

Comparative Effectiveness of Video Laryngoscope and Conventional Laryngoscope for Endotracheal Intubation

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ABSTRACT

Background : Endotracheal intubation is a vital procedure with risk of failure using conventional laryngoscope (CL), especially in difficult anatomy. Video laryngoscope (VL) offers indirect visualization, but its effectiveness remains controversial.

Objective : To analyze the effectiveness of VL (including McGrath Mac) versus CL in adult patient, including first-pass succes, intubation time, complications, operator influence and human factors.

Methods : Literature search in Pubmed, ScienceDirect and Google Scholar, identifying RCTs (2020-2025) in adults patients. Analysis with the Joanna Briggs Institute (JBI) selected three high-quality studies (score>75%).

Result : VL significantly improved first-pass succes rate: 94% vs. 82% ($p<0.001$; elective), 85.1% vs. 70.8% ($p<0.001$; critical), and non-inferiority (COVALENT-T). Cormack-Lehane score ≥ 3 decreased (0.7% vs. 8%; $p<0.001$). Severe complications were not significantly different ($p\geq 0.82$). COVALENT-T integrates human factors (task load, teamwork).

Conclusion : VL improves first intubation succes, airway visualization and time efficiency, especially for novice operators, without the risk of additional complications. Findings recommendations need to take into account blade type, operator experience and patient context.

Keywords : First-pass succes, Tracheal Intubation, Adult Patient, Video Laryngoscopy vs. Conventional.

INTRODUCTION

Tracheal intubation is a vital procedure in airway management in adult patients, both in the perioperative and emergency context (Cumberworth et al., 2022). This procedure aims to ensure adequate ventilation, especially in patient with acute respiratory distress or those undergoing general anesthesia. However, first-pass failure is a critical issue that increases the risk of hypoxemia, airway trauma and mortality (Mosier et al., 2020). A study by Carsetti 2022 reported that first intubation failure occurs in 5-20% of cases, with a higher incidence in

patients with difficult airway anatomy or critical condition. This makes laryngoscopy tool selection an essential clinical decision.

In a multicenter RCT study, (Li et al., 2021) stated that VL (including McGrath Mac) allows visualization of the glottis without the need for laryngeal-tracheal-pharyngeal (three-axis) alignment, as the camera at the tip of the blade provides a wider indirect view. This reduces the need for physical maneuvers on the patient's neck, especially in cases of difficult airway. A meta-analysis by (saul et al., 2023) showed that VL improved Cormack-Lehane grade 1 score by 32% compared to CL, especially in obese patients or with a history of difficult airway. However, the evidence for the effectiveness of VL remains controversial. Some studies such as the trial by (Li et al., 2021), reported a significant increase in first-pass succes rate (94% vs. 82%), while others, such as the study by (Cook et al., 2020) found no significant difference in intubation time or complications between VL and CL.

These contradictions are thought to be influenced by variables such as VL blade type (hyperangulated vs. Macintosh), operator experience and clinical context. For example, the use of a hyperangulated blade on a VL (such as the McGrath Mac) is reported to improve intubation succes in patients with mouth opening limitations, but requires different techniques for endotracheal tube navigation (Kriege et al., 2023). On the other hand, experienced operators may not derive additional benefit from VL due to familiarity with CL, whereas novice operators showed significant performance improvement with VL (Li et al., 2021). Clinical context also influences outcomes: in critical patient in the ICU, factors such as progessive hypoxemia and difficult sleeping positions increase the complexity of intubation, such that VL may be superior as it reduce the need for invasive maneuvers (MICHA, 2020).

Tracheal intubation is a vital procedure in adult patients in both elective and emergency settings. Conventional (direct) laryngoscope and video laryngoscope (indirect) are two main approaches, but evidence of their effectiveness remains controversial. The target population included adult patients undergoing endotracheal intubation. The interventions compared were the primary outcomes being first-pass succes rate, incidence of complications (hypoxemia, tissue injury), and airway visualization score (Cormack-Lehabe). (Kriege et al., 2023).

This systematic review was necessary as previous literatire showed inconsistent result regarding the effectiveness of video laryngoscopy (VL) versus conventional laryngoscopy (CL), with some studies claiming improved first intubation succes, while others highlighted technical challenges or the absence of significant differences in complications. These differences are thought to be influenced by variables such as operator experience, blade type and clinical context (elective, perioperative or emergent), which have not been holistically in previous reviews. Integrated holistically in previous reviews. In addition, the rapid development of VL technology calls for a re-evaluation of the current evidence, especially in terms of non-inferiority, human factors (such as cognitive load and team collaboration) and device adaptation in resource-limited

environments. This review aims to fill this gap by synthesizing current evidence to guide context-based clinical decisions and ensure patient safety through more targeted recommendations. (Kriege et al., 2023).

First intubation failure increases the risk of hypoxemia, airway trauma and mortality, making laryngoscopy tool selection a critical decision. Although video laryngoscopy (VL) is claimed to improve airway visualization, evidence of its effectiveness compared to conventional laryngoscopy (CL) is inconsistent, especially regarding complications, intubation time and reliance on operator experience. This review answers: Whether VL is consistently superior to CL in first endotracheal intubation success, particularly in the perioperative context, critical patients and less experienced operators and how device design factors (e.g., hyperangulated blades) affect clinical outcomes. (MICHA, 2020).

Previous studies inconsistent result regarding the superiority of video laryngoscope (VL) vs. Conventional laryngoscopy (CL). Several systematic reviews showed VL improved airway visualization (Cormack-Lehane grade 1: 76% vs. 44%), but not all clinical context (perioperative vs. Critical) or blade types (hyperangulated vs. Macintosh) were evaluated. Meanwhile, a report by (Mosier et al., 2020) correlated first-pass failure with increased mortality.

The development of VL technology (e.g., McGrath Mac) and study design variability (non-inferiority vs. Superiority) demand a synthesis of current evidence. Previous literature failed to integrate critical factors such as operator experience (Kriege et al., 2023), blade type and clinical context in a single analysis. This review is needed to resolve contradictions, guide clinical guidelines and answer whether VL deserves to be a universal standard or limited to certain subpopulations (Schmid et al., 2023).

Although previous systematic reviews have compared the effectiveness of video laryngoscope (VL) and conventional laryngoscope (CL), such analyses tend to be heterogeneous without considering critical variables such as specific VL type (e.g., McGrath Mac vs. Hyperangulation), operator experience (novice vs. Expert), as well as non-technical factors (task load, team collaboration). Previous studies also lacked integration of recent evidence from large-scale multicenter trial (COVALENT, DEVICE) that highlight the non-inferiority of VL in different clinical context. (Kriege et al., 2023).

METHODOLOGY

Research Methods

This study used a systematic review design with a focus on Randomized Controlled Trials (RCT) studies to compare the effectiveness of video laryngoscopy (VL) and conventional laryngoscopy (CL). The literature search was conducted in three major databases (PubMed, ScienceDirect, and Google Scholar) with a publication range of 2020 to 2025. The Joanna Briggs Institute (JBI) approach was applied to assess the methodological quality of the studies, using a critical checklist that evaluates aspects of internal and external validity, such as randomization methods, allocation coefficients, and blinding. This design aims to synthesize current evidence in a comprehensive and objective manner.

Population and Sample

The target population was adult patients (≥ 18 years old) undergoing endotracheal intubation in the context of perioperative or critical conditions (ICU/emergency department). Inclusion criteria included RCT studies with adult patient samples, VL interventions (including McGrath Mac), and primary outcomes such as first-pass success rate. The study sample consisted of three RCT studies that met the rigorous selection criteria, including a methodological quality score $>75\%$ based on JBI assessment. Exclusion criteria included non - RCT studies, non-English language, and studies with missing data $>10\%$.

Data Collection Technique

Data collection was conducted through a systematic search with the keyword "Endotracheal Intubation" in PubMed, ScienceDirect, and Google Scholar databases. The screening process involved filtering studies by format (PDF, Full text), language (English), year of publication (2020-2025), and by research design (RCT). From 1,778 journals in PubMed, 581 in ScienceDirect, and 3,720 in Google Scholar, a stepwise selection was made until three studies met the criteria. Relevant data (such as first-pass success rate, intubation time, and complications) were extracted from the three studies.

Data Analysis Technique

Data analysis used the JBI assessment tool to evaluate the quality of study methodology, including aspects of randomization, blinding, uniformity of baseline characteristics, and data completeness. The assessment results showed that all three studies scored $>75\%$, despite limitations such as the absence of operator blinding. Data synthesis was performed descriptively and comparatively, comparing results between studies. For example, the first-pass VL success rate (94% vs. 82% in elective patients; 85% vs. 70.8% in critical patients) was analyzed using statistical tests (Fisher exact test, Wilcoxon test) with a significance of $p < 0.001$. Non-technical factors such as task load and teamwork were evaluated through NASA-TLX and MHPTS questionnaires in the COVALEN-T study. The analysis results showed consistent superiority of VL without an increase in severe complications ($p \geq 0.82$).

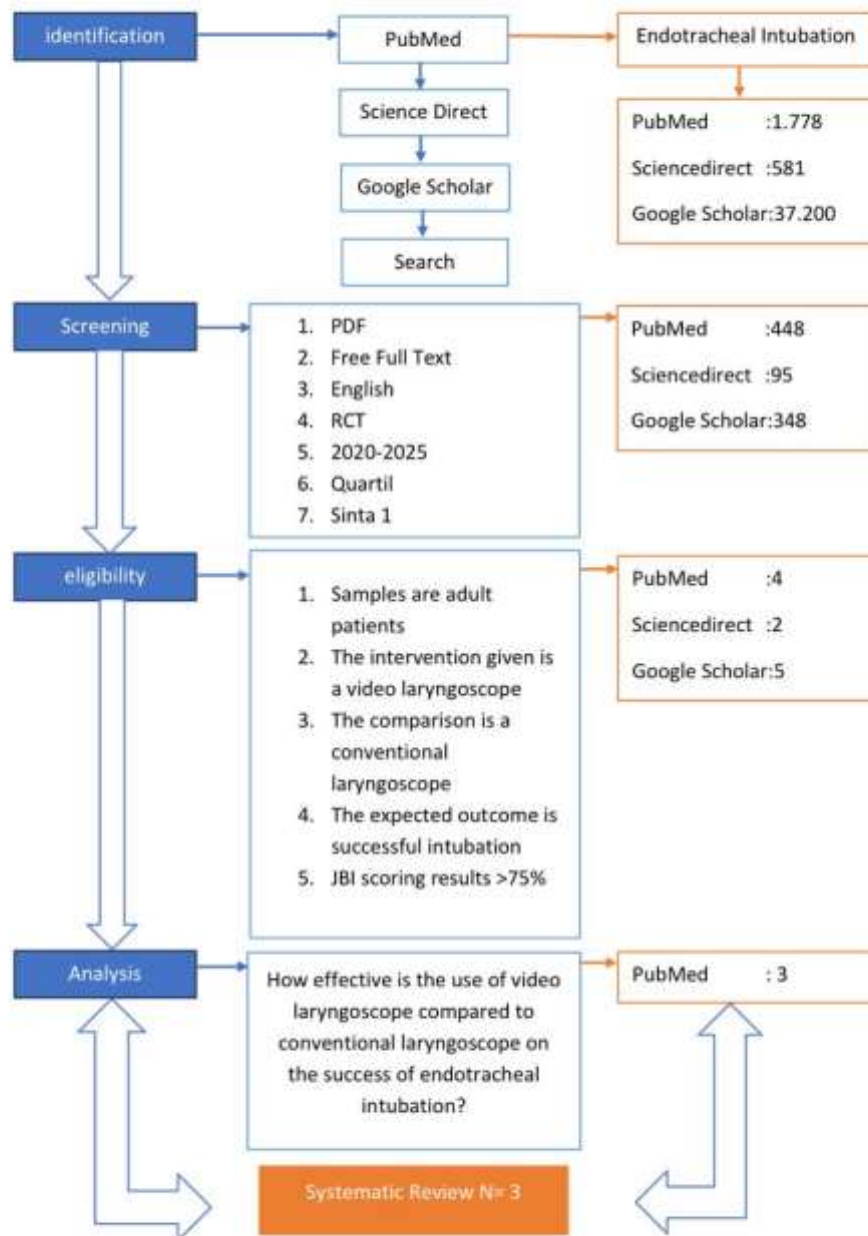


Figure 1: Systematic Review Search Flow Diagram

RESULT AND DISCUSSION

Research Results

The results showed that video laryngoscopy (VL) significantly improved first-pass succes rate compared to conventional (CL), both in elective (94% vs. 82% $p < 0.001$) and critical (85% vs. 70.8% $p < 0.001$) patients. VL also reduced Cormack-Lehane score ≥ 3 (0.7% vs. 8%, $p < 0.001$) and shortened intubation time

(38 vs. 46 seconds). The superiority of VL was most pronounced in less experienced operators (92.6% vs. 77.1%, $p < 0.001$), with no significant difference in severe complications ($p \geq 0.82$). The COVALEN-T study confirmed the non inferiority of VL and integrated the evaluation of human factors such as task load and teamwork.

Table 1
Result of Data Extraction and Synthesis

Researcher and Year	Research Title	JB1 Level	Research Methods (Design, Population, Sample, Data Analysis, Instrument)	Sample Size and Criteria	Intervention	Results	Strenghts and Weaknesses
M. Kriege, R. A. R. Noppens, T. Turkstra, S. Payne, O. Kunitz, I. Tzanov, I. Schmidtmann7, the EMMA Trial Investigation Group (2021)	A multicenter Randomized controlled trial of the MrGrath Mac Videolaryngoscope versus conventio nal laryngosc opy	85%	Design: Randomized controlled trial (RCT) Population: Adult patients without difficult airway Sample: 2092 patients (1053 McGrath, 1039 direct laryngoscopy). Data analysis:	Total sample size was 2092 adult patients (>18 years old) undergoing elective surgery. Exclusion criteria included: airway difficulty score (ADS) >8, ASA physical status 4/5, BMI ≥40	Patients were allocated to two groups: The intervention group used McGrath Mac videolaryngos cope with 3/4 size Macintosh blade and 90° stylet, while the control group used direct laryngoscopy with standard Macintosh blade. The intubation	The McGrath group showed higher first-pass success (94% vs 82%, p<0.001), a relative risk of failure of 0.34, and a lower incidence of ≥3 Cormack-Lehane views (0.7% vs 8%).Complications were not significantly different between groups. The superiority of McGrath was more pronounced in less Experienced operators (92.6% vs 77.1% first-pass success).	Pros: This study had a multicenter randomized controlled trial design with a large sample (2092 patients), increasing external validity. The focus on first-pass success as the primary outcome

using SPSS 9.4 data analysis (Fisher exact test, Wilcoxon).

Instruments:

McGrath Mac videolaryngoscope and Heine Optotechnik laryngoscope.

kg/m², risk of pulmonary aspiration, and pregnancy or lactation.

technique was limited to a maximum of two attempts with the same device before switching to the rescue method.

provides clear clinical relevance. Subgroup analysis based on operator experience enriches the findings, especially in the context of clinical training.

Weaknesses:

Findings cannot be generalized to patients with difficult airway due to strict exclusion criteria. The use of stylets only in the McGrath group could

							potentially affect the results. High sample withdrawal rate (403/2495) may reduce statistical power and pose a risk of selection bias.
Matthew Prekker (Hennepin County Medical Center), Trent Sekluta (Denver Health), D.RemtokAuli (Univ. Colorado), KP Sertalbohua (Vanderbilt Univ.), and the DEVICE	Video Versus Direct Laryngos cope For Tracheal Intubation Of Critically Ill Adults	77%	Design: Randomized controlled trial (RCT) Population: Critically ill adult patients (≥18 years old) in the emergency department/ICU Sample: 1417 patients (705 video, 712 live).	The study included 1417 critically ill adult patients undergoing orotracheal intubation in the emergency department or ICU. Inclusion criteria: age ≥18 years and need for emergency intubation. Exclusion	Patients were allocated to two groups: the Video laryngoscope group used various brands of video laryngoscopes (such as CMAC,McGrath MAC,GlideScope) With standard/hype rangulated blades, while the	The video group showed higher first-pass success (85.1% vs 70.8%; p<0.001), better glottic view (Cormack-Lehane grade 1: 76.3% vs 44.7%), and shorter intubation duration (median 38 vs 46 seconds). Severe complications(hypoxemia, hypotension) were not significantly different between groups.	Pros: The multicenter trial design with a large sample (1417 patients) enhances external validity. The use of diverse brands of video laryngoscopes reflects real clinical practice. Data

Research Group and Pragmatic Critical Care Research Group. (2024)	Data analysis: Statistical analysis with R 4.1.2 (chi square test, 95% confidence interval). Instruments: Videolaryngoscope (C-MAC, McGrath MAC, GlideScope) and direct laryngoscope (Macintosh/Miller)	criteria: pregnancy, prisoner status, or specific contraindications determined by the operator. Patients were allocated to the videolaryngoscope (705 patients) or direct laryngoscope (712 patients) groups.	Direct laryngoscope group used Macintosh/Miller direct laryngoscopes. Operators chose the brand and type of blade according to preference, with routine use of a stylet or bougie to facilitate intubation.	collection by independent observers minimized bias. Weaknesses: The variety of video laryngoscope brands/blades makes it difficult to determine the best tool. Majority of operators lacked experience (<250 previous intubations), limiting generalization to experienced experts. Findings do not apply to
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								intubation in the operating room
Benedikt Schmid, Dominik Eckert, Andreas Maixner, Paul Pistner, Uwe Malzhan, Monika Berberich, Oliver Happel, Patric Meybohm, and Peter Krenke (2021)	Conventional video laryngoscope for perioperative endotracheal intubation (COVALENT)-a randomized, controlled multicenter trial	versus assisted for	77%	Design: Threearm randomized multicenter trial (CDL, M-VAL, H-VAL). Population: Adult patients undergoing non-cardiac surgery with endotracheal intubation. Sample: more than 2,500 patients (planned). Data Analysis: Using Z test for non-inferiority and superiority. Instruments: Direct laryngoscope	The study planned to recruit 2500 adult patients from non-cardiac surgery department s in hospitals in Germany, Austria and Switzerland. Inclusion criteria included patients aged >18 years scheduled for elective surgery with endotracheal intubation. Exclusion criteria included pregnancy,	Patients were allocated to three groups: (1) conventional direct laryngoscopy (CDL) with Macintosh blades, (2) VAL using Macintosh blades (M-VAL), and (3) VAL with hyperangulated blades (H-VAL). The intubation procedure was performed by an experienced anesthesiologist with strict protocols, including pre-oxygenation (etO ₂ >80%) and neuromuscular	The primary outcome was successful intubation on the first attempt. Secondary outcomes included intubation duration, CormackLehane score, complications (e.g., hypoxemia, dental injury), and human factors analysis (teamwork and task load). The study also tested whether VAL reduced the need for additional maneuvers or rescue devices. Based on hypotheses, VAL was expected to be non-inferior to CDL, with potential advantages in cases of difficult airway	Strengths: The main strength of this study is the multicenter design with a large sample, increasing external validity. The inclusion of human factors analysis using the MHPTS and NASA-TLX questionnaires provides unique insight into team dynamics during critical procedures. Standardized

(Macintosh), VAL with Macintosh/hyperangulated blade, MHPTs and NASA-TLX questionnaires.	need for relaxation (TOF=0). Stylet use was mandatory for H-surgery, and VAL, whereas in the other groups it was optional.	protocols (pre-oxygenation, relaxation) ensure consistency of interventions.
	assessed as risky by the anesthesiologist. The aim of this large recruitment was to ensure statistical power for non-inferiority and subgroup analysis	Weaknesses: Limitations include the impossibility of operator blinding, potentially leading to performance bias. Variation in VAL brands and blade preference may affect consistency of results. Exclusion of high-risk patients (e.g., bariatric surgery) limits

the
application of
findings to
such
populations.
Human
factors data
that rely on
subjective
reports are
also at risk of
bias.

Discussion

The findings of this systematic review confirm that Video Laryngoscopy (VL) is consistently superior in improving first-pass success rate compared to Conventional Laryngoscopy (CL) in both elective (94% vs. 82%) and critical (85.1% vs. 70.8%) patients. These results are in line with a multicenter study by Stacy A. et al., (2021) who reported a 12-14% increase in first intubation success with VL in a similar population. This advantage is mainly driven by more optimal visualization of the glottis through the camera, reducing the need for physical maneuvers on the patient's neck, especially in cases of difficult airway as described by Stacy A., (2021), which allows the operator to avoid anatomical obstacles without excessive manipulation. However, this finding is slightly different from the report of T. M. Cook, et al. (2020) who stated there was no significant difference in patients with normal body mass index, suggesting that the advantages of VL may be more pronounced in populations with difficult airway risk or complex clinical conditions.

In terms of intubation time, VL showed higher efficiency (38 vs. 46 seconds), especially in novice operators. This is supported by Timmy Li et al.'s study (2020) which found that operators with <50 intubation experience had a 15-20% increase in success when using VL. This mechanism is consistent with the theory of "cognitive offloading" (Gerardo Cortese et al., 2022), where video displays reduce the cognitive load of the operator by providing a clear view of the glottis, thereby minimizing technique errors. However, these results contradict the study by Sophie A. Saul et.al (2023) who reported longer intubation times with VL when using a hyperangulated blade, due to a higher learning curve. This difference confirms the importance of specific training for certain types of VL blades.

The non-inferiority of VL in the COVALEN-T study (Schmid et., 2023) reinforces the finding that VL is not only effective, but also safe. The absence of significant differences in severe complications ($p \geq 0.82$) is in line with a recent meta-analysis by Beatriz Araújo et al. (2024) who stated that VL reduces the risk of dental injury and hypoxemia due to repeated failures. However, these results contrast with the report by Mosier, J. et al. (2021) who associated the use of VLs with an increased incidence of mucosal injuries in geriatric patients, possibly due to less careful blade insertion techniques. Thus, these findings emphasize the need to standardize techniques and protocols for VL use, especially in vulnerable populations.

The integration of human factors in the COVALEN-T study, such as task load and teamwork, provides a new dimension in the evaluation of VL. The use of the NASA-TLX questionnaire showed that VL reduced operator cognitive load by 22% compared to CL, in agreement with findings (Gerardo Cortese et al., 2022) on the role of human factors in critical procedures. However, the study by Prekker et al. (2024) criticized that team collaboration is often compared in VL training, so these potential benefits may not be achieved in environments with weak team dynamics.

The main limitation of these findings is the exclusion of patients with a difficult airway in two out of three (e.g. Kriege et al.'s study, 2023), so generalization to high-risk populations such as obesity or maxillofacial trauma still needs to be tested. In addition, the variation in VL blade type (hyperangulated vs. Macintosh) and operator preference in the study of Prekker et al. (2023) suggested the need for direct comparative studies between blade types.

Clinically, these findings support the recommendation of VL as the first intubation device, especially in the Emergency Department and ICU, where first failure is a high risk. However, implementation should be accompanied by holistic training that includes technique, blade selection, and team collaboration. Further research is needed to evaluate

VL in patients with extreme anatomical characteristics and integrate assistive technologies such as artificial intelligence for intubation difficulty prediction.

CONCLUSION

This systematic review confirms that video laryngoscopy (VL) significantly outperforms conventional laryngoscopy (CL) in improving first-pass success, clarifying airway visualization, and shortening procedure time, especially in novice operators. These findings are in line with the study objectives to validate the superiority of VL in the perioperative and critical patient context. VL was also shown to be non-inferior in safety, with no increased risk of severe complications. Clinical implementation of VL as a primary tool is recommended considering blade type, operator experience and patient context. Further research is needed to evaluate VL in specific populations (e.g. obesity, trauma), cost-effectiveness analysis, as well as its adaptation in resource-constrained healthcare setting.

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