Seeing is not enough: why introducer choice matters in hyperangulated videolaryngoscopy

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Videolaryngoscopy has largely solved the problem of seeing the larynx—but not necessarily the problem of intubating the trachea.

Airway management has undergone a substantial transformation over the past decade, driven by the widespread adoption of videolaryngoscopy (VL) and a growing understanding of the role of human factors in airway-related morbidity and mortality. International guidelines and consensus statements increasingly support VL as a first-line technique for tracheal intubation in both routine and difficult airways (1-6), citing improved glottic visualization, higher first-attempt success rates, and a reduction in airway-related complications (1,7). However, improved visualization does not automatically translate into successful tube delivery, particularly when hyperangulated blades are used, where airway geometry and tube-glottis alignment remain critical challenges (8-10).

In this context, tracheal tube introducers—stylets and bougies—have evolved from optional adjuncts to essential components of modern airway management, particularly during VL (11,12). Difficult airway guidelines consistently recommend the use of introducers to facilitate tracheal intubation when direct advancement of the endotracheal tube is challenging (1,2,4). Despite their widespread use, uncertainty persists regarding the optimal choice of introducer (13-15), especially during hyperangulated VL, where techniques derived from direct laryngoscopy may be poorly suited or even counterproductive (16).

Recent innovations, including articulated or dynamic bougies, aim to address these challenges by allowing active control of the distal tip and potentially improving

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Table 1 Practical considerations for selecting tracheal tube introducers during hyperangulated videolaryngoscopy

Introducer type	Key design features	Performance with hyperangulated videolaryngoscopy	Main advantages	Main limitations	Suggested clinical role
Stylet (blade-matched or rigid/ malleable)	Preloaded endotracheal tube; rigid or semi-rigid; curvature matched to blade geometry	Highest first-attempt success; shortest intubation time; best operator-rated ease, especially in difficult airways	Accurate tube-glottis alignment; fewer procedural steps; low cognitive load; intuitive use	Limited redirection once advanced; requires correct pre-shaping	First-line introducer for hyperangulated videolaryngoscopy, particularly in anticipated or evolving difficult airways
Dynamic (articulated) bougie	Distal tip articulation controlled by a trigger or slider mechanism	Intermediate performance; superior to static bougie; benefits more evident in difficult airways	Active tip control; potential to correct suboptimal alignment	Increased complexity; higher cognitive load; additional manipulation; potential safety concerns	Second-line or rescue option in selected difficult airways when stylet-based strategy fails
Static bougie	Semi-rigid introducer with fixed or minimally deformable tip	Lowest first-attempt success; poorest performance with hyperangulated blades, especially in difficult airways	Familiarity; simplicity; effective in direct laryngoscopy	Poor adaptation to hyperangulated geometry; railroading difficulties; higher failure rates	Generally not recommended as first-line with hyperangulated videolaryngoscopy; reserve for direct laryngoscopy contexts

navigation through the vocal cords (17). Systematic reviews suggest that while dynamic bougies do not consistently improve overall first-pass success compared with standard devices across all settings, they may offer advantages in genuinely difficult airways or under specific conditions (18). However, the existing evidence is heterogeneous, often methodologically limited, and frequently extrapolated across different laryngoscope types, restricting its applicability to hyperangulated VL (18).

Beyond device mechanics, contemporary airway safety frameworks emphasize that airway management is a sociotechnical process shaped by interactions between clinicians, devices, tasks, and the clinical environment (19). In this setting, device choice is not merely a technical decision, but a cognitive one (20). Analyses of major airway complications consistently show that failures more often arise from system design, cognitive overload, and suboptimal integration of technology than from a lack of equipment or technical expertise (21-23). Accordingly, the evaluation of airway devices must extend beyond efficacy alone to include usability, cognitive demand, and workflow integration under stress (20).

Against this background, the study by Dallyn *et al.* (24) provides timely and clinically relevant data by directly comparing static, dynamic, and stylet-based introducers during standard and simulated difficult intubations using a hyperangulated videolaryngoscope. By focusing on first-attempt success, time to intubation, and operator-rated usability, the authors address a critical gap at the intersection of device design, airway geometry, and real-world performance.

Overview of the study

Dallyn and colleagues (24) conducted a randomized, crossover, manikin-based study evaluating five tracheal tube introducers during intubation with a hyperangulated videolaryngoscope (C-MAC® D-blade). The devices represented the main introducer categories currently used in clinical practice, with their key characteristics summarized in *Table 1*: two stylets (the C-MAC Stylet and the Universal Stylet Bougie™, used as a stylet), two dynamic bougies (the Total Control Introducer™ and the Steerable Tracheal Intubation Guide™), and a conventional static bougie (the Portex® single-use bougie).

Thirty anaesthetists with prior experience in VL each performed ten intubations on a high-fidelity airway manikin—five under standard conditions and five under a deliberately configured difficult airway setup. Both the order of introducer use and the airway scenario were randomized. The difficult airway model was designed to reliably impair laryngeal exposure and tube delivery,

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allowing meaningful discrimination between devices in a controlled yet challenging environment.

The primary outcome was first-attempt tracheal intubation success. Secondary outcomes included successful intubation within 120 seconds, time to intubation, and subjective assessments of ease of intubation, ease of railroading, and force applied. Importantly, time to intubation was defined from adequate glottic visualization to lung ventilation, isolating introducer performance from laryngoscope handling.

Marked differences in performance were observed between devices. In the standard airway setup, first-attempt success ranged from 100% with the C-MAC stylet to 57% with the static Portex bougie, while in the difficult airway scenario success ranged from 93% with the C-MAC stylet to 33% with the static bougie. Stylet-based introducers also achieved the shortest intubation times, with a median time of approximately 22 s compared with 34–45 s for bougie-based strategies. Dynamic bougies demonstrated intermediate performance, while the static bougie performed worst across most outcomes. Performance differences widened substantially in the difficult airway scenario; notably, the success rate of the static bougie fell to one-third of attempts, underscoring the increasing importance of introducer choice as airway complexity increases.

Key findings and interpretation

The most salient finding of this study is the clear performance gradient between introducer types during hyperangulated VL. Stylet-based devices outperformed both dynamic and static bougies across objective and subjective measures. This difference was particularly evident in the simulated difficult airway scenario, where first-pass success with the C-MAC stylet reached 93%, compared with 87% for the Total Control Introducer, 73% for the Universal Stylet Bougie, 60% for the Steerable Tracheal Intubation Guide, and only 33% for the static Portex bougie. These findings reinforce that in hyperangulated VL, tube delivery—not visualization—is frequently the limiting step.

The superior performance of stylets appears closely linked to their ability to reproduce the curvature of the hyperangulated blade, thereby maintaining stable alignment between the endotracheal tube and the glottic opening. This design minimizes corrective maneuvers, reduces procedural steps, and shortens intubation time. In contrast, the comparatively poor performance of the static bougie is striking. While highly effective during direct laryngoscopy, static bougies appear poorly adapted to the geometry of hyperangulated blades, particularly in difficult airway conditions.

Dynamic bougies occupied an intermediate position. Although articulated tips theoretically offer greater navigational control, this potential advantage may be offset by increased procedural complexity, additional manipulation, and greater cognitive demand. Their relative benefit became more apparent in difficult airway conditions, consistent with previous evidence suggesting that dynamic introducers may be advantageous primarily when airway difficulty is substantial.

From a human factors perspective, these findings are particularly relevant. Devices that simplify task execution, reduce fine motor demands, and limit decision points are more likely to support reliable performance under stress. However, it is important to note that the present study did not directly measure cognitive workload or task complexity; therefore, these interpretations should be viewed as a theoretical explanation consistent with existing human factors literature rather than a mechanism empirically demonstrated in this study. Conversely, introducers requiring continuous manipulation or multi-step coordination may increase cognitive load and susceptibility to error at critical moments. In this regard, the apparent efficiency of stylet-based strategies may reflect not only mechanical suitability but also superior alignment with human performance capabilities.

Collectively, the results challenge the assumption that bougies should be the default introducer for VL and instead support a context-specific approach in which introducer selection is explicitly matched to the laryngoscopic technique employed.

Strengths of the study

This study addresses a clinically important and underexplored question: the comparative performance of tracheal tube introducers specifically during hyperangulated VL. By focusing on a single laryngoscope type, the authors avoided confounding related to blade geometry and visualization modality, enhancing internal validity.

A key methodological strength is the use of a deliberately configured difficult airway model. This approach mitigates the ceiling effects commonly encountered in clinical studies, where high first-pass success rates limit discrimination between devices. The randomized crossover design further

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strengthens the analysis by reducing inter-operator variability and allowing each participant to serve as their own control.

Outcome selection is another notable strength. By isolating introducer performance from laryngoscope handling and combining objective metrics with subjective usability assessments, the study provides a comprehensive evaluation that reflects both technical efficacy and operator experience. Finally, the inclusion of a broad range of introducer designs enhances the clinical relevance of the findings and facilitates translation into everyday practice.

Limitations and points for caution

Several limitations warrant consideration. As a simulation-based study, the findings may not fully translate to clinical practice, where anatomical variability, tissue compliance, secretions, bleeding, and physiological instability introduce additional complexity. The difficult airway model represents only one mechanism of difficulty, and device performance may vary across other airway phenotypes.

All intubations were performed using a single hyperangulated videolaryngoscope. Differences in blade curvature and design across manufacturers may influence introducer performance, limiting generalizability. Operator familiarity and device-specific learning curves may also have influenced the results. In routine clinical practice, many anaesthetists are more accustomed to using stylets than dynamic bougies, which could introduce a performance bias favoring stylet-based strategies. Although standardized training was provided before the study, dynamic introducers often require additional practice to master tip articulation and coordination. Differential prior exposure between devices may therefore have contributed to the observed performance differences.

Importantly, the study focuses on efficacy rather than safety. Simulation does not permit reliable assessment of airway trauma or other complications, particularly relevant for dynamic introducers with articulated or spring-loaded tips. Subjective measures, while informative, remain susceptible to bias and should be interpreted alongside objective outcomes.

These limitations do not detract from the study's value but frame its findings as context-dependent and hypothesis-generating.

Clinical implications

While the present findings should be interpreted cautiously given the simulation-based design of the study and the evaluation of a single videolaryngoscope platform, they nonetheless raise important considerations regarding introducer selection in hyperangulated VL. The results may have immediate implications for airway management in the era of widespread VL. Introducer choice should no longer be viewed as interchangeable but as a critical determinant of success, particularly when hyperangulated blades are used.

Static bougies, while effective during direct laryngoscopy, appear less well suited to hyperangulated VL and may potentially contribute to failed tube delivery in this context. Stylet-based strategies, especially those designed to match blade curvature, offer a more reliable and efficient approach, with potential benefits including fewer attempts, reduced airway trauma, and lower risk of hypoxaemia.

Dynamic bougies may retain a role in selected difficult airway scenarios or as rescue devices, but their increased complexity underscores the need for structured training and clear guidance on their intended use. At a systems level, airway equipment, training, and cognitive aids should be aligned with contemporary VL-based practice, ensuring that introducers optimized for VL are readily available and routinely used.

Although these findings derive from a simulation-based study, they suggest that departments routinely using hyperangulated VL may wish to reassess whether the introducers they stock and teach as default options are optimally aligned with videolaryngoscopic techniques.

Implications for future research

Future studies should focus on clinical evaluation of introducers specifically in hyperangulated VL, with attention to airway phenotype, physiological outcomes, and airway trauma. Research integrating human factors methodologies—such as cognitive workload and error analysis—would further enhance understanding of device performance under stress. Comparative studies examining introducer-laryngoscope combinations, rather than devices in isolation, are also needed to inform procurement, training, and guideline development.

Conclusions

This study provides robust evidence that the choice of tracheal tube introducer significantly influences the success of hyperangulated VL, particularly in difficult airway conditions. Stylet-based devices designed to match

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blade curvature consistently outperformed both static and dynamic bougies, while static bougies demonstrated clear limitations in this setting.

These findings challenge assumptions derived from direct laryngoscopy practice and highlight the need to adapt airway strategies to modern videolaryngoscopic techniques. Improving airway safety will depend not only on better devices, but on better alignment between technology, human performance, and system design. This study represents an important and timely step toward that goal.

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