

Beyond Success Rates: The Broader Impact of Videolaryngoscopy on Human Factors: A Conceptual Educational Review

Au-delà des taux de succès à l'intubation: L'impact de la vidéolaryngoscopie sur les facteurs humains. Une revue conceptuelle et pédagogique.

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ABSTRACT

Videolaryngoscopy (VL) has evolved from a rescue technique for difficult tracheal intubation into an increasingly adopted first-line approach in airway management. While much of the literature has focused on technical outcomes such as intubation success rates and glottic visualization, these metrics alone may not fully capture the broader clinical implications of VL. This narrative and conceptual review explores VL beyond procedural performance, with particular emphasis on human factors, team dynamics, patient safety, and education.

By providing shared visualization of the airway, VL transforms tracheal intubation from an individual technical procedure into a collective cognitive process. This shared visual field may enhance communication, support the development of shared mental models, and improve situational awareness within interprofessional teams. These effects are especially relevant in high-risk or time-critical situations, where cognitive load, stress, and coordination failures contribute substantially to adverse events. Emerging evidence suggests that VL may help reduce perceptual errors, facilitate anticipation of complications, and support more effective crisis resource management.

Videolaryngoscopy also offers important educational advantages by enabling real-time supervision, structured feedback, and integrated teaching of both technical and non-technical skills in clinical and simulation-based settings. Concerns regarding routine VL use, including the potential erosion of direct laryngoscopy skills and the relatively low incidence of catastrophic airway events, are also discussed from a patient-centred and ethical perspective.

Videolaryngoscopy should therefore not be evaluated solely through the lens of procedural success rates. Its broader contributions to patient safety, teamwork, human factors, and education support its growing role as a central component of contemporary airway management.

Keywords: Videolaryngoscopy; Airway management; Human factors; Patient safety; Crisis resource management; Medical education

RÉSUMÉ

La vidéolaryngoscopie (VL) est passée d'une technique de sauvetage pour les intubations trachéales difficiles à une approche de première intention de plus en plus courante dans la gestion des voies aériennes. Si la plupart des publications se sont concentrées sur les résultats techniques tels que les taux de réussite d'intubation et la visualisation de la glotte, ces indicateurs ne rendent pas pleinement compte de toutes les implications cliniques de la VL. Cette revue narrative et conceptuelle explore la VL au-delà de la simple performance procédurale, en mettant l'accent sur les facteurs humains, la dynamique d'équipe, la sécurité des patients et la formation.

En offrant une visualisation partagée des voies aériennes, la vidéolaryngoscopie (VL) transforme l'intubation trachéale d'une procédure technique individuelle en un processus cognitif collectif. Ce champ visuel partagé peut améliorer la communication, favoriser l'élaboration de modèles mentaux communs et accroître la conscience situationnelle au sein des équipes interprofessionnelles. Ces effets sont particulièrement pertinents dans les situations à haut risque ou critiques, où la charge cognitive, le stress et les problèmes de coordination contribuent fortement aux événements indésirables. Des données récentes suggèrent que la VL peut contribuer à réduire les erreurs de perception, faciliter l'anticipation des complications et favoriser une gestion plus efficace des ressources en situation de crise.

La vidéolaryngoscopie offre également d'importants avantages pédagogiques en permettant une supervision en temps réel, un retour d'information structuré et un enseignement intégré des compétences techniques et non techniques, tant en milieu clinique qu'en simulation. Les préoccupations liées à l'utilisation systématique de la vidéolaryngoscopie, notamment l'érosion potentielle des compétences en laryngoscopie directe et la faible incidence relative d'événements indésirables graves au niveau des voies respiratoires, sont également abordées dans une perspective éthique et centrée sur le patient.

La vidéolaryngoscopie ne doit donc pas être évaluée uniquement à l'aune de ses taux de réussite. Ses contributions plus larges à la sécurité des patients, au travail d'équipe, aux facteurs humains et à la formation justifient son rôle croissant en tant que composante essentielle de la prise en charge moderne des voies aériennes.

Mots-clés : Vidéolaryngoscopie, Gestion des voies respiratoires, Facteurs humains, sécurité des patients, Gestion des ressources en situation de crise, formation médicale

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INTRODUCTION

Over the past fifteen years, videolaryngoscopy (VL) has emerged as a major innovation in airway management. Initially introduced as an alternative technique for anticipated or encountered difficult tracheal intubation, VL is now increasingly adopted as a first-line approach across a wide range of clinical settings. Although the literature is rich in quantitative data regarding intubation success rates, glottic visualization, and complication profiles, these technical outcomes alone may not

fully capture the broader clinical implications of VL. Beyond procedural performance, videolaryngoscopy influences communication, team dynamics, supervision, and decision-making during airway management. As such, VL raises important educational, ethical, and human factors considerations that warrant broader critical reflection. This article provides a narrative and conceptual perspective on videolaryngoscopy, with particular emphasis on patient safety, team cognition, human factors, and the implications for contemporary anaesthesia practice (Figure 1).

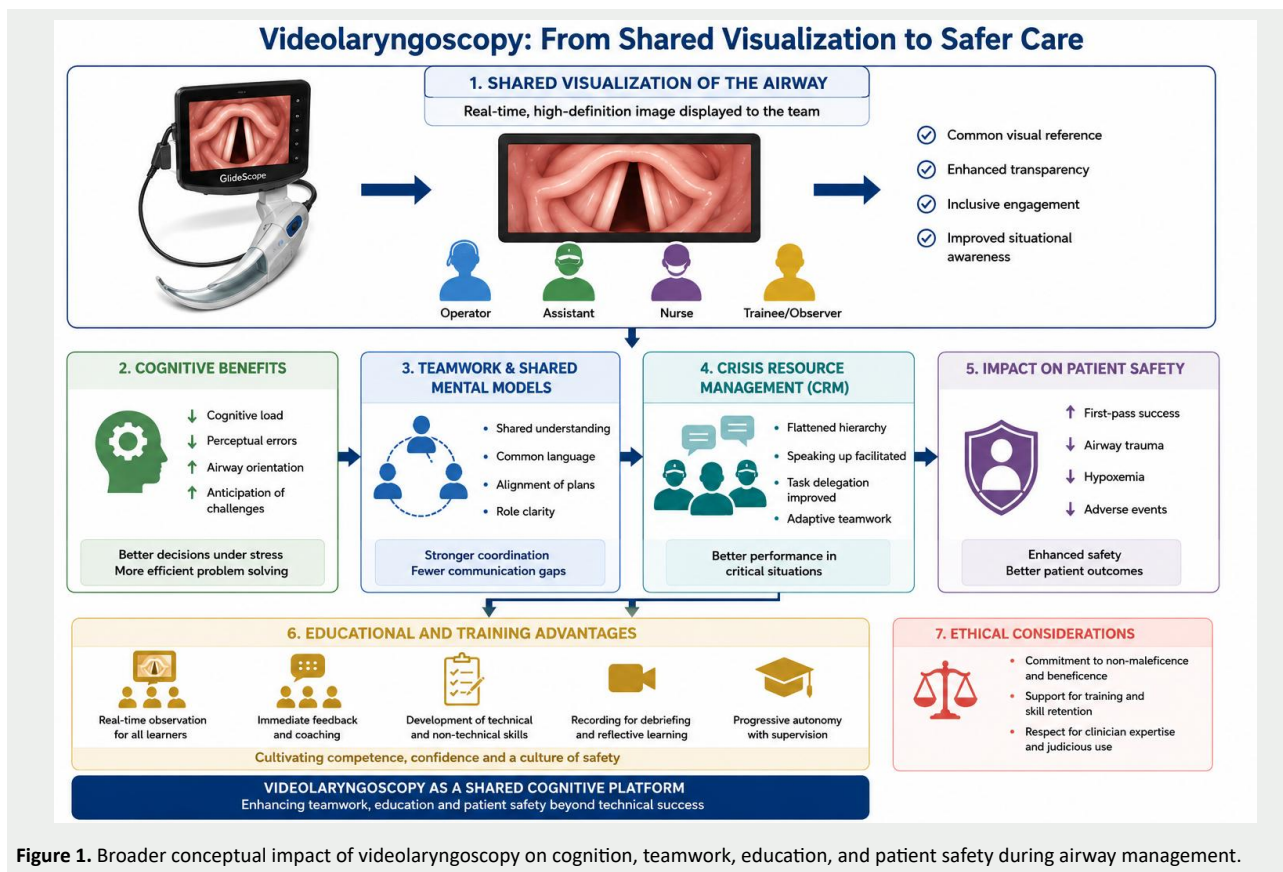


Figure 1. Broader conceptual impact of videolaryngoscopy on cognition, teamwork, education, and patient safety during airway management.

METHODOLOGY

This article is a narrative and conceptual review informed by literature identified through targeted searches of PubMed and Google Scholar. The search strategy focused on publications related to videolaryngoscopy, airway management, patient safety, human factors, cognitive workload, crisis resource management (CRM), teamwork, situational awareness, and airway education. Priority was given to contemporary reviews, randomized trials, human factors literature, and guideline or position statements from recognized anesthesia and airway societies.

Rather than aiming to provide a systematic quantitative synthesis, this review adopts an analytical and integrative perspective intended to explore the broader conceptual implications of videolaryngoscopy beyond procedural success rates alone. The selected literature was

interpreted through the lens of patient safety, team cognition, and educational theory to examine how shared airway visualization may influence communication, decision-making, supervision, and interprofessional coordination during airway management.

VIDEOLARYNGOSCOPY BEYOND TECHNICAL PERFORMANCE

Videolaryngoscopy and Human Factors

One of the most frequently cited arguments supporting videolaryngoscopy relates to its potential impact on patient safety through human factors. Difficult tracheal intubation associated with repeated attempts, airway trauma, hypoxemia, and operator stress may contribute to adverse clinical outcomes.

Several studies suggest that videolaryngoscopy may reduce airway trauma related to repeated intubation attempts(1, 2), lessen operator and patient stress by facilitating smoother procedures, and improve anticipation and team communication through shared visualization on the screen(2-6). Whether these potential advantages justify broader first-line adoption in the absence of definitive evidence from large, randomized trials remains an open question. Nevertheless, the historical integration of major perioperative innovations—such as capnography, pulse oximetry, and point-of-care ultrasound—demonstrates that implementation into routine practice has often relied on pragmatic safety considerations and clinical utility rather than exclusively on large-scale randomized evidence(7, 8).

Human Factors and Collective Airway Cognition

VL does more than improve the operator's visual field. It may also influence the collective dynamics of the clinical team, particularly during high-risk or time-critical situations(5, 6). Tracheal intubation is rarely a purely technical act. Rather, procedural performance is continuously shaped by communication, information sharing, stress management, situational awareness, and interprofessional coordination(9-16). In this context, videolaryngoscopy may transform airway management from an individual technical procedure into a shared cognitive process.

Videolaryngoscopy as a Shared Cognitive Platform

With traditional direct laryngoscopy (DL), visualization of the glottis is limited to the operator(17, 18), while other team members must rely on verbal descriptions that may be incomplete or imprecise during stressful situations. VL modifies this dynamic by projecting the airway view onto a shared screen accessible to the entire team(4, 10). This shared visualization may facilitate the development of a common language, as anatomical landmarks and procedural challenges become immediately interpretable by all participants. It may also reduce subjectivity by transforming the Cormack–Lehane grade or Percentage of Glottic Opening (POGO) score into a collective visual reference rather than a purely individual assessment(10, 11).

Furthermore, VL supports supervision and teaching by enabling senior clinicians to guide trainees' manoeuvres in real time using the same visual field(6, 17, 18). In this respect, the shared visual information resembles that provided by ultrasound in regional anaesthesia, shifting what was once a solitary task toward a more transparent, collaborative, and objectified process(3, 19).

Reduction of Cognitive Load and Perceptual Error

In emergency settings, operators must simultaneously perform technical manoeuvres, anticipate complications, communicate with the team, and make rapid decisions under stress(20). This concurrence of tasks may generate substantial cognitive load, further amplified by

environmental constraints such as noise, time pressure, or limited personnel. VL may help mitigate this burden in several ways. By providing a clear and stable view of the airway, it can reduce the mental effort required to identify anatomical structures and maintain procedural orientation.

The shared screen additionally enables redistribution of cognitive workload among team members(21). For example, nursing staff may remind the operator of procedural steps, while colleagues can anticipate rescue interventions because they share access to the same visual information. VL may also help reduce perceptual and cognitive errors, such as anchoring or confirmation bias, by allowing collective verification of airway findings rather than reliance on a single subjective interpretation(22).

In this context, VL may contribute not only to procedural performance but also to improved situational awareness and the development of shared mental models within the team(20). These elements are central to contemporary crisis resource management (CRM) frameworks(20, 21, 23, 24).

Team Dynamics and Crisis Resource Management

Traditionally, tracheal intubation positioned the operator as the sole holder of visual information, technical execution, and immediate procedural responsibility. Such a vertical dynamic could limit effective participation from other team members. VL may foster a different interactional model in which respiratory therapists, assistants, and trainees can anticipate procedural steps more effectively because they share access to the same visual information as the operator.

This transparency may facilitate participation, improve coordination, and reduce hesitation in offering corrective suggestions or assistance. Team members may more confidently intervene to adjust tube positioning, optimize stylet angulation, or anticipate equipment needs because the procedural context is visually shared(4, 25). In critical situations, such as severe hypoxemia, difficult or impossible ventilation, or hemodynamic instability, VL may also facilitate more efficient communication, support collective decision-making, and reduce stress-related errors by decreasing uncertainty and increasing visual transparency.

When considered within the framework of Crisis Resource Management, VL may therefore support coordinated team behaviour during airway emergencies. It promotes shared mental models, reduces ambiguity(3), may help limit cognitive biases(4, 9), and enhances collective situational awareness(9, 10, 15, 16).

Educational Implications and Safety Culture

VL also represents a valuable educational tool in both clinical and simulation-based settings. Shared visualization enables instructors to demonstrate appropriate techniques, supervise procedures in real time, and analyse technical errors in a structured and collaborative manner(26, 27). Beyond procedural

teaching, VL facilitates the development of non-technical skills such as communication, anticipation, leadership, and role distribution(28).

In this respect, videolaryngoscopy extends beyond its purely technical function and contributes to the development of a broader culture of patient safety. By transforming tracheal intubation into a shared task in which success depends on team coordination as much as individual technical expertise, VL may enhance collective performance in ways that are not fully captured by conventional procedural metrics(18).

LIMITATIONS, COUNTERARGUMENTS

Despite its many advantages, several considerations continue to temper enthusiasm regarding the systematic or “default” adoption of VL for all tracheal intubations. These concerns primarily relate to the maintenance of direct laryngoscopy (DL) competence, the relatively low incidence of catastrophic airway complications, issues of resource allocation and device availability, and the broader question of clinician preference versus patient-centred practice.

One of the most frequently cited concerns relates to the potential decline in proficiency with direct laryngoscopy. As VL becomes increasingly integrated into routine practice, reduced exposure to DL may gradually diminish clinicians’ technical competence with conventional laryngoscopy(29). This issue remains particularly relevant because DL may still serve as a fallback option in situations involving device malfunction, limited equipment availability, difficult screen visualization, or challenging environmental conditions. However, this argument also warrants critical examination. It could be argued that relying on a technique generally considered less effective and potentially associated with greater procedural difficulty as the primary rescue strategy may itself be suboptimal(1, 30-32). From this perspective, airway rescue algorithms may need to evolve beyond the traditional DL-versus-VL dichotomy and instead incorporate alternative VL designs, rigid stylets, hyperangulated blades, flexible bronchoscopic techniques, and supraglottic airway devices as complementary strategies. Importantly, contemporary difficult airway guidelines already emphasize supraglottic airway devices, not repeated DL attempts, as the preferred rescue strategy following failed intubation.

Another argument commonly advanced against widespread VL adoption relates to the relatively low incidence of severe airway complications in modern anaesthesia practice. For example, unrecognized oesophageal intubation during anaesthesia remains exceedingly rare, with reported incidences approximating 1 in 360,000 cases(4). Nevertheless, rarity should not be conflated with insignificance. Major airway complications, although infrequent, may carry devastating consequences for patients, families, and healthcare professionals alike. Beyond immediate clinical morbidity, such events may lead to long-term psychological consequences for clinicians, including the well-described “second victim”

phenomenon(33). From a patient safety perspective, even uncommon complications may justify preventive strategies when the associated harms are substantial and when the intervention itself carries relatively limited additional risk.

Resource-related considerations also deserve acknowledgement. The routine implementation of VL across operating rooms, emergency departments, intensive care units, and prehospital environments may present financial and logistical challenges, particularly in lower-resource healthcare systems. Device acquisition, maintenance, blade availability, staff training, and standardization of equipment across institutions all represent important operational considerations. However, these concerns should also be weighed against the potential downstream costs associated with airway-related complications, failed intubation attempts, procedural delays, and adverse patient outcomes.

Finally, some clinicians argue that airway management techniques should primarily reflect operator preference and familiarity. While this reasoning is intuitively understandable, it may place greater emphasis on clinician comfort than on patient-centred outcomes. A patient-centred approach would instead suggest that clinicians should preferentially use the technique with which they are most competent among those demonstrated to provide the safest and most reliable conditions for tracheal intubation. In this context, the debate surrounding VL may ultimately reflect not only a discussion about technology, but also a broader evolution in how airway management is conceptualized: from an individual procedural skill toward a system-oriented practice integrating human factors, team cognition, communication, and patient safety principles.

ETHICAL AND EDUCATIONAL IMPLICATIONS OF VIDEOLARYNGOSCOPY

Whether it remains justified to train junior anaesthesiologists extensively in direct laryngoscopy (DL) at the expense of VL is an increasingly debated question. As VL becomes more widely integrated into routine airway management, maintaining DL competence while simultaneously ensuring optimal patient safety creates an important educational and ethical tension. Withholding a technology that may improve visualization, reduce technical difficulty, and facilitate team support in order to preserve future competence with a potentially less effective technique raises complex ethical considerations(34). This tension reflects a broader challenge frequently encountered in medical education: balancing the preservation of traditional procedural skills with the adoption of innovations that may improve patient care and safety.

At the same time, VL represents far more than a technical alternative to DL. It constitutes a powerful educational modality in its own right. In both simulation-based training and real clinical environments, shared visualization enables instructors to observe learners’ manoeuvres continuously, provide immediate corrective feedback,

and guide airway management step by step(13, 25, 26, 35-38). Unlike DL, where supervision often depends on indirect observation and delayed feedback, VL creates a common visual field that facilitates real-time teaching and more precise identification of technical errors. This may accelerate psychomotor learning, improve anatomical understanding, and reinforce cognitive aspects of airway management.

Importantly, the educational value of VL extends beyond technical skill acquisition alone. By making airway management visually accessible to the entire team, VL also supports the teaching of non-technical competencies such as communication, anticipation, leadership, workload distribution, and crisis resource management. These elements align closely with contemporary educational approaches emphasizing human factors, team cognition, and patient safety culture(7, 24, 36). In this regard, VL may contribute not only to procedural competence, but also to the development of a broader systems-based understanding of airway management. Rather than viewing VL and DL as competing educational paradigms, future training models may need to focus on developing adaptive airway expertise, in which clinicians acquire competence across multiple techniques while prioritizing approaches that optimize patient safety, team performance, and clinical reliability.

CONCLUSION

Videolaryngoscopy (VL) has progressively evolved from a rescue device for difficult airway management into a technology that may influence broader dimensions of clinical practice, including patient safety, team dynamics, human factors, and education. While its technical benefits in airway visualization and intubation performance are well recognized, its broader contribution may lie in its ability to transform tracheal intubation into a more transparent, collaborative, and cognitively shared process.

Rather than focusing exclusively on whether VL should replace direct laryngoscopy in all situations, the more relevant question may be how VL can be integrated thoughtfully into contemporary airway management strategies. This integration may include its use as a first-line approach in at-risk contexts, such as obesity, anticipated difficult intubation, emergency airway management, or out-of-operating-room settings, as well as its incorporation into simulation-based education, continuing professional development, and crisis resource management training(8).

Importantly, the methodological limitations inherent to airway management research make it unlikely that definitive randomized evidence addressing all clinically relevant outcomes will ever be obtained 24. Severe airway complications remain fortunately rare, limiting the feasibility of adequately powered trials capable of demonstrating differences in major morbidity or mortality. Consequently, decisions regarding VL adoption will likely continue to rely on a synthesis of the best available evidence, human factors research, pragmatic

clinical reasoning, educational value, and established patient safety principles(7, 30, 37, 39, 40).

Ultimately, videolaryngoscopy should perhaps be viewed not solely as a device that improves intubation success, but as a technology that may contribute to safer, more collaborative, and more educationally transparent airway management practices.

Declaration of generative AI and AI-assisted technologies in the manuscript preparation process

During the preparation of this work the corresponding author used ChatGPT-5 in order to correct spelling and grammatical errors. After using this tool, the author reviewed and edited the content as needed and takes full responsibility for the content of the published article.

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