Yuan *et al.*
European Journal of Medical Research (2025) 30:282
https://doi.org/10.1186/s40001-025-02525-3

European Journal of Medical Research

REVIEW

Open Access

Comparison of video laryngoscopy with direct laryngoscopy in critically ill patients: a systematic review and meta-analysis of randomized controlled trials

Jun Yuan[1†], Penglei Yang[1†], Lina Yu[1], Wenguang Zhang[2], Jiangquan Yu[3] and Qihong Chen[1*]

Abstract

Background Although Video laryngoscope (VL) can reduce the difficulty of endotracheal intubation and improve the glottic view, its use in critically ill patients is controversial.

Methods Randomized controlled trials (RCTs) of VL and direct laryngoscopy (DL) for critically ill patients were searched on electronic databases, including Web of Science, PubMed, and Embase. Additional publications were identified by screening the reference lists of the identified articles and relevant previously published reviews.

Results Overall, 25 RCTs involving 5836 critically ill patients were included in the analysis. There was no significant difference in the first intubation rate between the VL and DL groups (25 studies; RR, 1.03; 95% CI 0.96–1.11; n = 5836; p = 0.37; very low certainty). However, Multivariate meta-regression analysis identified two main sources of bias: whether intubation was performed in a hospital (p = 0.04) and operator proficiency with DL compared to VL (p < 0.001). Subgroup analysis showed that VL improved the first intubation rate in in-hospital intubation (19 studies; RR, 1.12; 95% CI 1.04–1.22; n = 4441; p < 0.01, very low certainty) and VL showed good potential to reduce the first-attempt intubation success rates, but not significantly (6 studies; RR, 0.75; 95% CI 0.56–1.00; n = 1395; p = 0.05, very low certainty). In subgroups with similar operator proficiency VL and DL, VL increased the success rate for first intubation (16 studies; RR, 1.14; 95% CI 1.06–1.23; n = 3,971; p < 0.01; very low certainty). However, VL decreased the first intubation rate (4 studies; RR, 0.65; 95% CI 0.49–0.88; n = 810; p < 0.01; very low certainty) in a subgroup where operator proficiency was higher for DL than for VL.

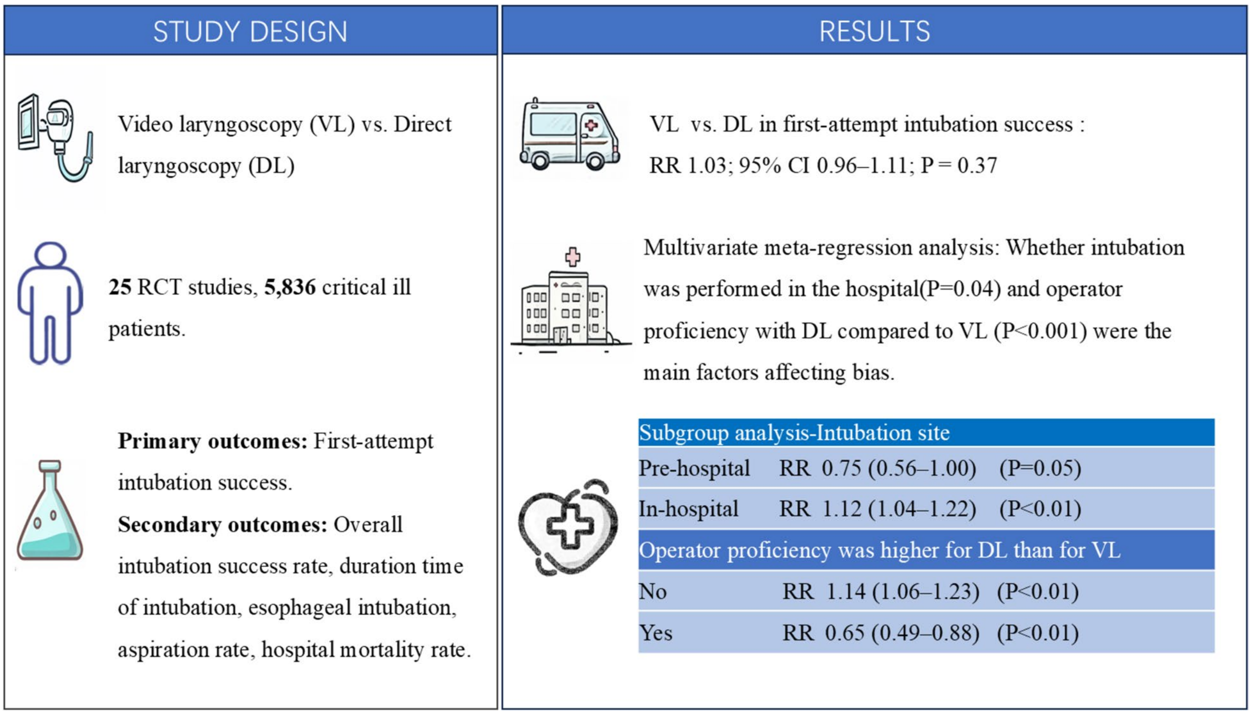
Conclusion VL does not increase the first intubation rate. However, VL increases the first-attempt intubation success rate for in-hospital intubation and operators with similar proficiency in VL and DL.

Keywords Video laryngoscopy, Direct laryngoscopy, Randomized controlled trials, Systematic review and meta-analysis

†Jun Yuan and Penglei Yang are the co-first authors.

*Correspondence:
Qihong Chen
jiangdurenyiicu@163.com
Full list of author information is available at the end of the article

Graphical Abstract



Introduction

Airway obstruction and respiratory failure are important causes of rapid death in critically ill patients [1]. Rapid and effective tracheal intubation is an important measure to improve life-threatening respiratory symptoms. The first-attempt intubation success rate in critically ill patients is significantly related to the risk of death [2]. However, the first intubation in critically ill patients still has a high failure rate of about 20–30% [3].

Video laryngoscope (VL) is equipped with a camera at the distal end of the blade, which can expose the glottis and facilitate tracheal intubation even when the oral, pharyngeal, and laryngeal axes are not aligned [4]. VL reduces the difficulty and operator threshold of tracheal intubation [5].

While direct laryngoscope (DL) has been a mainstay of clinical practice for tracheal intubation, the use of VL has increased dramatically in recent years [6, 7]. Although VL has achieved good results in surgical patients [8], its application in critically ill patients remains controversial [9, 10]. Numerous randomized controlled trials (RCTs) have been conducted to evaluate the impact of VL and DL on the first-attempt intubation success rate in critically ill patients. However, inconsistent results have been obtained due to factors such as patient disease type, operator proficiency, and difficult airway proportion, among others [3, 11–13]. Jiang et al. conducted a meta-analysis and reported that VL might not improve the first-attempt intubation success rate [9]. However, subsequent RCTs [3, 12, 14] reported that VL had a higher first-attempt intubation success rate than DL. Recently, Kim et al. conducted a meta-analysis and reported that although VL could not improve the first-attempt intubation success rate, it outperformed DL in inpatients, the difficult airway subgroup, and operators with limited experience [10].

Araújo et al. reported that VL could improve the first-attempt intubation success rate, but their study did not include patients with prehospital intubation [15]. Their meta-analysis did not perform a subgroup analysis to determine operators' experience with VL [10, 15].

The use of VL increased significantly after the coronavirus disease 2019 (COVID-19) pandemic, during which experience with VL expanded across various institutions, potentially influencing the results. Previous meta-analyses did not account for the research period [9, 10]. Meanwhile, a recent high-quality, large-scale RCT reported that the first-attempt intubation success rate of the VL group was significantly higher than that of the DL group, potentially influencing the findings [3].

Herein, a meta-analysis of RCTs was conducted to explore whether VL can increase the first-attempt intubation success rate and reduce intubation complications compared to DL.

Methods

This meta-analysis was registered in the International Prospective Register of Systematic Reviews (PROSPERO, registration number CRD42023456356). Two investigators (Yang and Yuan) performed a literature search, data extraction, and statistical analysis, and any discrepancies were resolved through a consensus discussion with a third party (Chen).

Literature search

Relevant studies were searched on the Web of Science, PubMed, and Embase electronic databases from inception until September 8, 2023. Additional publications were identified by screening the reference lists of the identified articles and relevant previously published reviews. Relevant publications were searched by a combination of subject terms and subheadings. The search terms used in this study were derived from a previous study, which included "video laryngoscope," "Glidescope," "video laryngoscopy," "C-MAC," and "McGrath," among others [9]. The search strategy is detailed in the supplementary document (Table S1).

Literature selection

Only RCTs comparing VL and DL for tracheal intubation of critically ill patients were included in this meta-analysis. The experimental population included patients in pre-hospital emergency care, emergency departments, and intensive care units.

Patient screening

The inclusion criteria included adult patients and critically ill patients requiring tracheal intubation. The exclusion criteria were surgical patients, patients with cervical spine injury, pediatric patients, cadaver models, and human models.

Outcomes

The primary outcome was the first-attempt intubation success rate. Secondary outcomes included intubation duration, overall intubation success rate, esophageal intubation rate, aspiration incidence rate, and hospital mortality rate.

Data extraction

Two investigators (Yang and Yu) independently performed data extraction, focusing mainly on patient baseline characteristics. The extracted data included study execution time, operator proficiency, sedative use, muscle relaxant use, presence of a difficult airway, incidence of cardiac arrest, and type of VL device used.

Experienced operators were defined as registered anesthesiologists, emergency medical service personnel, or physicians with over 3 years of intubation experience or >30 intubations [9]. Unlike previous studies, operator proficiency with VL was also assessed. Operator proficiency with VL was defined as VL long-term use experience before the study or ≥ 30 successful intubations with VL.

The mean and standard deviation (SD) for continuous variables were extracted, but if they could not be directly extracted, the median and interquartile range were converted to the mean and SD as previously described [16].

Based on previous studies, studies with a proportion of cardiopulmonary resuscitation patients close to or exceeding 50% were defined as Main, whereas those with less than 50% were defined as less [10]. Since the Cormack–Lehane score has high accuracy in predicting difficult airways, a Cormack–Lehane score ≥ 3 was defined as a difficult airway in our study. Meanwhile, studies with difficult airways $\geq 40\%$ were defined as Main, while those with $<40\%$ were defined as less.

Risk of bias and study quality assessment

Risk of bias assessment and study quality evaluation were conducted by two investigators (Yang and Yu). The Risk of Bias version 2 (ROB2) tool was used for risk of bias assessment [16]. The Grading of Recommendations Assessment, Development, and Evaluation (GRADE) system was used to evaluate the outcomes [17].

Statistical analysis

Continuous data were expressed as standardized mean difference (SMD) and 95% confidence interval (CI). Binary data were expressed as relative risk (RR) and 95% CI. A p-value <0.05 was considered statistically significant. The chi-squared test and I2 statistic were used to quantify heterogeneity. A random effects model should be used if the chi-squared test shows a p-value of less than 0.1. An I^2-value $\geq 50\%$ indicated high heterogeneity, and the random effects model was applied. An I^2-value $<50\%$ indicated low heterogeneity, and the fixed effects model was applied. If the results of the main outcome were from at least 10 trials, a funnel plot was used to assess bias qualitatively, and the trim-and-fill method was used to evaluate the change in results after correcting bias. The Begg's test method was used to quantitatively assess reporting bias.

Sensitivity analysis was performed for the first-attempt intubation success rate using the leave-one-out method. Meta-regression and subgroup analyses were performed for a pre-hospital and in-hospital emergency, difficult airway, study time, respiratory, cardiac arrest, operator proficiency, and VL proficiency.

Results

The initial search strategy yielded 4034 articles, of which 1489 were retained after removing duplicates. After screening the titles and abstracts, 84 articles were selected. Nine articles on pediatric patients, five on cervical spine injury, eight on non-RCTs, 15 on surgical patients, and 22 on irrelevant studies were excluded after full-text screening. Twenty-five studies involving 5836 patients were included in the final analysis [3, 11–14, 18–37] (Fig. 1).

Study characteristics and quality

The characteristics of the included studies are shown in Table 1. Five studies were multicenter RCTs [3, 22, 34, 35, 37], and 20 were single-center RCTs [11–14, 18–21, 23–33, 36]. Six studies were conducted in a pre-hospital setting [13, 33–37], and 19 studies were conducted in a hospital setting [3, 11, 12, 14, 18–32]. The 25 included studies were conducted in 14 countries, including Austria, Canada, Egypt, France, Germany, India, Iran, Japan, Korea, Switzerland, Thailand, Turkey, the United States, and China. Two studies [13, 25] were conducted before 2011, 8 studies [20, 24, 26–28, 30, 33, 37] were conducted between 2011 and 2014, 11 studies [11, 12, 18, 19, 21, 22, 29, 31, 32, 34, 35] were conducted between 2015 and 2018, and 4 studies [3, 14, 23, 36] were conducted after 2018. Seven studies focused on patients with cardiac arrest [13, 30, 33–37]. Fourteen studies [3, 11–13, 18, 19, 23, 27, 30, 32, 33, 35–37] had operators with extensive experience in endotracheal intubation, but only six studies [3, 12, 18, 23, 30, 36] had operators with extensive experience in VL. In the study by Arima et al. [33], although their institution had experience with VL, DL was used more often, and user experience bias could affect the final outcome, and this has been highlighted in the limitations section. Therefore, we classified the experience with VL in their study as "Unknown". In 4 studies [11, 13, 33, 37], the operators were more familiar with DL than VL. Only one study [26] had patients with difficult airways as the main. The specific characteristics are shown in Table 1. Figure 2 shows that 19 studies [3, 12–14, 18–21, 23, 25, 27–29, 31–33, 35–37] were categorized as low risk, five studies [22, 24, 26, 30, 34] were high risk, and one study had unknown risk. Table S2 shows the GRADE scores for the results.

First-attempt intubation success rate

No statistically significant difference in the first-attempt intubation success rate of patients was found between VL and the DL groups (25 studies; RR, 1.03; 95% CI 0.96–1.11; n = 5,836; $p = 0.37$; very low certainty) (Fig. 3, Table 2). Besides, no statistically significant difference in first-attempt intubation success rate was detected after correcting for bias by drawing a funnel plot with the trim-and-fill method (RR, 0.99; 95% CI 0.93–1.07; $p = 0.88$) (Figure S1). The Begg's test showed no obvious publication bias ($p = 0.76$).

Sensitivity and meta-regression analyses

The leave-one-out sensitivity analysis suggested that Trimmel et al. [13] and Trimmel et al. [37] had a great impact on the study results but without a statistical difference ($p > 0.05$) (Fig. 4). Meta-regression analysis revealed that study time (Fig. 5), whether intubation was performed in the hospital, cardiac arrest, and the difference in operator proficiency in VL and DL were the primary sources of bias ($p < 0.05$) (Table 3). Multivariate meta-regression analysis showed that whether an intubation was performed in the hospital and the operator proficiency with the difference between VL and DL were the main factors of bias ($p < 0.05$) (Table S3). After excluding studies with a difference in operator proficiency in VL and DL, the first-attempt intubation success rate was significantly higher in the VL group than in the DL group (21 studies; RR, 1.11; 95% CI 1.04–1.19; n = 5,026; $p < 0.01$, very low certainty) (Figure S2).

Subgroup analysis

In the pre-hospital subgroup, VL shows a trend towards reduced first-attempt intubation success rates, but without statistical significance (6 studies; RR, 0.75; 95% CI 0.56–1.00; n = 1395; $p = 0.05$, very low certainty) (FigureS3). In the in-hospital subgroup, the VL group had a significantly higher first-attempt intubation success rate than the DL group (19 studies; RR, 1.12; 95% CI 1.04–1.22; n = 4441; $p < 0.01$, very low certainty) (Figure S3). In the main difficult airway subgroup, only one report showed that the VL group had a higher first-attempt intubation success rate than the DL group (1 study; RR, 1.22; 95% CI 1.02–1.47; n = 97; $p = 0.03$; low certainty) (Figure S4, Table 2). In the less difficult airway subgroup, no statistical difference in the first-attempt intubation success rate was found between VL and DL groups (22 studies; RR, 1.02; 95% CI 0.94–1.11; n = 4,976; $p = 0.59$; very low certainty) (Figure S4, Table 2). In the main-cardiac arrest subgroup, the VL group had a lower risk of first-attempt intubation success than the DL group, but without a statistical difference (6 studies; RR, 0.85; 95% CI 0.68–1.08; n = 1,323; $p = 0.18$; very low certainty) (Figure S5, Table 2). In the less-cardiac arrest subgroup, VL improved the first-attempt intubation success rate

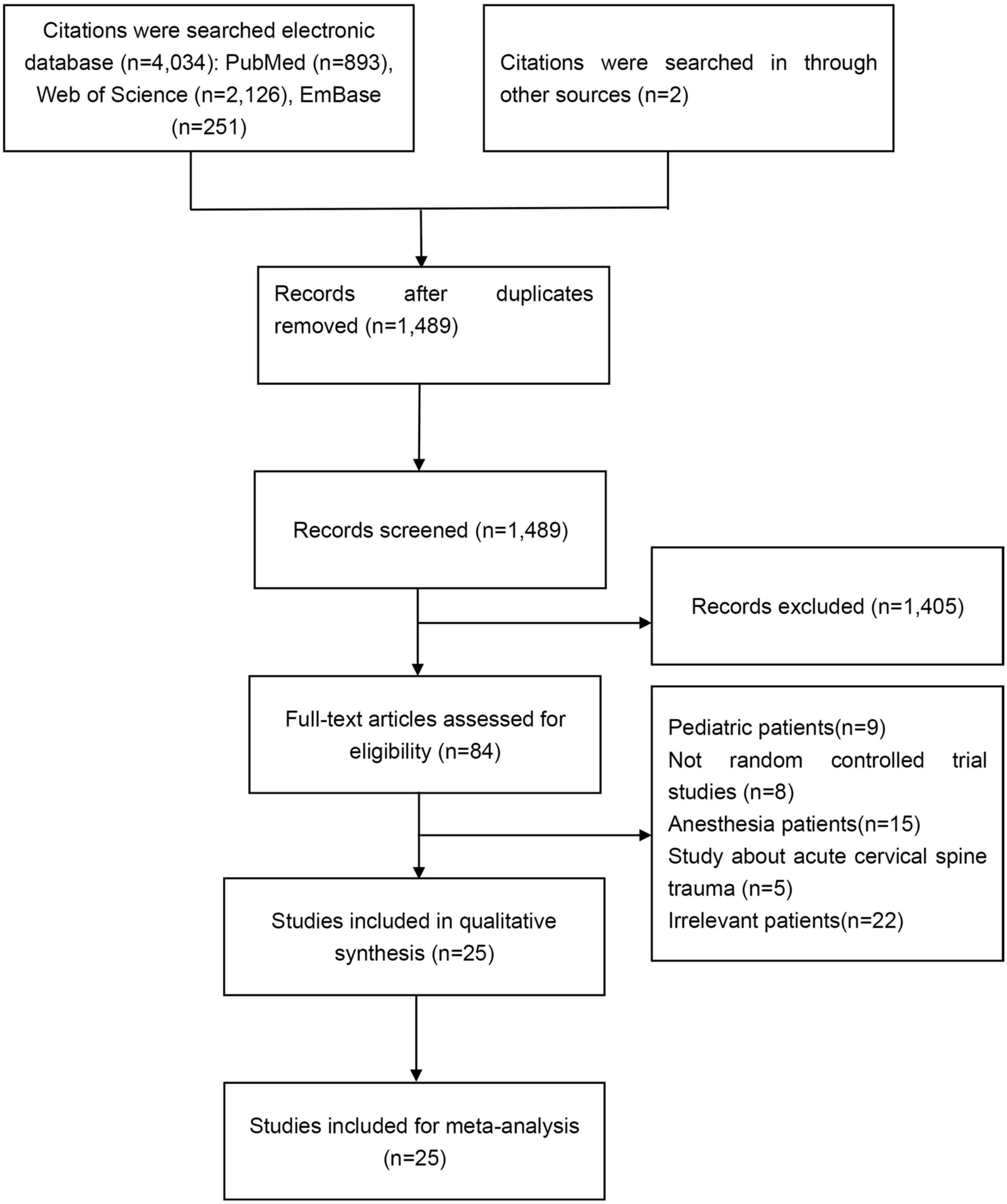


Fig. 1 Literature screening flowchart

of patients compared with DL (19 studies; RR, 1.09; 95% CI 1.00–1.18; n = 4,513; p = 0.04; very low certainty) (Figure S5, Table 2). No statistical difference in the first-attempt intubation success rate was found between VL and DL groups in the Lower 2011 subgroup (2 studies; RR, 0.73; 95% CI 0.37–1.41; n = 835; p = 0.34, low certainty), 2011–2014 subgroup (8 studies; RR, 1.02; 95% CI 0.81–1.28; n = 1177; p = 0.85; very low certainty) and the 2015–2018 subgroup (11 studies; RR, 1.06; 95% CI 0.97–1.16; n = 2040; p = 0.19) (Figure S6, Table 2). VL significantly increased the first-attempt intubation success rate in the Higher 2018 subgroup (4 studies; RR, 1.16; 95% CI 1.06–1.26; n = 1784; p < 0.01; low certainty) (Figure S6, Table 2). No significant

Table 1 Characteristics of the included studies

Study	Country	Time	Site	Sedatives in RSI	Muscle relaxants in RSI	Experience for VL	Experience for DL	Difficult airway	Cardiac arrest	Visualize the device
Trimmel et al. [13]	Austria	2008–2009	Pre-hospital	Used	Used	Unexperienced-Underwent a prestudy Airtraq instruction, manikin training, and gained supervised clinical Airtraq experience (two to five cases)	Experienced—Anesthesiologists and physicians with ≥ 3 y of clinical experience comprising at least 80 endotracheal intubations per year	Less	Less (cardiac arrest 47.6%)	Airtraq
Arima et al. [33]	Japan	2012–2013	Pre-hospital	Not used	Not used	Unknown-6 physicians had generally performed 100 intubations of 15 to 30 VL intubations per year.5 physicians had done an anesthesia rotation least 50 intubations, but fewer experiences with AL intubation	Experienced—physicians ≥ 3 years of working experience	Less	Main (cardiac arrest 92.6%)	Airway scope
Trimmel et al. [37]	Austria and Norway	2011–2012	Pre-hospital	Used	Used	Unexperienced-Physicians underwent 2 h of GlideScope training and were guided intubations (average, five cases) in the operating room	Experienced—physician-minimum clinical experience was 3.5 years (experienced)	Less	Main (cardiac arrest 63.2%)	GlideScope
Ducharme et al. [34]	United States	2014–2016	Pre-hospital	Not used	Not used	Unexperienced-Physicians had less experience for intubation	Unexperienced—physicians had performed proctored intubations on a manikin using each device	Less	Main (cardiac arrest 97.5%)	King Video

Table 1 (continued)

Study	Country	Time	Site	Sedatives in RSI	Muscle relaxants in RSI	Experience for VL	Experience for DL	Difficult airway	Cardiac arrest	Visualize the device
Kreutziger et al. [35]	Austria	2017–2018	Pre-hospital	Used	Used	Unknown-No report	Experienced—anesthesiologists or physicians with at least 4 years of post-graduate training including inpatient anesthesia	Less	Main (cardiac arrest 50%)	McGrathVL
Macke et al. [36]	Germany	2017–2019	Pre-hospital	Unknown	Unknown	Experienced-Had 1 year experienced	Most experienced—the experienced group had an experience > 100 intubations prior to this study, the less experienced group < 100 intubations in total	Less	Main (cardiac arrest 55.2%)	C-MAC
Ahmadi et al. [26]	Iran	2011	In-hospital	Unknown	Unknown	Unexperienced-Physicians had less experience for intubation	Unexperienced—second or third-year residents of emergency medicine	Main	Less (exclusion cardiopulmonary arrest)	GlideScope
Driver et al. [27]	United States	2011–2013	In-hospital	Used	Used	Unkonwn-No report	Most experienced—senior residents	Less	Less (cardiac arrest 4.5%)	C-MAC
Goksu et al. [28]	Turkey	2013–2014	In-hospital	Used	Unkonwn	Unexperienced-Physicians had less experience for intubation	Most unexperienced—the operators were residents and attending physicians	Less	Less (cardiac arrest 18%)	C-MAC
Kim et al. [30]	Korea	2011–2013	In-hospital	Not used	Not used	Experienced-Had 1 year experienced	Experienced—the advanced cardiovascular life support team (> 50 successful intubation)	Unknown	Main (only cardiac arrest)	GlideScope

Table 1 (continued)

Study	Country	Time	Site	Sedatives in RSI	Muscle relaxants in RSI	Experience for VL	Experience for DL	Difficult airway	Cardiac arrest	Visualize the device
Sulser et al. [32]	Switzerland	2014–2015	In-hospital	Used	Used	Unknown-No report	Experienced—Three experienced anesthesia consultants	Less	Less (exclusion cardiac arrest)	C-MAC
Ilbagi et al. [29]	Iran	2016–2018	In-hospital	Used	Used	Unexperienced-Physicians had less experience for intubation	Unexperienced—the second year emergency medicine resident	Less	Less (exclusion cardiac arrest)	Glidescope
Sanguanwit et al. [31]	Thailand	2015–2016	In-hospital	Used	Unknown	Unexperienced-Physicians had less experience for intubation	Unexperienced—students and Emergency Medicine Resident	Less	Less (report less cardiac arrest)	Glidescope
Prekker et al. [3]	United States	2022	In-hospital	Used	Used	Experienced-Video laryngoscope using proportion 0.69 (0.50 to 0.80)	Most experienced—91.5% of the intubations were performed by an emergency medicine resident or a critical care fellow	Less	Less (cardiac arrest 8.0%)	C-MAC, McGrath, MAC,GlideScope, LoPro,GlideScope A/GVL
Yeatts et al. [25]	United States	2008–2010	In-hospital	Used	Used	Unexperienced-Physicians had less experience for intubation	Most unexperienced—emergency medicine or anesthesiology residents with a minimum of 1 year of previous intubation experience	Unknown	Less (cardiac arrest 2.8%)	GlideScope
Griesdale et al. [20]	Canada	2009–2011	In-hospital	Used	Used	Unexperienced-Physicians had less experience for intubation	Unexperienced—medical students or non-anesthesiology residents	Less	Less (exclusion cardiopulmonary arrest)	Glidescope

Table 1 (continued)

Study	Country	Time	Site	Sedatives in RSI	Muscle relaxants in RSI	Experience for VL	Experience for DL	Difficult airway	Cardiac arrest	Visualize the device
Silverberg et al. [24]	United States	2012–2013	In-hospital	Used	Used	Unexperienced-Physicians had less experience for intubation	Unexperienced—eight fellows participated, with training levels ranging from post-graduate year 4 through 8	Less	Less (report less cardiac arrest)	Glidescope
Janz et al. [21]	United States	2014–2015	In-hospital	Used	Used	Unexperienced-Physicians had less experience for intubation	Unexperienced—Trained pulmonary and critical care medicine fellows	Less	Less (report less cardiac arrest)	McGrath MAC (98.6%), GlideScope (1.4%)
Lascarrou et al. [22]	France	2015–2016	In-hospital	Used	Used	Unexperienced-Physicians had less experience for intubation	Unexperienced (84.8%) and 15.2% experienced intubators	Less	Less (Exclusion cardiopulmonary arrest)	McGrath MAC
Gao et al. [11]	China	2014–2016	In-hospital	Used	Not used	Unexperienced-Physicians received handson training	Experienced—All the physicians involved had either worked at ICUs for at least 5 years	Less	Less (report less cardiac arrest)	VL300M,
Abdelgalel et al. [18]	Egypt	2016–2017	In-hospital	Used	Not used	Experienced-Performed more than 30 intubations with each of Airtraq and Glidescope	Experienced—ICU physician with more than 3 years and performed more than 30 intubations	Less	Less (exclusion cardiopulmonary arrest)	Glidescope and Airtraq
Grensemann et al. [19]	Germany	2016–2018	In-hospital	Used	Used	Unknown-No report	Experienced—at least one is a fellow or an attending physician with experience in intensive care medicine	Less	Less (report less cardiac arrest)	VivaSight

Table 1 (continued)

Study	Country	Time	Site	Sedatives in RSI	Muscle relaxants in RSI	Experience for VL	Experience for DL	Difficult airway	Cardiac arrest	Visualize the device
Dey et al. [12]	India	2017–2018	In-hospital	Used	Used	Experienced-Had experience of minimum fifty video laryngoscopies using C-MAC	Experienced—Snesthesiologists (laryngoscopes) had experience of minimum fifty intubation	Less	Less (exclusion cardiac arrest)	C-MAC
Dharanindra et al. [14]	India	2019	In-hospital	Used	Used	Unknown-No report	Unkonwn-anesthesia	Less	Less (report less cardiac arrest)	The King Vision
Shukla et al. [23]	India	2022	In-hospital	Used	Used	Experienced-Had done at least 30 successful intubation	Experienced-primary investigator who had done at least 30 successful intubations previously with each of these laryngoscopes	Less	Less (exclusion cardiac arrest)	BPL VL-02

VL Video laryngoscopy, *DL* direct laryngoscopy, *RSI* rapid sequence intubation

Fig. 2 Risk of bias summary

statistical difference in the first-attempt intubation success rate was observed between the VL and DL groups in the experienced operator subgroup (14 studies; RR, 0.98; 95% CI 0.89–1.08; n = 3841; p = 0.64; very low certainty) (Figure S7, Table 2). In the -inexperienced operator subgroup, there was an upward trend in the first-attempt intubation success rate in the VL group, but without a statistical difference (10 studies; RR, 1.11; 95% CI 0.99–1.24; n = 1852; p = 0.09; very low certainty) (Figure S7, Table 2). No significant difference was found between the VL and DL groups in the VL inexperienced subgroup (13 studies; RR, 0.99; 95% CI 0.84–1.15; n = 2553; p = 0.87, very low certainty) (Figure S8 Table 2). Similarly, there was an upward trend in first-attempt intubation success rate in the VL group in the VL experienced subgroup (6 studies; RR, 1.18; 95% CI 1.08–1.30; n = 2119; p < 0.01; very low certainty) (Figure S8, Table 2). VL reduced the first-attempt intubation success rate in the subgroup of operator proficiency with DL over VL (4 studies; RR, 0.65; 95% CI 0.49–0.88; n = 810; p < 0.01; very low certainty). VL increased the first-attempt intubation success rate in the operator proficiency without difference between the VL and DL subgroup (16 studies; RR, 1.14; 95% CI 1.06–1.23; n = 3971; p < 0.01; very low certainty) (Figure S9, Table 2).

Secondary outcomes

No statistically significant difference in the overall intubation success rate was found between VL and DL groups (19 studies; RR, 0.98; 95% CI 0.93–1.03; n = 4261; p = 0.34; very low certainty) (Figure S10, Table S4). Similarly, there was no significant difference in the intubation time between the two groups (21 studies; SMD, −0.05; 95% CI −0.29–0.18; n = 5273; p = 0.65; very low certainty) (Figure S11, Table S4). The esophageal intubation rate of the VL group was significantly lower than that of the DL group, with a statistically significant difference (13 studies; RR, 0.36; 95% CI 0.21–0.61; n = 3376; p < 0.01; moderate certainty) (Figure S12, Table S4). No statistically significant difference in the aspiration rate was observed between the two groups (7 studies; RR, 0.88; 95% CI 0.51–1.54; n = 2463; p = 0.66; low certainty) (Figure S13, Table S4). No statistically significant difference in the hospital mortality rate was found between VL and DL groups (6 studies; RR, 1.04; 95% CI 0.93–1.18; n = 2591; p = 0.47; low certainty) (Figure S14, Table S4).

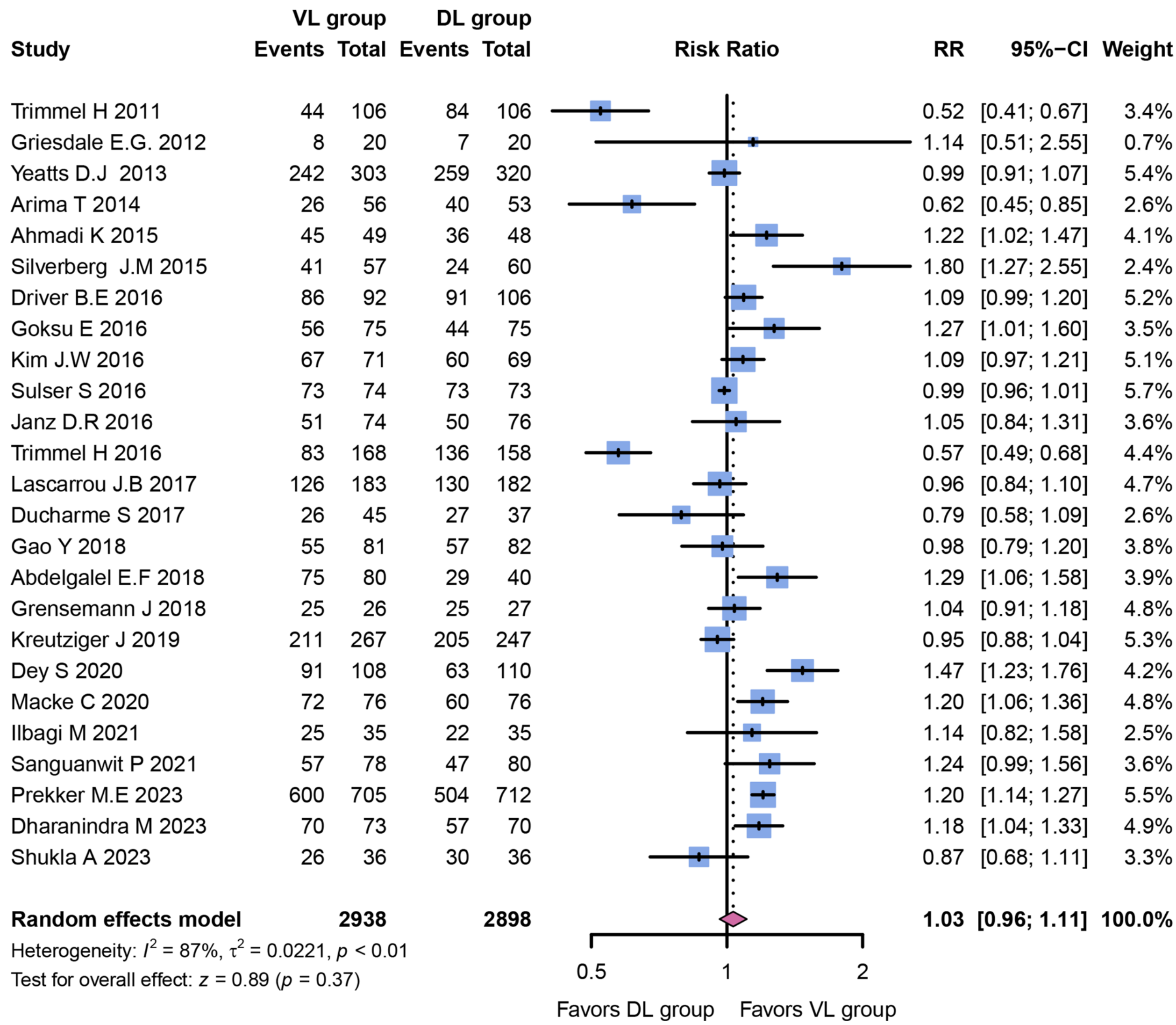


Fig. 3 VL vs. DL for first-attempt intubation success rate. *VL* Video laryngoscopy, *DL* direct laryngoscopy, *RR* relative risk, *CI* confidence interval

Discussion

In this study, VL did not significantly increase the first-attempt intubation success rate compared with DL. However, there was marked heterogeneity in the results. Meta-regression analysis with an unadjusted model showed that the primary sources of heterogeneity were the time of the study, whether intubation was performed in-hospital, cardiac arrest, and differences in operator proficiency in the application of DL and VL. Multivariate meta-regression analysis shows the result is influenced by the operator proficiency with DL over VL, study site. Sensitivity analysis excluding studies of operator proficiency with DL over VL showed that the VL group had a higher first-attempt intubation success rate than the DL group. In the in-hospital subgroup, less-cardiac arrest subgroup, main-difficult airway subgroup, higher 2018 subgroup, VL experienced subgroup, and operator proficiency with no difference between VL and DL subgroup, VL increased the first-attempt intubation success rate. Meanwhile, VL reduced the probability of esophageal intubation.

VL is a laryngoscope blade with a high-definition camera mounted on the front end, which transmits the image in front of the laryngoscope to a monitor [38]. VL has a better view than the traditional laryngoscope. While the operator's field of view is only 10–15 degrees under DL, the VL expands the field of view to about 60–80 degrees, significantly improving the visibility of the glottis [39]. VL has achieved good results in surgical anesthesia applications, increasing the patient's

Table 2 VL vs. DL for first-attempt intubation success rate

First outcome	Studies	Patients	Heterogeneity	Heterogeneity statistical method	Effect estimate (p value)
First-attempt intubation success rate	25	5836	87%, p < 0.01	Risk ratio (M-H, random, 95% CI)	1.03 [0.96–1.11] (p = 0.37)
Sensitivity analysis	21	5026	86%, p < 0.01	Risk ratio (M-H, random, 95% CI)	1.11 [1.04–1.19] (p < 0.01)
Subgroup analysis					
Intubation site					
Pre-hospital	6	1395	94%, p < 0.01	Risk ratio (M-H, random, 95% CI)	0.75 [0.56–1.00] (p = 0.05)
In-hospital	19	4441	87%, p < 0.01	Risk ratio (M-H, random, 95% CI)	1.12 [1.04–1.22] (p < 0.01)
Difficult airway					
Less	22	4976	89%, p < 0.01	Risk ratio (M-H, random, 95% CI)	1.02 [0.94–1.11] (p = 0.59)
Main	1	97	_	Risk ratio (M-H, random, 95% CI)	1.22 [1.02–1.47] (p = 0.03)
Cardiac arrest					
Less	19	4513	88%, p < 0.01	Risk ratio (M-H, random, 95% CI)	1.09 [1.00–1.18] (p = 0.04)
Main	6	1323	93%, p < 0.01	Risk ratio (M-H, random, 95% CI)	0.85 [0.68–1.08] (p = 0.18)
Study time					
Lower2011	2	835	98%, p < 0.01	Risk ratio (M-H, random, 95% CI)	0.73 [0.37–1.41] (p = 0.34)
2011–2014	8	1177	92%, p < 0.01	Risk ratio (M-H, random, 95% CI)	1.02 [0.81–1.28] (p = 0.85)
2015–2018	11	2040	80%, p < 0.01	Risk ratio (M-H, random, 95% CI)	1.06 [0.97–1.16] (p = 0.19)
Higher2018	4	1784	53%, p = 0.10	Risk ratio (M-H, random, 95% CI)	1.16 [1.06–1.26] (p < 0.01)
Operator proficiency for intubation					
Experienced	14	3841	92%, p < 0.01	Risk ratio (M-H, random, 95% CI)	0.98 [0.89–1.08] (p = 0.64)
Unexperienced	10	1852	63%, p < 0.01	Risk ratio (M-H, random, 95% CI)	1.11 [0.99–1.24] (p = 0.09)
Operator proficiency for VL					
Experienced	6	2119	68%, p < 0.01	Risk ratio (M-H, random, 95% CI)	1.18 [1.08–1.30] (p < 0.01)
Unexperienced	13	2553	87%, p < 0.01	Risk ratio (M-H, random, 95% CI)	0.99 [0.84–1.15] (p = 0.87)
Operator proficiency was higher for DL than for VL					
No	16	3971	71%, p < 0.01	Risk ratio (M-H, random, 95% CI)	1.14 [1.06–1.23] (p < 0.01)
Yes	4	810	85%, p < 0.01	Risk ratio (M-H, random, 95% CI)	0.65 [0.49–0.88] (p < 0.01)

VL Video laryngoscopy, *DL* direct laryngoscopy, *RCT* Randomized controlled trials, *RR* relative risk, *CI* confidence interval, *M-H* Mantel–Haenszel

one-time intubation success rate and reducing the risk of esophageal intubation, ultimately achieving better results in difficult airway patients and inexperienced doctors [40, 41].

Critical patients often have difficulty in effective pain relief and sedation, hemodynamic instability, severe airway contamination, severe hypoxemia, and other conditions. Tracheal intubation of critically ill patients is more difficult than that of surgical patients. Critically ill patients have hypoxia, and rapid establishment of the airway can help reduce hypoxia time and complications such as atrial fibrillation, hypotension, aspiration, bleeding, etc. [42]. The clinical application of VL in critically ill patients remains controversial. Trimmel et al. and Arima et al. reported that VL reduced the first-attempt intubation success rate [13, 33, 37]. However, some RCTs reported that VL can increase the first-attempt intubation success rate of critically ill patients [12, 24, 26, 36]. The discrepancies between the results may be attributed to variations in in-hospital intubation rates, study time, difficult airway ratio, respiratory cardiac arrest ratio, and operator proficiency.

Our study found that VL did not increase the first-attempt intubation success rate but with high levels of heterogeneity. This result is consistent with that reported in a previous study [10]. In contrast, Azam et al. found that VL is a more effective and safer strategy than DL in terms of improving the first-attempt intubation success. This difference observed with our findings is likely due to the inclusion of observational studies in Azam's study [43]. Meta-regression analysis with an unadjusted model showed that this result was affected by different factors such as in-hospital intubation, study time, respiratory cardiac arrest ratio, and operator proficiency of VL and DL. VL reduced the first-attempt intubation success rate in the pre-hospital emergency subgroup (p = 0.05) but increased the first-attempt intubation success rate in the in-hospital intubation patients. This result is similar to the meta-analysis results of Jing et al. and Kim et al. [9, 10]. Pre-hospital emergency intubation often faces

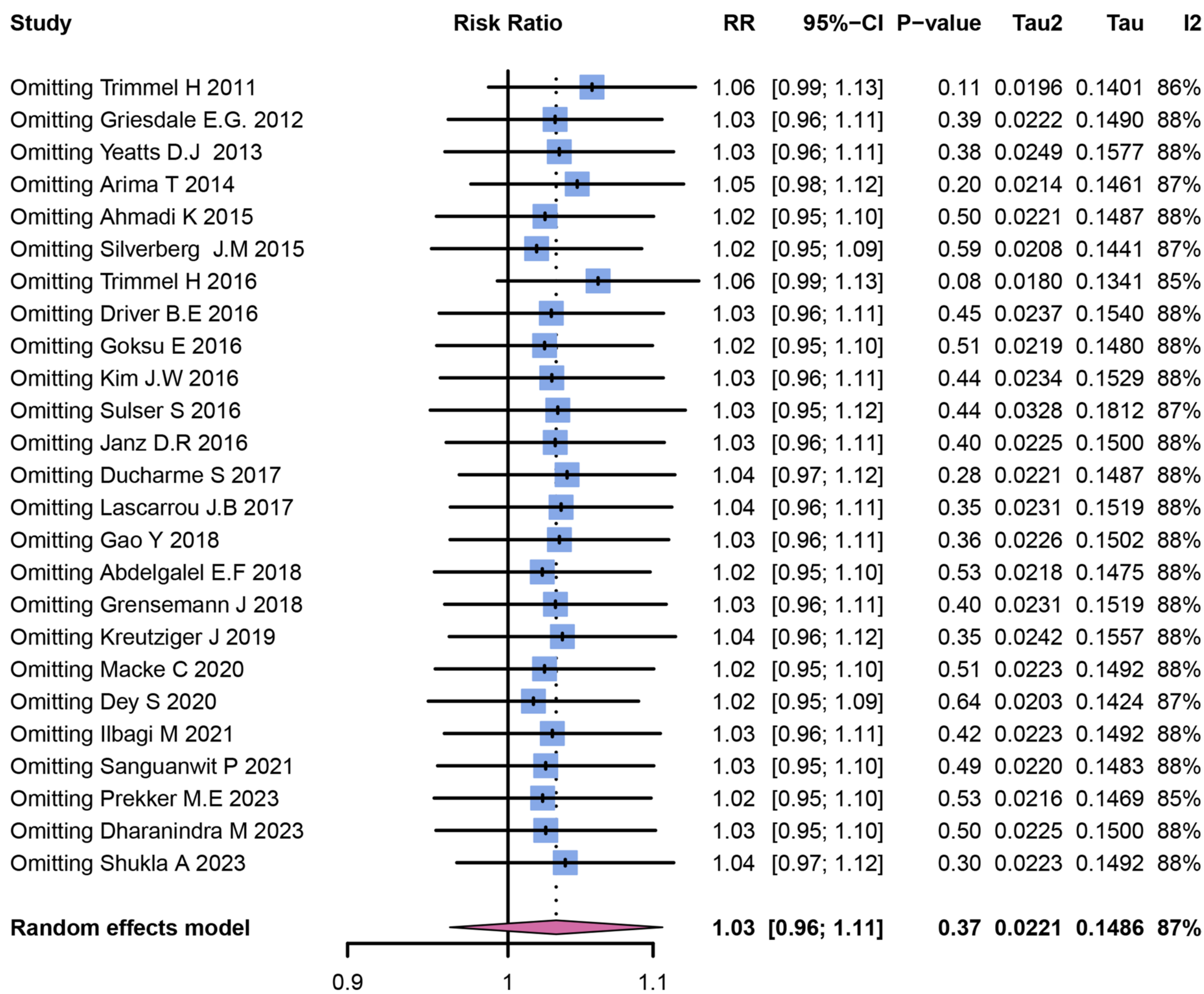


Fig. 4 Leave-one-out sensitivity analysis forest plot for first-attempt intubation success rate. *VL* Video laryngoscopy, *DL* direct laryngoscopy, *RR* relative risk, *CI* confidence interval

a series of problems. Trimmel et al. reported that the main reason for the failure of VL intubation was oral contamination, leading to insufficient light source and lens fogging, as well as environmental light, which leads to insufficient display brightness [13, 37]. Although VL can better expose the glottis, it further complicates the intubation process because the mouth, pharyngeal axis, and laryngeal axis are not in a straight line, offsetting the benefits of sufficient exposure [3, 22]. In-hospital intubation has some advantages over pre-hospital intubation, such as adequate staff and external environment, timely treatment of oral contamination, reduced camera fogging, and sufficient analgesia and sedation for patients. The different outcomes of pre-hospital and in-hospital intubation may also be influenced by factors such as study time and operator proficiency. Some studies in the pre-hospital subgroup were completed before 2019, and meta-regression analysis showed that the results were more favorable to the VL group as the study year increased. Additionally, in the pre-hospital subgroup, although Trimmel et al. studies had operators with more tracheal intubation experience, they only used VL for 2–5 cases under the operating room [13, 37]. In the study by Arima et al. [33], half of the operators had VL experience but significantly less than DL. It is likely that these operators may have some mastery of DL but to a lesser degree compared with VL. After excluding studies with this phenomenon [11, 13, 33, 37], sensitivity analysis showed that VL increased the first-attempt intubation success rate of critically ill patients. Whether VL can increase the first-attempt intubation success rate of pre-hospital intubation patients warrants further exploration.

The subgroup analysis on time demonstrated that studies after 2018 tended to show that VL increased the

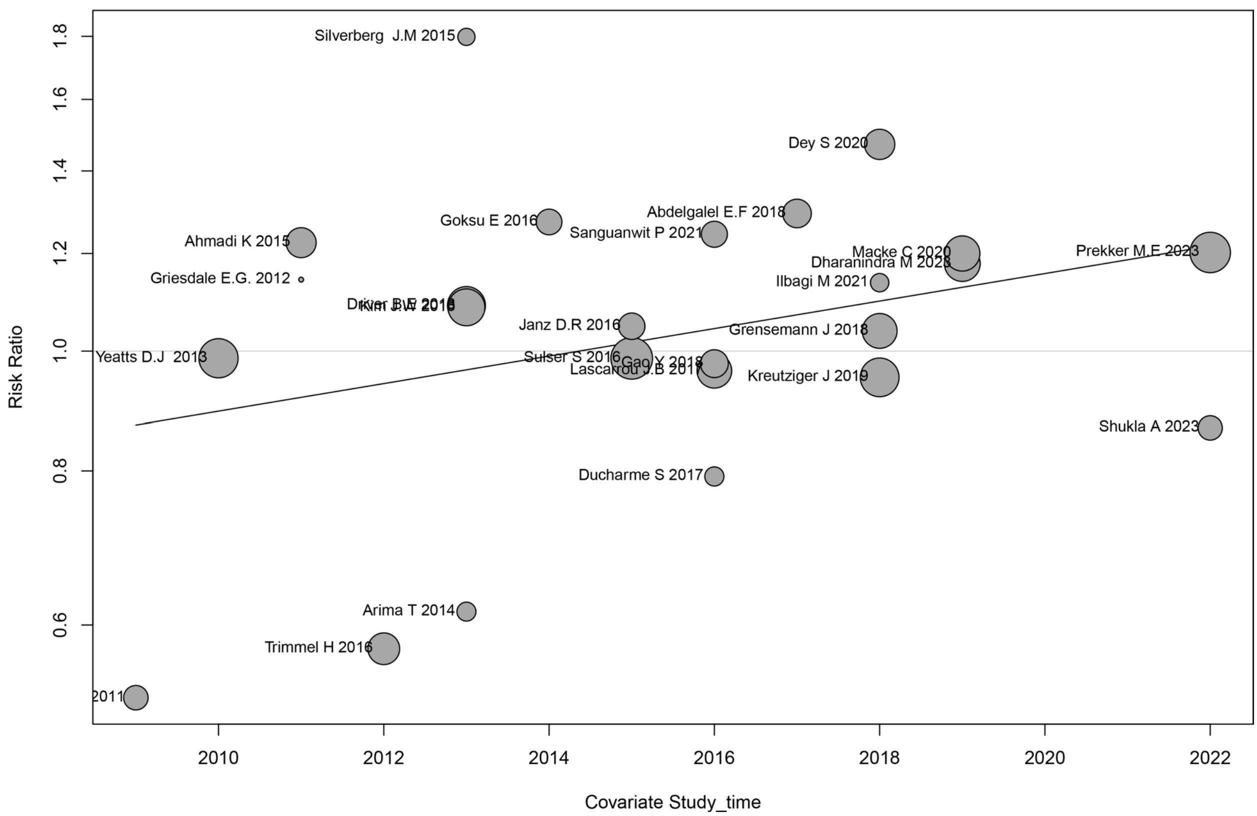


Fig. 5 Meta-regression analysis bubble plot of study time and first intubation success rate

Table 3 The results of meta-regression analysis of unadjusted model

Factor	Tau^2	Estimate	95%CI	p
Site-prehospital	0.02	−0.37	−0.53 ~ −0.21	< 0.001
Study time	0.02	0.03	0.01 ~ 0.05	< 0.001
Difficult airway-Main	0.03	0.18	−0.20 ~ 0.56	0.347
Cardiac arrest-Main	0.02	−0.21	−0.38 ~ −0.05	0.009
Operator proficiency for intubation-Unexperienced	0.02	0.13	−0.03 ~ 0.29	0.102
Operator proficiency for VL -Unexperienced	0.03	−0.18	−0.39 ~ 0.03	0.084
Operator proficiency was higher for DL than for VL	0.01	−0.52	−0.69 ~ −0.35	< 0.001

VL Video laryngoscopy, *DL* direct laryngoscopy, *CI* confidence interval

first-attempt intubation success rate. This may be related to the increased experience of using VL after 2018. VL was increasingly applied during the COVID-19 epidemic to increase the distance between physicians and patients and reduce the risk of infection [44]. Meanwhile, based on the studies included in the analysis, the proportion of experienced physicians in the VL group increased significantly after 2018. In a multifactorial meta-regression model, no significant difference in the study time was found between the two groups, but there was a significant statistical in operator proficiency between VL and DL. The high effect of research time on the outcome may be ascribed to the increase in VL usage experience.

Subgroup analysis suggested that patients with a lower proportion of cardiopulmonary arrest were more likely to benefit from VL. This result was different from that of Kim et al. [10], mainly due to the inclusion of a study by Prekker et al. [3], a large-sample, multi-center study in which VL showed better performance than DL [3, 10].

Cox et al. and Jing et al. reported that VL can reduce the rate of esophageal intubation [9, 45], which corresponds with our results. This may be related to the better visual exposure of VL. Intubation under direct vision can reduce the possibility of the tube entering the esophagus.

Although we found that VL did not improve the first-attempt intubation success rate, the quality of evidence is low due to the high heterogeneity among populations enrolled in the respective studies and methods used. Proficiency is a major factor influencing the success rate of first-attempt intubation. As clinicians become familiar with the use of VL, its adoption will increase in multiple institutions. Although the results do not support the utility of VL in pre-hospital emergency care, the results regarding the benefits of DL and VL differ across studies due to differences in operator proficiency. Therefore, further studies are needed to clarify whether VL can improve the success rate of first-attempt intubation in prehospital emergency care.

Limitations

Firstly, due to the complexity of the study design, each subgroup included different patients, differing in whether they were intubated in the hospital, blade types, channel-type VL, difficult airway proportion, cardiopulmonary arrest proportion, and operator proficiency. These factors may bias the study results. In the subgroup analysis, it was difficult to control other factors while controlling for one factor, resulting in results with a high level of heterogeneity. Secondly, there is no accurate and quantitative indicator for assessing operator proficiency, and thus, the intubation level varied even among operators who were rated as experienced. Moreover, it was difficult to determine the number of VL in most studies, which might reduce the robustness of results of the VL proficiency subgroup.

Conclusions

In this study, VL did not improve the first-attempt intubation success rate compared with DL, but this finding may be affected by the high heterogeneity across studies, the operator proficiency with DL over VL, and in-hospital intubation. In addition, VL can improve the first-attempt intubation success rate in in-hospital intubation, difficult airway, non-respiratory cardiac arrest, and rich experience in VL operation subgroups.

Abbreviations

VL	Video laryngoscopy
RCTs	Randomized controlled trials
DL	Direct laryngoscopy
COVID-19	Coronavirus disease 2019
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
SD	Standard deviation
GRADE	Grading of Recommendations Assessment, Development, and Evaluation
SMD	Standardized mean difference
CI	Confidence interval
RR	Relative risk

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s40001-025-02525-3.

Supplementary Material 1. Figure S1. Enhanced funnel of first-attempt intubation success rate drawing by trim and filling method.

Supplementary Material 2. Figure S2. The sensitivity analysis removes studies with differences in operator proficiency between VL and DL. VL: Video laryngoscopy; DL: Direct laryngoscopy; RCT: Randomized controlled trials; RR: Relative risk; CI: Confidence interval; M-H: Mantel-Haenszel.

Supplementary Material 3. Figure S3. Subgroup of intubation sites in first-attempt intubation success rate. VL: Video laryngoscopy; DL: Direct laryngoscopy; RCT: Randomized controlled trials; RR: Relative risk; CI: Confidence interval.

Supplementary Material 4. Figure S4. Subgroup of difficult airways in first-attempt intubation success rate. VL: Video laryngoscopy; DL: Direct laryngoscopy; RCT: Randomized controlled trials; RR: Relative risk; CI: Confidence interval.

Supplementary Material 5. Figure S5. Subgroup of cardiac arrest in first-attempt intubation success rate. VL: Video laryngoscopy; DL: Direct laryngoscopy; RCT: Randomized controlled trials; RR: Relative risk; CI: Confidence interval.

Supplementary Material 6. Figure S6. Subgroup of study time in first-attempt intubation success rate. VL: Video laryngoscopy; DL: Direct laryngoscopy; RCT: Randomized controlled trials; RR: Relative risk; CI: Confidence interval.

Supplementary Material 7. Figure S7. Subgroup of intubators experience in first-attempt intubation success rate. VL: Video laryngoscopy; DL: Direct laryngoscopy; RCT: Randomized controlled trials; RR: Relative risk; CI: Confidence interval.

Supplementary Material 8. Figure S8. Subgroup of operator proficiency for VL in first-attempt intubation success. VL: Video laryngoscopy; DL: Direct laryngoscopy; RCT: Randomized controlled trials; RR: Relative risk; CI: Confidence interval.

Supplementary Material 9. Figure S9. Subgroup of operator proficiency with difference between VL and DL in first-attempt intubation success. VL: Video laryngoscopy; DL: Direct laryngoscopy; RCT: Randomized controlled trials; RR: Relative risk; CI: Confidence interval.

Supplementary Material 10. Figure S10. VL vs. DL for overall intubation success rate. VL: Video laryngoscopy; DL: Direct laryngoscopy; RR: Relative risk; CI: Confidence interval.

Supplementary Material 11. Figure S11. VL vs. DL for intubation time. VL: Video laryngoscopy; DL: Direct laryngoscopy; SD: Standard Deviation; SMD: Standardized Mean Difference; CI: Confidence interval.

Supplementary Material 12. Figure S12. VL vs. DL for esophageal intubation rate. VL: Video laryngoscopy; DL: Direct laryngoscopy; RR: Relative risk; CI: Confidence interval.

Supplementary Material 13. Figure S13. VL vs. DL for aspiration rate. VL: Video laryngoscopy; DL: Direct laryngoscopy; RR: Relative risk; CI: Confidence interval.

Supplementary Material 14. Figure S14. VL vs. DL for hospital mortality. VL: Video laryngoscopy; DL: Direct laryngoscopy; RR: Relative risk; CI: Confidence interval.

Supplementary Material 15. Table S1. Search strategy and process.

Supplementary Material 16. Table S2. GRADE score of results.

Supplementary Material 17. Table S3. The results of multivariate meta-regression analysis of first intubation success rate. VL: Video Laryngoscopy; DL: Direct Laryngoscopy; CI: Confidence Interval.

Supplementary Material 18. Table S4. Secondary outcomes. RR: Relative Risk; CI: Confidence Interval; M-H: Mantel-Haenszel; SMD: Standardized Mean Difference.

Acknowledgements

The authors would like to thank all the reviewers who participated in the review, and MJEditor (www.mjeditor.com), for providing English editing services during the preparation of this manuscript.

Author contributions

PL Y and J Y designed the study, performed data analysis, and wrote the manuscript; QH C and J W revised the manuscript and submitted the report. WG Z and JQ Y wrote the results and the discussion. LN Y prepared picture. All authors read and approved the final manuscript.

Funding

This study was supported by funding obtained from the Jiangsu Health Committee scientific research project (Z2022008) and the project of the Yangzhou Health Commission (2023-2-27).

Availability of data and materials

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

Approval by an ethics committee was not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Author details

[1]Department of Critical Care Medicine, Jiangdu People's Hospital Affiliated to Yangzhou University, Yangzhou 225200, China. [2]Department of Emergency, Jingjiang People's Hospital, Jingjiang 214599, China. [3]Department of Critical Care Medicine, Northern Jiangsu People's Hospital, Yangzhou 225001, Jiangsu, China.

Received: 3 April 2024 Accepted: 27 March 2025
Published online: 15 April 2025

References

1. Gannon WD, Lederer DJ, Biscotti M, et al. Outcomes and mortality prediction model of critically ill adults with acute respiratory failure and interstitial lung disease. Chest. 2018;153(6):1387–95.
2. Mort TC. Emergency tracheal intubation: complications associated with repeated laryngoscopic attempts. Anesth Analg. 2004;99(2):607–13 (**table of contents**).
3. Prekker ME, Driver BE, Trent SA, et al. Video versus direct laryngoscopy for tracheal intubation of critically ill adults. N Engl J Med. 2023;389(5):418–29.
4. Berkow LC, Morey TE, Urdaneta F. The technology of video laryngoscopy. Anesth Analg. 2018;126(5):1527–34.
5. MacKinnon J, McCoy C. Use of video laryngoscopy versus direct laryngoscopy as a teaching tool for neonatal intubation: a systematic review. Can J Respir Ther. 2023;59:111–6.
6. Russotto V, Myatra SN, Laffey JG, et al. Intubation practices and adverse Peri-intubation events in critically ill patients from 29 countries. JAMA. 2021;325(12):1164–72.
7. Groombridge CJ, Maini A, Olaussen A, et al. Unintended consequences: the impact of airway management modifications introduced in response to COVID-19 on intubations in a tertiary center emergency department. Emerg Med Australas. 2021;33(4):728–33.
8. Aziz MF, Brambrink AM, Healy DW, et al. Success of intubation rescue techniques after failed direct laryngoscopy in adults: a retrospective comparative analysis from the multicenter perioperative outcomes group. Anesthesiology. 2016;125(4):656–66.
9. Jiang J, Ma D, Li B, et al. Video laryngoscopy does not improve the intubation outcomes in emergency and critical patients—a systematic review and meta-analysis of randomized controlled trials. Crit Care. 2017;21(1):288.
10. Kim JG, Ahn C, Kim W, et al. Comparison of video laryngoscopy with direct laryngoscopy for intubation success in critically ill patients: a systematic review and Bayesian network meta-analysis. Front Med (Lausanne). 2023;10:1193514.
11. Gao YX, Song YB, Gu ZJ, et al. Video versus direct laryngoscopy on successful first-pass endotracheal intubation in ICU patients. World J Emerg Med. 2018;9(2):99–104.
12. Dey S, Pradhan D, Saikia P, et al. Intubation in the intensive care unit: C-MAC video laryngoscope versus Macintosh laryngoscope. Med Intensiva (Engl Ed). 2020;44(3):135–41.
13. Trimmel H, Kreutziger J, Fertsak G, et al. Use of the Airtraq laryngoscope for emergency intubation in the prehospital setting: a randomized control trial. Crit Care Med. 2011;39(3):489–93.
14. Dharanindra M, Jedge PP, Patil VC, et al. Endotracheal intubation with king vision video laryngoscope vs macintosh direct laryngoscope in ICU: a comparative evaluation of performance and outcomes. Indian J Crit Care Med. 2023;27(2):101–6.
15. Araújo B, Rivera A, Martins S, et al. Video versus direct laryngoscopy in critically ill patients: an updated systematic review and meta-analysis of randomized controlled trials. Crit Care. 2024;28(1):1.
16. Higgins JPT GS, editors. http://handbook-5-1.cochrane.org/. Cochrane handbook for systematic reviews of interventions. Version 5.1 [updated March 2011]. The Cochrane Collaboration. http://handbook-5-1.cochrane.org/. Accessed 15 June 2015.
17. Guyatt GH, Oxman AD, Schünemann HJ, et al. GRADE guidelines: a new series of articles in the Journal of Clinical Epidemiology. J Clin Epidemiol. 2011;64(4):380–2.
18. Abdelgalel EF, Mowafy SMS. Comparison between Glidescope, Airtraq and Macintosh laryngoscopy for emergency endotracheal intubation in intensive care unit: Randomized controlled trial. Egypt J Anaesth. 2018;34(4):123–8.
19. Grensemann J, Eichler L, Wang N, et al. Endotracheal tube-mounted camera-assisted intubation versus conventional intubation in intensive care: a prospective, randomised trial (VivaITN). Crit Care. 2018;22(1):235.
20. Griesdale DE, Chau A, Isac G, et al. Video-laryngoscopy versus direct laryngoscopy in critically ill patients: a pilot randomized trial. Can J Anaesth. 2012;59(11):1032–9.
21. Janz DR, Semler MW, Lentz RJ, et al. Randomized trial of video laryngoscopy for endotracheal intubation of critically ill adults. Crit Care Med. 2016;44(11):1980–7.
22. Lascarrou JB, Boisrame-Helms J, Bailly A, et al. Video laryngoscopy vs direct laryngoscopy on successful first-pass orotracheal intubation among ICU patients: a randomized clinical trial. JAMA. 2017;317(5):483–93.
23. Shukla A, Shanker R, Singh VK, et al. Non-channeled video laryngoscopy as an alternative to conventional laryngoscopy for intubating adult patients in the intensive care unit. Cureus. 2023;15(6): e40716.
24. Silverberg MJ, Li N, Acquah SO, et al. Comparison of video laryngoscopy versus direct laryngoscopy during urgent endotracheal intubation: a randomized controlled trial. Crit Care Med. 2015;43(3):636–41.
25. Yeatts DJ, Dutton RP, Hu PF, et al. Effect of video laryngoscopy on trauma patient survival: a randomized controlled trial. J Trauma Acute Care Surg. 2013;75(2):212–9.
26. Ahmadi K, Ebrahimi M, Hashemian AM, et al. GlideScope video laryngoscope for difficult intubation in emergency patients: a quasi-randomized controlled trial. Acta Med Iran. 2015;53(12):738–42.
27. Driver BE, Prekker ME, Moore JC, et al. Direct versus video laryngoscopy using the C-MAC for tracheal intubation in the emergency department, a randomized controlled trial. Acad Emerg Med. 2016;23(4):433–9.
28. Goksu E, Kilic T, Yildiz G, et al. Comparison of the C-MAC video laryngoscope to the Macintosh laryngoscope for intubation of blunt trauma patients in the ED. Turk J Emerg Med. 2016;16(2):53–6.

29. Ilbagi M, Nasr-Esfahani M. The efficacy of using video laryngoscopy on tracheal intubation by novice physicians. Iran J Otorhinolaryngol. 2021;33(114):37–44.
30. Kim JW, Park SO, Lee KR, et al. Video laryngoscopy vs. direct laryngoscopy: which should be chosen for endotracheal intubation during cardiopulmonary resuscitation? A prospective randomized controlled study of experienced intubators. Resuscitation. 2016;105:196–202.
31. Sanguanwit P, Yuksen C, Laowattana N. Direct versus video laryngoscopy in emergency intubation: a randomized control trial study. Bull Emerg Trauma. 2021;9(3):118–24.
32. Sulser S, Ubmann D, Schlaepfer M, et al. C-MAC videolaryngoscope compared with direct laryngoscopy for rapid sequence intubation in an emergency department: a randomised clinical trial. Eur J Anaesthesiol. 2016;33(12):943–8.
33. Arima T, Nagata O, Miura T, et al. Comparative analysis of airway scope and Macintosh laryngoscope for intubation primarily for cardiac arrest in prehospital setting. Am J Emerg Med. 2014;32(1):40–3.
34. Ducharme S, Kramer B, Gelbart D, et al. A pilot, prospective, randomized trial of video versus direct laryngoscopy for paramedic endotracheal intubation. Resuscitation. 2017;114:121–6.
35. Kreutziger J, Hornung S, Harrer C, et al. Comparing the McGrath Mac video laryngoscope and direct laryngoscopy for prehospital emergency intubation in air rescue patients: a multicenter, randomized. Controlled Trial Crit Care Med. 2019;47(10):1362–70.
36. Macke C, Gralla F, Winkelmann M, et al. Increased first pass success with C-MAC videolaryngoscopy in prehospital endotracheal intubation-a randomized controlled trial. J Clin Med. 2020;9(9):2719.
37. Trimmel H, Kreutziger J, Fitzka R, et al. Use of the GlideScope ranger video laryngoscope for emergency intubation in the prehospital setting: a randomized control trial. Crit Care Med. 2016;44(7):e470-476.
38. Stopar Pintarič T. Videolaryngoscopy as a primary intubation modality in obstetrics: a narrative review of current evidence. Biomol Biomed. 2023;23:949.
39. Scott-Brown S, Russell R. Video laryngoscopes and the obstetric airway. Int J Obstet Anesth. 2015;24(2):137–46.
40. Hansel J, Rogers AM, Lewis SR, et al. Videolaryngoscopy versus direct laryngoscopy for adults undergoing tracheal intubation. Cochrane Database Syst Rev. 2022;4(4): CD011136.
41. Lee J, Cho Y, Kim W, et al. Comparisons of videolaryngoscopes for intubation undergoing general anesthesia: systematic review and network meta-analysis of randomized controlled trials. J Pers Med. 2022;12(3):363.
42. Sklar MC, Detsky ME. Emergent airway management of the critically ill patient: current opinion in critical care. Curr Opin Crit Care. 2019;25(6):597–604.
43. Azam S, Khan ZZ, Shahbaz H, et al. Video versus direct laryngoscopy for intubation: updated systematic review and meta-analysis. Cureus. 2024;16(1): e51720.
44. El-Boghdadly K, Wong DJN, Owen R, et al. Risks to healthcare workers following tracheal intubation of patients with COVID-19: a prospective international multicentre cohort study. Anaesthesia. 2020;75(11):1437–47.
45. Cox L, Tebbett A. Videolaryngoscopy versus direct laryngoscopy for endotracheal intubation of cardiac arrest patients in hospital: a systematic literature review. Resusc Plus. 2022;11: 100297.

Publisher's Note