Original Article

Association between glottic view and tracheal intubation during videolaryngoscopy: a prospective observational study

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Summary

Introduction A good view of the glottis with videolaryngoscopy does not translate consistently into straightforward tracheal tube delivery, suggesting a dissociation between visualisation and procedural execution. When videolaryngoscopy documentation is based on laryngeal view alone, it does not reliably reflect the performance of tracheal intubation. We evaluated this relationship and the reproducibility of a structured classification framework for videolaryngoscopic tracheal intubation.

Methods We conducted a prospective multicentre observational study across 44 hospitals. Videolaryngoscopic tracheal intubations were assessed independently by an airway operator and an observer using a three-domain classification: blade geometry; glottic view using the percentage of glottic opening (POGO) score; and tracheal tube delivery. Inter-rater reliability was assessed. The relationship between glottic view and tracheal tube delivery was analysed across predefined POGO categories.

Results A total of 5302 tracheal intubations with paired assessments were analysed. The overall inter-rater agreement for the three-domain classification was high (Krippendorff's $\alpha = 0.86$, 95%CI 0.85–0.87). Among tracheal intubations with poor view (POGO < 25%), 37/151 (24.5%) were classified as easy. Among tracheal intubations with POGO ≥ 25%, 527/5151 (10.2%) were classified as difficult or failed. Even with excellent glottic view (POGO > 75%), the initial strategy was classified as difficult or failed in 252/4025 (6.3%) of cases.

Discussion The ease of tracheal intubation with videolaryngoscopy cannot be inferred from glottic view alone. A structured approach that incorporates what was used, what was seen and what was done may improve communication in clinical practice.

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Introduction

Videolaryngoscopy is recommended widely as a first-line technique for tracheal intubation [1–5]. By providing an indirect view of the larynx that is independent of line-of-sight alignment, videolaryngoscopy improves glottic view and the likelihood of successful tracheal intubation on

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the first attempt [6]. However, videolaryngoscopy documentation practices are derived largely from direct laryngoscopy practice, where laryngeal view and tracheal intubation success are linked closely [7]. With videolaryngoscopy, a dissociation exists between visualisation and execution, whereby excellent glottic view may coexist with difficult or failed tracheal tube delivery, a phenomenon described as `can see but cannot intubate´, while successful tracheal tube delivery may still occur despite suboptimal views [8–11]. As a result, the use of view-based descriptors in isolation provides an incomplete, and potentially misleading, representation of airway difficulty.

Accurate airway documentation informs future airway planning, supports clinical handover and contributes to patient safety. Videolaryngoscopy performance is influenced not only by laryngeal view but also by blade geometry, adjunct use and tracheal tube delivery [10, 11]. Incomplete documentation may impair communication and situational awareness [12]. In addition, adjuncts used to facilitate videolaryngoscopic tracheal intubation are not without risk and so their documentation is clinically relevant [13].

The Video Classification of Intubation (VCI) score is a simple, process-based framework that extends beyond glottic view when documenting videolaryngoscopic tracheal intubation, also incorporating blade geometry and ease of tracheal tube delivery [14–17]. An international multicentre feasibility study showed high inter-rater reliability of the VCI framework across diverse clinical settings [16]. However, its performance in large-scale routine clinical practice and its relationship with tracheal intubation outcomes have not been established. Therefore, we conducted a prospective, multicentre study (VCISpain) to evaluate the relationship between glottic view and tracheal tube delivery and to assess the inter-rater reliability of the VCI score.

Methods

This prospective observational study was conducted in 44 hospitals in Spain, including tertiary centres, regional and community hospitals. This study was approved by the Research Ethics Committee of the University of Navarra, Pamplona, Spain and was conducted in accordance with the Declaration of Helsinki. Reporting follows the STROBE statement for observational studies [18].

Patients aged ≥ 18 y with ASA physical status 1–4 who were scheduled to undergo tracheal intubation with videolaryngoscopy for surgical, diagnostic or therapeutic procedures were eligible to participate in this study. Written informed consent was obtained.

Anaesthetic management, including induction technique and use of neuromuscular blocking drugs and monitoring of their effects was not standardised or recorded as part of the study protocol. The airway management strategy and videolaryngoscope used to perform tracheal intubation were at the discretion of the airway operator. The videolaryngoscopes used included: McGrath (Medtronic, Minneapolis, MN, USA); C-MAC (Karl Storz, Tuttlingen, Germany); Airtraq (Prodol Meditec S.A., Vizcaya, Spain); GlideScope (Verathon, Bothell, WA, USA); Insighters videolaryngoscopes (Insighters Medical Technology, Shenzhen, China); KingVision (Ambu, Ballerup, Denmark); and VisionPRO (HEINE Optotechnik GmbH & Co. KG, Herrsching, Germany).

The primary objective of this study was to evaluate the inter-rater reliability of a structured videolaryngoscopy classification framework (VCI score) between airway operators and observers. Secondary objectives were to assess the association between glottic view and ease of tracheal tube delivery and to describe the incidence of procedure-related complications during tracheal intubation.

The VCI score comprises three sequential domains: blade geometry, glottic view and tracheal tube delivery (Fig. 1). Blade geometry was classified as Macintosh-type (standard geometry) or hyperangulated. Glottic view was characterised by estimating the proportion of the glottic aperture visible at the moment of tracheal tube delivery, from the anterior commissure to the interarytenoid notch, known as the percentage of glottic opening (POGO) score. One of four categories was selected: < 25%; ≥ 25–50%; > 50–75%; and > 75% [19, 20]. A target glottic view was not stipulated. Tracheal tube delivery was classified as easy, difficult or failed. Easy tracheal tube delivery was defined as successful tracheal intubation on the first attempt using the chosen videolaryngoscope and standard technique. The standard technique for Macintosh-type videolaryngoscopy was to attempt tracheal intubation without an adjunct. The standard technique for hyperangulated videolaryngoscopy was to attempt tracheal intubation using a pre-shaped stylet. Difficult tracheal tube delivery was defined as successful tracheal intubation that required the use of an adjunct (other than a stylet with a hyperangulated blade) and/or more than one attempt, without change of device or primary operator. Failed tracheal tube delivery was defined as the need to change blade geometry and/or operator to achieve successful tracheal intubation.

A change of device was considered to have occurred only when a change in blade geometry was required, either

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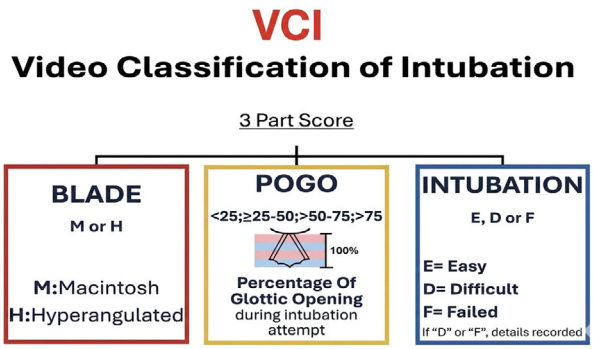


Figure 1 Video classification of intubation score.

by changing blade type within the same videolaryngoscope system or by changing to a different videolaryngoscope system with a different blade geometry. Only first-attempt tracheal intubation success was recorded specifically. Detailed counts of subsequent attempts were not collected as part of the study protocol. The specific number of tracheal intubation attempts was not recorded but the need for more than one attempt was incorporated into the definition of `difficult´ tracheal tube delivery.

The airway operator and the observer recorded VCI scores independently after tracheal intubation. The primary VCI score reflected the initial tracheal intubation strategy. When tracheal tube delivery failed, a rescue VCI score was recorded, reflecting the first attempt of the new operator and/or blade. A change in operator typically meant that the individuals acting as operator and observer switched roles. All operators and observers completed a structured pre-study training programme consisting of a 1-h virtual session covering operational definitions of each VCI domain and how to complete the standardised electronic case report form. Ongoing standardisation was reinforced through monthly investigator meetings and a dedicated online platform for protocol-related queries.

Predefined complications were recorded for each attempt at tracheal intubation, including: hypoxaemia (SpO_2 < 90% for ≥ 10 s); oesophageal intubation; dental injury; laryngeal trauma; bronchospasm; and laryngospasm.

The VCI scores and study variables were recorded in a secure REDCap database. Inter-rater reliability was prespecified in the published study protocol as Cohen's κ [17]. Before data access, this approach was revised in favour of Krippendorff's α, given its methodological advantages for multiple raters, applicability to nominal and ordinal data and ability to accommodate missing data. Agreement was assessed for the VCI score and for each individual VCI domain [21]. Krippendorff's α 95%CIs were calculated using bootstrap resampling with 1000 iterations. The association between glottic view and ease of tracheal tube delivery was evaluated using the χ^2 test. Comparisons between groups were performed using the χ^2 test or Fisher's exact test for categorical variables and the Mann–Whitney U test or Kruskal–Wallis test for continuous variables. All tests were two-sided and a p value < 0.05 was considered statistically significant for the primary outcome.

The sample size calculation was based on estimation of inter-rater agreement for the primary outcome. Assuming an expected agreement coefficient of 0.80, a desired precision of ±0.11 and a 95%CI, the minimum required sample size was estimated at 1329 patients. Allowing for an anticipated 5% dropout rate resulted in a target sample size of 1395 patients. Statistical analyses were performed using IBM SPSS Statistics (version 29.0, IBM Corp., Armonk, NY, USA) and Krippendorff's α was calculated using the Hayes–Krippendorff macro.

Results

Between September 2024 and September 2025, videolaryngoscopic tracheal intubations during 5333 patient encounters across 44 participating hospitals were documented (online Supporting Information Appendix S2).

A primary VCI assessment was completed separately by the airway operator and the observer in 5302 patient encounters, yielding 10,604 ratings. Baseline patient, operator and procedural characteristics are summarised in Table 1.

At the moment of tracheal tube delivery, glottic view was rated as POGO > 75% in 8075 (76.2%) assessments; > 50–75% in 1649 (15.6%); ≥ 25–50% in 573 (5.4%); and < 25% in 307 (2.9%). Tracheal tube delivery was classified as easy in 9341 (88.1%) assessments, difficult in 1069 (10.1%) and failed in 194 (1.8%). The distribution of VCI scores is shown in Figure 2.

There was overall agreement on the VCI score in 4803 (90.6%) of patients, with high inter-rater reliability; Krippendorff's α = 0.86 (95%CI 0.85–0.87) (Table 2). Disagreement on POGO assessment occurred in 499 (9.4%) patients, disagreement on tracheal tube delivery occurred in 70 (1.3%) and disagreement on blade geometry occurred in 10 (0.2%) patients. Fifteen (0.3%) paired assessments differed in more than one VCI domain. There was also high inter-rater reliability for rescue VCI assessments, Krippendorff's α 0.820 (95%CI 0.72–0.90). Transitions between primary and rescue strategies are summarised in online Supporting Information Appendix S3.

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Table 1 Baseline patient and procedural characteristics in 5302 patients. Values are mean (SD) or number (proportion).

	n = 5302
Age; y	56 (16.7)
Sex; female	2594 (48.9%)
BMI; $kg.m^{-2}$	27.4 (5.7)
ASA physical status	
1	776 (14.6%)
2	2941 (55.5%)
3	1440 (27.2%)
4	145 (2.7%)
Clinical setting	
Operating theatre	5200 (98.1%)
Non-operating room anaesthesia	80 (1.5%)
Emergency department	17 (0.3%)
Intensive care unit	5 (0.1%)
Airway operator seniority	
Specialist (consultant)	2944 (55.5%)
Resident (trainee)	2358 (44.5%)
Airway operator anaesthesia experience; y	
< 4	2401 (45.3%)
4–8	685 (12.9%)
> 8	2216 (41.8%)
Airway operator videolaryngoscopy experience; number of tracheal intubations	
< 25	1056 (19.9%)
25–50	999 (18.9%)
> 50	3247 (61.2%)
Observer seniority	
Specialist (consultant)	4742 (89.4%)
Resident (trainee)	560 (10.6%)
Observer anaesthesia experience; y	
< 4	560 (10.6%)
4–8	1037 (19.5%)
> 8	3705 (69.9%)
Observer videolaryngoscopy experience; number of tracheal intubations	
< 25	456 (8.6%)
25–50	458 (8.6%)
> 50	4388 (82.8%)
First videolaryngoscope used	
McGrath	2204 (41.6%)
C-MAC	1067 (20.1%)
Airtraq	921 (17.4%)
GlideScope	810 (15.3%)
Insighters	213 (4.0%)
KingVision	38 (0.7%)
Vision Pro	26 (0.5%)
Blade geometry	
Macintosh-type blade	3062 (57.8%)
Hyperangulated blade	2240 (42.2%)

The relationship between glottic view and tracheal tube delivery is shown in Table 3. Tracheal tube-delivery outcomes differed significantly across POGO categories (χ^2 test for trend, $p < 0.001$).

Hypoxaemia (SpO_2 < 90% for ≥ 10 s) occurred in 60 (1.1%) patients, minor mucosal trauma or bleeding in 29 (0.6%), laryngospasm or bronchospasm in 10 (0.2%), oesophageal intubation in seven (0.1%) and dental injury in four (0.1%) patients. Most failed tracheal tube deliveries were managed successfully following a change of device and/or operator, but tracheal intubation was not achieved with videolaryngoscopy in five (0.1%) patients due to: videolaryngoscope malfunction requiring use of direct laryngoscopy (n = 2); previously undiagnosed subglottic stenosis (n = 2); and significant bleeding due to airway instrumentation (n = 1). In all five instances, the procedures were postponed and the patients emerged from anaesthesia without any further complication.

Discussion

This nationwide, prospective multicentre study showed high inter-rater reliability of the VCI score. The participating centres encompassed a wide range of institutional settings and operator experience levels, providing a heterogeneous context for assessing agreement.

While reproducibility is a necessary requirement for any classification system, it does not in itself establish clinical utility [22]. Assessment of laryngeal view by POGO is simple and reproducible [14, 23]. However, this study highlights the dissociation between the laryngeal view obtained and the ease of tracheal intubation. Although most tracheal intubations were performed successfully on the first attempt when glottic view was good (POGO > 75%), some required more than one attempt or unplanned use of an adjunct, and a smaller subset progressed to device and/or operator change.

When glottic view was poor (POGO < 25%), a wide range of outcomes arose, suggesting that clinically relevant anatomical differences are not captured fully. In these situations, complementary qualitative description of visible anatomical landmarks, aligned with elements of the

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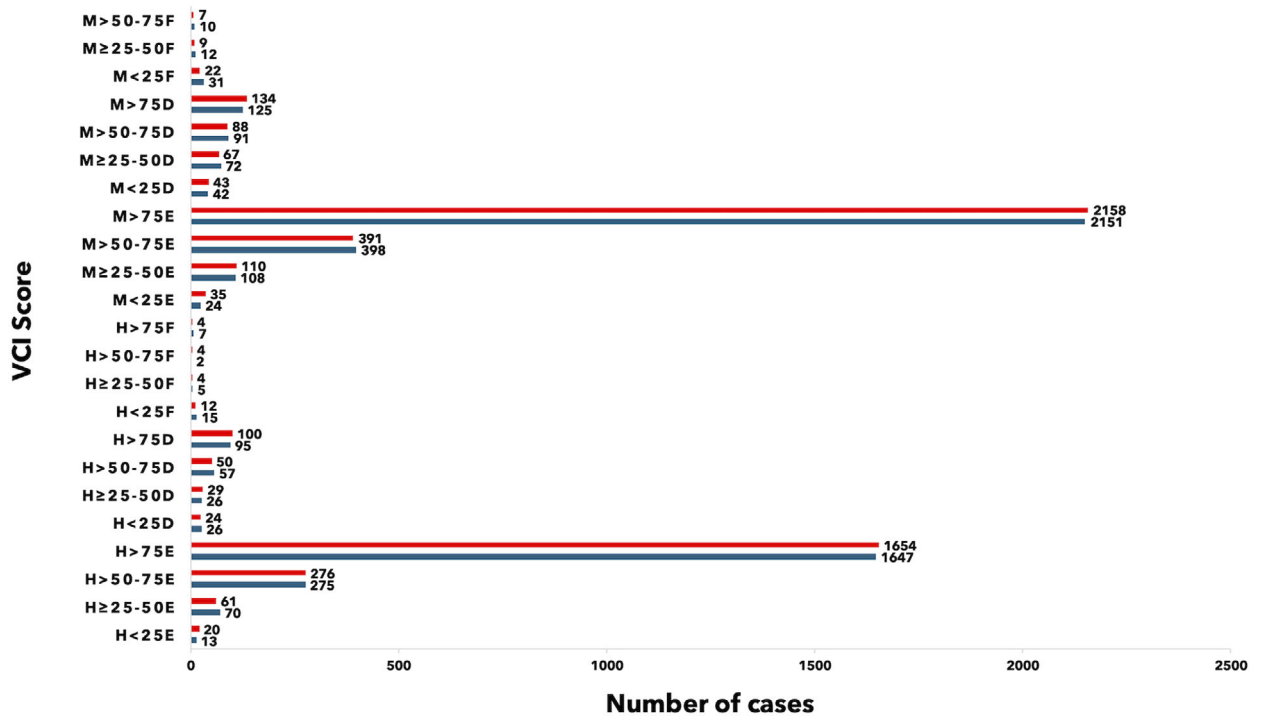


Figure 2 Distribution of video classification of intubation (VCI) scores. Bars represent the frequency of VCI scores as assessed by the airway operator (blue) and the observer (red). The numerical value on the y-axis represent the percentage of glottic opening. M and H denote Macintosh-type and hyperangulated videolaryngoscope blades, respectively. E, D and F denote easy, difficult and failed tracheal tube delivery, respectively.

Table 2 Agreement between airway operator and observer assessments of glottic view and tracheal tube delivery. Values are number (proportion) of the airway operator category.

A. Blade geometry

	Blade geometry	Observer	
		Macintosh-type	Hyperangulated
Airway operator	**Macintosh-type**	3055 (99.8%)	7 (0.2%)
	Hyperangulated	3 (0.1%)	2237 (99.9%)

B. Percentage of glottic opening (POGO)

	POGO	Observer			
		< 25%	≥ 25–50%	> 50–75%	> 75%
Airway operator	< 25%	115 (76.2%)	19 (12.6%)	4 (2.6%)	13 (8.6%)
	≥ 25–50%	25 (8.5%)	200 (68.3%)	45 (15.4%)	23 (7.8%)
	> 50–75%	4 (0.5%)	55 (6.6%)	624 (74.9%)	150 (18.0%)
	> 75%	12 (0.3%)	6 (0.1%)	143 (3.6%)	3864 (96.0%)

C. Tracheal tube delivery

	Tracheal tube passage	Observer		
		Easy	Difficult	Failed
Airway operator	Easy	4642 (99.6%)	18 (0.4%)	1 (< 0.1%)
	Difficult	30 (5.6%)	504 (94.4%)	0
	Failed	8 (7.5%)	13 (12.1%)	86 (80.4%)

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Table 3 Distribution of tracheal tube delivery according to percentage of glottic opening (POGO), based on airway operator assessments. Values are as number (proportion) within each POGO category.

POGO	Easy	Difficult	Failed	Total
< 25%	37 (24.5%)	68 (45.0%)	46 (30.5%)	151
≥ 25–50%	178 (60.8%)	98 (33.4%)	17 (5.8%)	293
> 50–75%	673 (80.8%)	148 (17.8%)	12 (1.4%)	833
> 75%	3773 (93.7%)	220 (5.5%)	32 (0.8%)	4025
Total	4661	534	107	5302

Cormack–Lehane classification, may provide additional clinical context [24, 25]. Emerging automated image-analysis approaches using videolaryngoscopy images and video recordings may allow more objective and reproducible assessment of glottic exposure [26–28].

As blade geometry influences the spatial relationship between camera orientation, airway curvature and tracheal tube trajectory, identical laryngeal views may carry different procedural implications depending on blade design [29, 30]. Incorporation of blade size and specific device characteristics into the VCI score could improve procedural characterisation [31].

Within the VCI score, glottic view is recorded at the moment of tracheal tube delivery, as this reflects the functional conditions under which tracheal intubation is achieved. Adjunct use, device change and operator change are integral procedural components with direct safety implications, as introducer-related airway trauma remains a recognised risk [13, 16, 22]. Other videolaryngoscopy classification systems prioritise view-based descriptors or incorporate multiple procedural elements that may limit routine documentation [32–34].

This study has several limitations. Ratings were obtained in real-time during the procedure which may have influenced agreement estimates. Only adult patients were studied and the number of tracheal intubations performed in emergency departments and ICU was small. The number of patients with poor glottic view was also small, which limits applicability of study findings to this scenario. The requirement to use videolaryngoscopy to be eligible for inclusion in this study may have influenced device choice. The number of tracheal intubation attempts for each patient was not recorded and no comparisons were made with other classification systems. While high inter-rater agreement supports reproducibility, it does not establish clinical validity, predictive performance or impact on patient outcomes.

In conclusion, in this large multicentre cohort, the VCI score showed high inter-rater agreement in routine practice. By separating what was used, what was seen and what was done, it provides a structured framework for describing videolaryngoscopic tracheal intubation beyond glottic view alone.

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Supporting Information

Additional supporting information may be found online via the journal website.

Appendix S1. VCI-Spain Trial investigators group.

Appendix S2. Participating hospitals by autonomous community.

Appendix S3. Failed primary VCI scores and corresponding rescue VCI scores with documented rescue mechanisms based on intubating clinician assessments among rescue tracheal intubation cases.

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