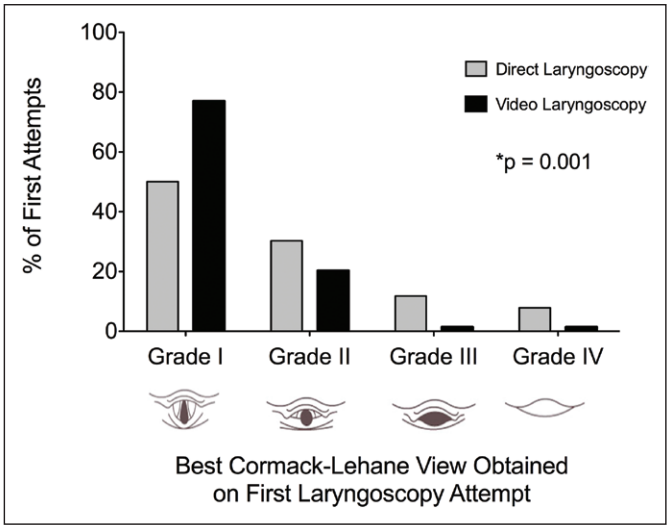


Figure 2. Cormack-Lehane glottic views obtained on the first laryngoscopy attempt. Video laryngoscopy results in better glottic views during the first laryngoscopy attempt compared with direct laryngoscopy ($p = 0.001$, chi-square for a trend).

and the primary investigators showed perfect interrater agreement ($\kappa = 1.0$; $p = 0.001$).

Subgroup Analyses

There was no significant increase in the odds of intubation on first attempt with VL in any of the prespecified subgroups (**Fig. 3**). The presence or absence of apneic oxygenation (24) did not modify the effect of VL on intubation on first attempt (p value for interaction = 0.77). An additional post hoc subgroup analysis suggested that operators' total prior intubating experience might modify the effect of VL on intubation on first attempt (**eFig. 2**, Supplemental Digital Content 3, http://links.lww.com/CCM/B887; legend, Supplemental Digital Content 1, http://links.lww.com/CCM/B885). Operators with less than 50 total prior intubations had higher odds of intubation on first attempt with VL than more experienced operators (≥ 50 total prior intubations) who had no increased odds of intubation on first attempt with VL (p value for interaction = 0.031). Given potential confounding between total intubating experience and experience with a given laryngoscopy device, we fit a multivariable logistic regression model adjusting for prior experience with the assigned device and found that there was no longer a statistically significant interaction between previous total intubation experience and VL for the outcome of intubation on first attempt (p value for interaction = 0.17) (eFig. 2, Supplemental Digital Content 3, http://links.lww.com/CCM/B887; legend, Supplemental Digital Content 1, http://links.lww.com/CCM/B885).

DISCUSSION

This randomized trial comparing VL and DL for endotracheal intubation of critically ill adults by PCCM fellows did not demonstrate an increase in intubation on first attempt with VL. The lack of effect persisted after adjustment for the operator's previous experience with the intubating device and across all prespecified subgroups.

The results of the current trial are in contrast with results of prior studies demonstrating improved procedural success with VL (15, 18, 26). There are several potential explanations for this difference. Prior studies limited to noncritically ill populations (17) may not apply to the patient, operator, and procedural conditions surrounding intubation in the ICU. Unblinded observational study designs (3, 18, 19, 27), nonrandom patient assignments (15), and "before-after" quality improvement studies (26) may suffer from confounding by selection bias, changes in practice over time, and the observer bias associated with self-reported data. Observer bias is of particular concern in studies reporting unexpectedly high rates of intubation failures with DL compared with VL (15, 18, 21, 26). A lack of accounting of the experience of the operator at the time of the procedure (15, 16, 18, 26, 27) may also confound the results of prior work. Neuromuscular blockade, which is associated with improved glottic view and reduced intubation attempts with DL (8, 28, 29), was used in 96% of intubations in the current trial but less frequently (18, 26, 27) or not at all (15) in past studies.

More specific to the patient population of interest, the findings in the current trial are also in conflict with those of the only prior controlled trial of VL versus DL in the ICU (15); however, both results may be true. Operator view is improved when neuromuscular blockade is used for intubation (8, 28) and the use of neuromuscular blockade in 96% of patients in the current trial compared with 0% in the prior trial may explain the higher rate of success with DL in the current trial (66% vs 40%, respectively). Alternatively, the near-exclusive use of the McGrath MAC video laryngoscope in the current trial compared with that of the GlideScope video laryngoscope used in the prior trial might contribute to the difference in findings; however, these two video laryngoscopes performed similarly in both trials regarding rates of grade I or II glottic view (> 90%) and intubation on first attempt (around 70%) in the VL arm of each trial.

Because uncertainty regarding the role of routine VL use in ICU intubations persisted despite previous studies, we incorporated three design features into our trial to more definitively test this key question. Study group assignments were concealed until after enrollment and randomization had occurred. Randomization using variable-sized permuted blocks prevented operator or study personnel from knowing which device would be assigned next. Observer bias was minimized by using trained, independent data collectors uninvolved in the procedure, and validating the quality of their data collection by concurrent collection of the same data by study personnel. We also deliberately used a relatively homogenous operator population (PCCM fellows) but nonetheless anticipated that operator experience would not remain balanced over the course of the study and adjusted for continuously updated imbalances in operator device experience at the time when the procedure was performed.

There are a number of possible reasons why improving glottic view with VL does not translate into procedural success. Our study suggests that despite obtaining a better view of the glottis, there may be more difficulty inserting an endotracheal tube

TABLE 2. Secondary Clinical Outcomes for the Video Versus Direct Laryngoscopy Groups

Clinical Outcomes	Video Laryngoscopy ($n = 74$)	Direct Laryngoscopy ($n = 76$)	p
Intubation on first laryngoscopy attempt, *n* (%)	51 (68.9)	50 (65.8)	0.68
No. of laryngoscopy attempts, median (IQR)	1 (1)	1 (1–2)	0.24
Time from induction to intubation, median (IQR) (s)	126 (89–197)	153 (93–253)	0.13
Time to intubation when only one attempt, median (IQR), seconds ($n = 101$)	105 (75–150)	112 (86–156)	0.45
Lowest arterial oxygen saturation, median (IQR) (%)	91% (82–98)	90% (82–97)	0.75
Change in arterial oxygen saturation from baseline, median (IQR) (%)	−4% (−14.5 to −1)	−4% (−11 to 0)	0.39
Best Cormack-Lehane view obtained on first attempt*, *n* (%)			
Grade I	57 (77)	38 (50)	0.001
Grade II	15 (20.3)	23 (30.3)	
Grade III	1 (1.4)	9 (11.8)	
Grade IV	1 (1.4)	6 (7.9)	
Difficulty of intubation*, *n* (%)			
Easy	64 (86.5)	54 (71.1)	0.051
Moderate	9 (12.2)	17 (22.4)	
Difficult	1 (1.4)	5 (6.6)	
Procedural complications*, total *n* (%)	26 (35.1)	29 (38.1)	0.73
Aspiration	1 (1.4)	1 (1.3)	1
Esophageal intubation	1 (1.4)	4 (5.3)	0.36
Systolic blood pressure < 80 mm Hg	8 (10.8)	7 (9.2)	0.79
Arterial oxygen saturation < 80%	14 (19.4)	16 (21.1)	0.84
Cardiac arrest	1 (1.4)	1 (1.3)	1
Airway trauma	1 (1.4)	0	0.49
Duration of mechanical ventilation, median (IQR) (d)	3 (1–11)	3 (1–8)	0.69
ICU length of Stay, median (IQR) (d)	6 (2–11)	4 (3–9)	0.41
In-hospital mortality, *n* (%)	31 (41)	32 (42)	1

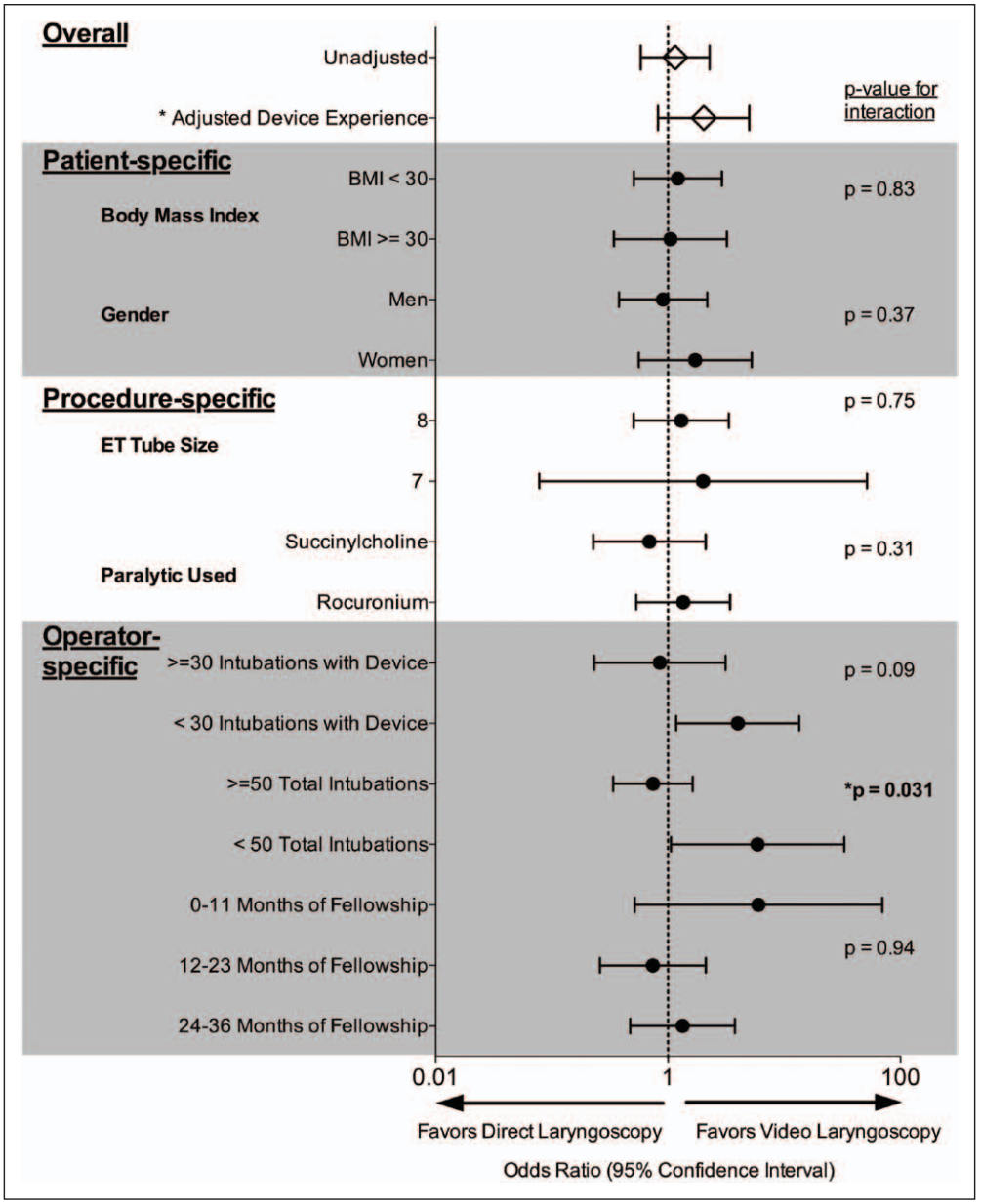
IQR = interquartile range.

*Grade of view, airway difficulty description, and complications were reported by the operator.

Data given as median (25th percentile–75th percentile) or number (percentage) of patients. p value = Mann-Whitney U test, Pearson's chi-square, or chi-square for a trend.

with VL as evidenced by the higher use of endotracheal tube introducers in the VL group. In addition, as a result of accounting for the operator's previous experience, our data contain the intriguing suggestion that improving glottic view with VL may only matter to less experienced operators (Fig. 3; and eFig. 2, Supplemental Digital Content 3, http://links.lww.com/CCM/B887; legend, Supplemental Digital Content 1, http://links.lww.com/CCM/B885). However, this was a post hoc analysis that was not significant after rigorously accounting for experience with each device and should only be considered hypothesis generating. Finally, the effect of VL on intubation on first attempt was not modified by the apneic oxygenation half of the factorial design as the p value for interaction was 0.77, and apneic oxygenation did not increase the lowest arterial oxygen saturation compared with usual care (24).

The current trial has some limitations. First, exclusions of intubations where the operator believed the patient needed a specific laryngoscopy device for the safe performance of the procedure was necessary for safety reasons but may limit the extrapolation of these results to all critically ill patients, and data were not collected as to how operators came to this decision. The rate of intubation on first attempt with VL and DL in these excluded patients was not collected. Although the proportion of eligible patients excluded by physician preference criteria (9%) was similar to prior interventional critical care trials (30–32), it means our study findings apply only to the 90% of ICU intubations for



Figures 3. Subgroup analyses and evaluation for effect modification. Subgroup analyses were conducted by patient, procedure, and operator-specific variables. Odds ratios and 95% CIs for the outcome of intubation on first attempt using video laryngoscopy are displayed for the overall study at the top of the figure followed by all subgroups. *Adjusted Device Experience represents the primary outcome for reference. The right justified columns are *p* values for interaction terms entered into the logistic regression model to test for effect modification of any of the subgroup variables. There were neither patient- or procedure-specific subgroups that benefitted from intubation with video laryngoscopy nor any statistically significant interactions detected. Regarding the operator-specific variables of previous experience with the assigned intubating device, previous total intubating experience, and previous fellowship training experience, operators less experienced with the assigned device (< 30 previous uses of the device, median) and the intubation procedure (< 50 total intubations, lowest quartile of experience) had a higher odds of intubation on first attempt with video laryngoscopy. However, only previous total intubating experience (< 50 total intubations) modified the effect of video laryngoscopy on intubation on first attempt ($p = 0.031$). BMI = body mass index.

which there is not an a priori indication for the use of a specific laryngoscopy device. Specifically, our results cannot inform how VL and DL would compare among patients anticipated to have difficult upper airway anatomy or other potential indications for VL. Second, although a clear definition of the primary outcome and trained, independent observers collecting the data mitigates observer bias, intubation on first attempt is not directly linked to patient-centered clinical outcomes. However, patient-centered clinical outcomes were collected, and we found no difference between study groups. Third, although operators were allowed to choose the specific VL and DL devices, this was largely a trial of the McGrath MAC video laryngoscope and curved intubating blades. Therefore, these data may not be generalizable to operators using video laryngoscopes other than the McGrath MAC and direct laryngoscopes with straight blades. In addition, once patients were randomized to VL or DL, patients in the VL group were more likely to receive rocuronium rather than to receive succinylcholine for neuromuscular blockade (eTable 1, Supplemental Digital Content 3, , http://links.lww.com/CCM/B887; legend, Supplemental Digital Content 1, http://links.lww.com/CCM/B885), which may influence measures of procedural success. However, in a subgroup analysis (Fig. 3), there was no significant effect modification of the paralytic medication chosen on intubation on first attempt. Finally, although designed with 90% statistical power to detect a difference between arms of 23% based on a past study of PCCM fellows performing endotracheal intubation (26), our trial was not powered to detect small differences between arms.

Where do these results leave the question of routine VL use for trainees performing endotracheal intubation outside of the operating room? Despite a wealth of observational data promoting VL for the intubation of critically ill adults (16–18, 26, 27), the two largest randomized trials including 623 critically ill adults with trauma (20) and the current trial of 150 critically ill adults in the medical ICU have not shown benefit. Considering the results of large

randomized trials and importance of exposure to various techniques during training (23), exclusive use of VL in out-of-OR airway management appears premature. Future studies should use rigorous trial designs with true randomization, objectively collected data, and careful accounting of patient, operator, and device characteristics to definitively determine the circumstances under which VL should be the first line for airway management in the critically ill patient.

CONCLUSIONS

Among critically ill adults undergoing endotracheal intubation by PCCM fellows, VL does not improve the rate of intubation on first attempt. These results do not support the routine use of VL for all ICU intubations. Future study should focus on whether VL improves the rate of intubation on first attempt in operators with limited intubating experience.

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