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Comparison Of MAC Style Video Laryngoscope And Macintosh Laryngoscope For Endotracheal Intubation In A Simulated Difficult Airway: A Prospective Randomised Study

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Abstract
Background: *Endotracheal intubation remains a cornerstone of airway management. Direct laryngoscopy with the Macintosh blade can be compromised when anatomical alignment is restricted. MAC style video laryngoscopes retain familiar blade geometry and add an indirect view of the glottis. Limited data exist on their performance against the Macintosh in standardised models of difficult intubation.*
Objectives: *To compare laryngeal visualisation, intubation time, adjunct use, first attempt success, complications and ease of intubation between the MAC style video laryngoscope and the Macintosh laryngoscope in a simulated difficult airway.*
Methods: *This prospective randomised single blind study enrolled 110 adults (ASA I-II, age 18- 65 years) undergoing elective surgery under general anaesthesia at a single tertiary centre. A cervical collar simulated difficult airway conditions. Patients were randomised to intubation with a Macintosh laryngoscope (ML group, n = 55) or a MAC style video laryngoscope (MV group, n = 55). The primary outcome was Cormack-Lehane grade. Secondary outcomes included intubation time, bougie and external laryngeal manipulation use, first attempt success, complications and ease of intubation.*
Results: *All 55 patients in the MV group achieved good laryngeal views (Cormack-Lehane grade I-II, 100%) versus 44 of 55 in the ML group (80.0%; p = 0.0006). Poor views (grade III-IV) occurred only in the ML group (20.0%). Mean intubation time was shorter in the MV group (35.33 ± 6.59 s vs 41.99 ± 8.19 s; p < 0.0001). Bougie use (3.6% vs 21.8%; p = 0.008) and external laryngeal manipulation (18.2% vs 38.2%; p = 0.033) were less frequent with the video laryngoscope. First attempt success was comparable (94.5% vs 87.3%; p = 0.320). Complications were uncommon in both groups (3.6% vs 14.5%; p = 0.093). Intubation was rated easy in 89.1% of MV cases versus 54.5% in the ML group (p < 0.001).*
Conclusion: *The MAC style video laryngoscope provided superior laryngeal visualisation, shorter intubation times, reduced adjunct requirements and improved ease of intubation compared with the Macintosh laryngoscope in a simulated difficult airway. Both devices achieved high first attempt success and acceptable safety profiles.*
Keywords: *video laryngoscopy; Macintosh laryngoscope; difficult airway; cervical collar; Cormack-Lehane grade; intubation time; simulated airway*

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I. Introduction

Endotracheal intubation secures ventilation, prevents aspiration and provides a stable conduit for anaesthetic gases. Failure to intubate or oxygenate can produce hypoxic injury within minutes.[1,2] Difficult and failed intubation remain significant contributors to airway morbidity and litigation across operating theatres, intensive care units and emergency departments.[3,4] Accurate prediction of difficulty is imperfect; mouth opening, cervical mobility, thyromental distance and a prior history of difficult laryngoscopy all carry prognostic weight, yet surprises persist.[5,6]

The Macintosh laryngoscope has been the reference device for direct laryngoscopy since the mid twentieth century. Its curved blade engages the vallecula and lifts the epiglottis indirectly, creating a line of sight view of the glottis when oral, pharyngeal and laryngeal axes are aligned.[7,8] The technique is familiar to clinicians across training grades. Reduced mouth opening, cervical immobilisation, an anterior larynx, obesity and airway oedema all degrade the direct view and increase tissue contact forces.[9,10] Under such constraints, first pass success falls and repeated attempts raise the risk of hypoxaemia, haemodynamic instability and airway trauma.[11]

Video laryngoscopy addresses these constraints by placing a camera and light source near the blade tip and projecting the image to a screen. This decouples visualisation from strict anatomical alignment. Blade geometry divides video laryngoscopes into hyperangulated, channelled and MAC style categories. Hyperangulated devices often show an excellent glottic image but demand a preshaped stylet and a different delivery arc for the tube. MAC style platforms retain Macintosh curvature and allow either direct or indirect viewing from the same insertion; the transition from conventional technique is therefore shorter.[12-14] A Cochrane review of 66 randomised studies found that video laryngoscopy modestly increased first attempt success (relative risk 1.03) and consistently improved glottic views, with benefits most pronounced in difficult airways.[15] The DEVICE trial involving 1417 critically ill adults demonstrated a 14.3 percentage point improvement in first pass success with video laryngoscopy and no increase in severe complications.[16]

Cervical immobilisation is a widely used model of simulated difficulty. A semi rigid collar restricts atlanto occipital extension and reduces mouth opening, and this directly degrades the laryngoscopic view.[17,18] Simulation provides a controlled environment for comparing devices while standardising difficulty and capturing performance metrics without exposing patients to avoidable harm.[19] Data that specifically compare MAC style video laryngoscopes with the Macintosh blade under standardised simulated difficulty remain limited; most trials pool device subtypes or study hyperangulated platforms. The present study aimed to compare a MAC style video laryngoscope with the Macintosh laryngoscope for endotracheal intubation in a simulated difficult airway, with laryngeal visualisation as the primary outcome.

II. Materials And Methods

Study design and setting

This prospective randomised single blind study was conducted at the Department of Anaesthesiology, School of Medical Sciences and Research, Sharda Hospital, Greater Noida, India, from April 2024 to November 2025. The institutional ethics committee approved the protocol. Written informed consent was obtained from all participants in their preferred language.

Participants

Adults aged 18 to 65 years of either sex, ASA physical status I or II, posted for elective surgery under general anaesthesia with endotracheal intubation were eligible. Inclusion required Mallampati class I or II, an El Ganzouri Risk Index score of 7 or less and a body mass index below 30 kg/m^2. Patients were excluded if they refused participation, had a risk of gastric aspiration, were undergoing oropharyngeal surgery or had a known unstable cervical spine injury.

Sample size

The sample size was based on published data by Taylor et al. (2013), who reported Cormack- Lehane grade I views in 95% of patients with a McGrath video laryngoscope versus 24% with a Macintosh blade.[20] Using the two proportion comparison formula with 90% power and a two sided alpha of 0.05, the highest required sample was 54 per group. The total enrolment was set at 110 (55 per group) to account for possible attrition.

Randomisation and blinding

Randomisation was performed using computer generated random numbers in Microsoft Excel. An anaesthesiologist who was not part of the intubating team allocated patients to one of two groups: the Macintosh laryngoscope group (ML) or the MAC style video laryngoscope group (MV). The patient and the outcome assessor for Cormack-Lehane grading were blinded to group allocation where feasible; the intubating anaesthesiologist could not be blinded to the device.

Anaesthetic management and simulated difficulty

Standard monitoring (electrocardiography, pulse oximetry, capnography and noninvasive blood pressure) was applied. Patients were preoxygenated for three minutes with 100% oxygen. Premedication consisted of glycopyrrolate 0.04 mg/kg and fentanyl 2 mcg/kg. Anaesthesia was induced with propofol 2 mg/kg. After confirmation of adequate mask ventilation, a cervical collar (MGRM Medicare Pvt Limited, Telangana, India) was applied. The collar size was matched to each patient's sternomental distance per the manufacturer's instructions. If the inter incisor distance fell below 18 mm, the collar was loosened to permit blade insertion. Succinylcholine 2 mg/kg was then administered and the patient ventilated with nitrous oxide, oxygen and isoflurane until relaxation was achieved.

Intubation procedure

All intubations were performed by a single experienced anaesthesiologist with at least ten prior video laryngoscope exposures. The head was maintained in a neutral position. In the ML group, a Macintosh laryngoscope with a size 3 or 4 blade was used. In the MV group, a BPL VL 01 MAC style video laryngoscope

(BPL Medical Technologies, Bangalore, India) with a size 3 or 4 blade was used. An appropriately sized endotracheal tube was passed through the vocal cords under vision; correct placement was confirmed by capnography and auscultation. Maintenance of anaesthesia continued with nitrous oxide, oxygen, isoflurane and vecuronium 0.05 mg/kg.

Outcome measures

The primary outcome was laryngeal visualisation graded by the Cormack-Lehane classification. For the ML group, glottic view was assessed during direct laryngoscopy. For the MV group, the view was first assessed by Macintosh blade (for comparison) and then intubation proceeded with the video laryngoscope. Secondary outcomes included intubation time (measured from insertion of the device into the oral cavity to placement of the tube between the vocal cords), use of bougie, external laryngeal manipulation (ELM), first attempt success, number of attempts, intubation related complications (lip injury, oral mucosal injury, dental injury, laryngospasm, bronchospasm, sore throat and postoperative stridor) and operator rated ease of intubation (easy, satisfactory or difficult). A failed attempt was defined as failure to intubate within 120 seconds or oxygen saturation falling below 90%.

Statistical analysis

Distributional variables were expressed as counts and percentages and compared using chi square or Fisher exact tests. Quantitative variables were presented as descriptive statistics. Normality was assessed by the Shapiro-Wilk test. Normally distributed data were compared with unpaired t tests; non normal data with the Mann-Whitney U test. Correlations were assessed with Spearman coefficients. A two sided p value of 0.05 or less was considered significant. Analysis was performed in SPSS version 22.0 (IBM Corporation, Chicago, IL, USA).

III. Results

The study enrolled 110 patients, with 55 allocated to each group. Baseline characteristics are presented in Table 1. Age was comparable between groups (42.71 ± 13.82 vs 44.40 ± 13.72 years; p = 0.521) as was BMI (23.74 ± 2.95 vs 23.56 ± 3.01 kg/m^2; p = 0.747). The MV group had a higher proportion of male patients (72.7% vs 52.7%; p = 0.068) and more ASA II patients (45.5% vs 23.6%; p = 0.027). Mallampati class distribution was identical across groups (58.2% class I in both; p = 1.000). El Ganzouri risk scores showed a nonsignificant trend toward lower values in the MV group (3.58 ± 2.36 vs 4.40 ± 2.22; p = 0.064).

Table 1. Baseline demographics and clinical characteristics by group

Variable	ML (n = 55)	MV (n = 55)	p value
Age (years), mean ± SD	42.71 ± 13.82	44.40 ± 13.72	0.521
Sex, male n (%)	29 (52.7)	40 (72.7)	0.068
BMI (kg/m²), mean ± SD	23.74 ± 2.95	23.56 ± 3.01	0.747
ASA I, n (%)	42 (76.4)	30 (54.5)	0.027
ASA II, n (%)	13 (23.6)	25 (45.5)	
Mallampati I, n (%)	32 (58.2)	32 (58.2)	1.000
Mallampati II, n (%)	23 (41.8)	23 (41.8)	
El Ganzouri score, mean ± SD	4.40 ± 2.22	3.58 ± 2.36	0.064

BMI, body mass index; ASA, American Society of Anesthesiologists; SD, standard deviation. Bold p values indicate statistical significance (p < 0.05).

The primary outcome strongly favoured the MAC style video laryngoscope (Table 2). All 55 patients in the MV group achieved Cormack-Lehane grade I or II views (100%) compared with 44 of 55 in the ML group (80.0%; p < 0.001). Grade I views were recorded in 78.2% of MV patients versus 41.8% in the ML group. Poor views (grade III or IV) occurred exclusively in the ML group, affecting 11 patients (20.0%); nine had grade III views and two had grade IV views. The overall distribution of Cormack-Lehane grades differed significantly between devices (p < 0.001).

Table 2. Cormack-Lehane grade distribution and view quality by group

CL Grade	ML n (%)	MV n (%)	p value
Grade I	23 (41.8)	43 (78.2)	< 0.001
Grade II	21 (38.2)	12 (21.8)	
Grade III	9 (16.4)	0 (0.0)	
Grade IV	2 (3.6)	0 (0.0)	

Good view (I-II)	44 (80.0)	55 (100.0)	< 0.001
Poor view (III-IV)	11 (20.0)	0 (0.0)	

CL, Cormack-Lehane. p value for overall distribution (chi square) shown for Grade I row; p value for good vs poor view (Fisher exact) shown for Good view row.

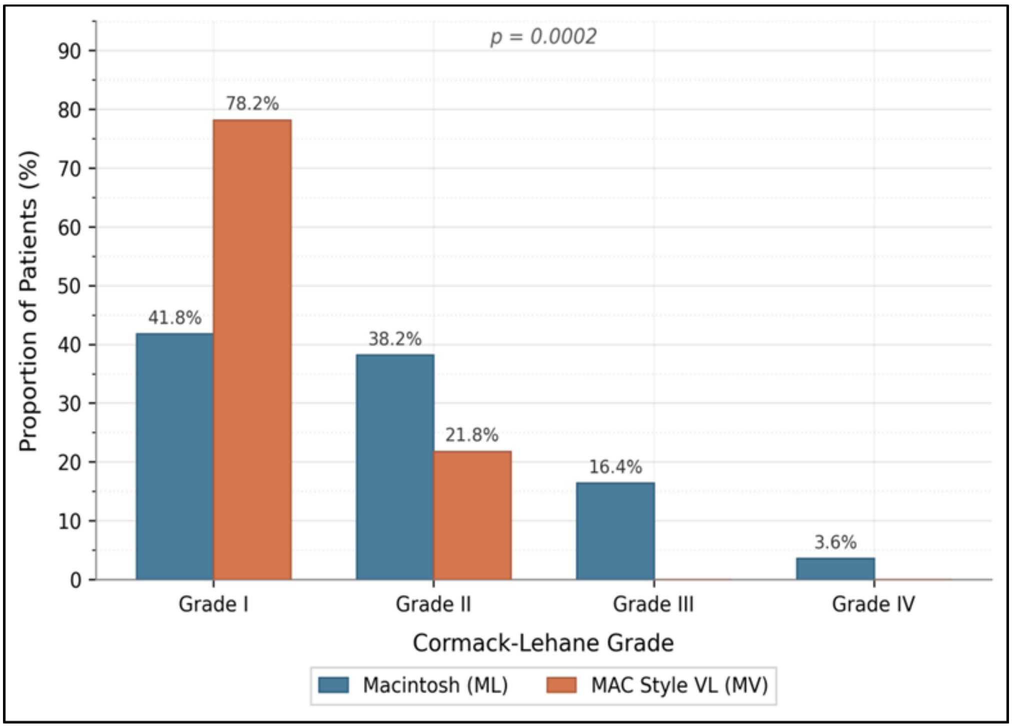

Figure 1. Cormack-Lehane grade distribution by device group. The MAC style video laryngoscope (MV) eliminated grade III and IV views and nearly doubled the proportion of grade I views compared with the Macintosh laryngoscope (ML). p = 0.0002 for overall distribution.

Intubation time was significantly shorter in the MV group (35.33 ± 6.59 s vs 41.99 ± 8.19 s; p < 0.0001), a mean reduction of 6.7 seconds (Table 3). First attempt success was high in both groups and did not differ significantly (94.5% vs 87.3%; p = 0.320). Bougie use was required in 3.6% of MV patients compared with 21.8% in the ML group (p = 0.008), a six fold reduction. External laryngeal manipulation was also less frequent with the video device (18.2% vs 38.2%; p = 0.033). Intubation was rated easy by the operator in 89.1% of MV cases versus 54.5% in the ML group (p < 0.001).

Table 3. Secondary outcomes: intubation performance by group

Outcome	ML (n = 55)	MV (n = 55)	p value
Intubation time (s), mean ± SD	41.99 ± 8.19	35.33 ± 6.59	< 0.0001
First attempt success, n (%)	48 (87.3)	52 (94.5)	0.320
Bougie use, n (%)	12 (21.8)	2 (3.6)	0.008
ELM use, n (%)	21 (38.2)	10 (18.2)	0.033
Ease: Easy, n (%)	30 (54.5)	49 (89.1)	< 0.001
Ease: Satisfactory, n (%)	22 (40.0)	5 (9.1)	
Ease: Difficult, n (%)	3 (5.5)	1 (1.8)	

ELM, external laryngeal manipulation; SD, standard deviation. Bold p values indicate statistical significance.

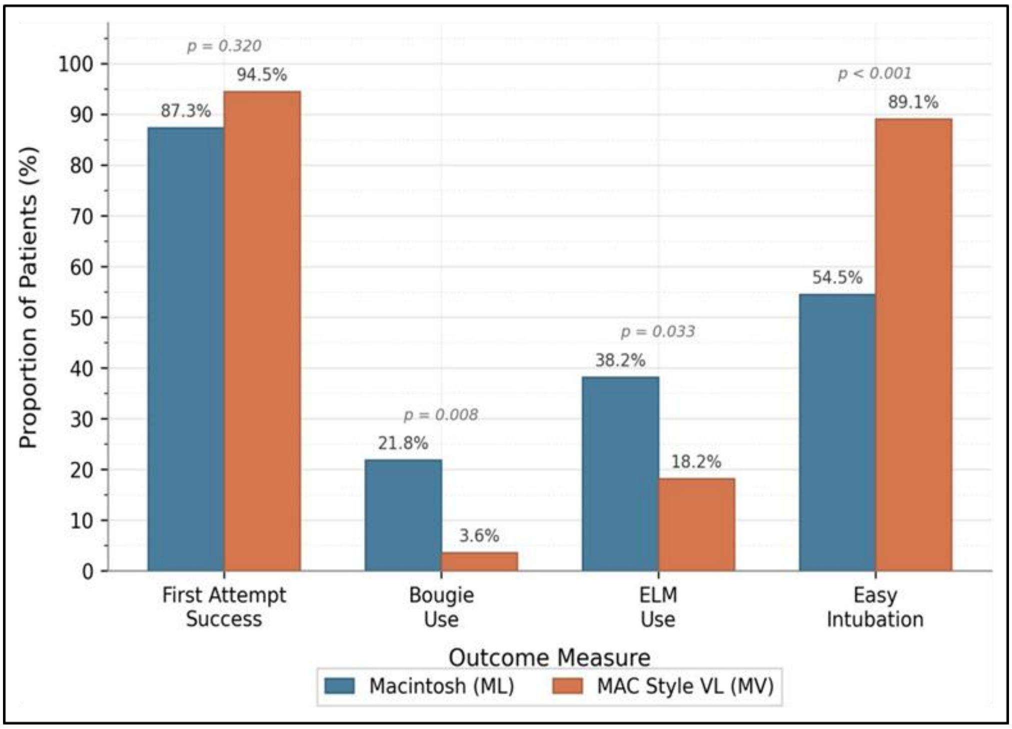

Figure 2. Comparison of secondary outcomes between device groups. The MAC style video laryngoscope (MV) showed significantly lower bougie and ELM use and a higher proportion of easy intubations. First attempt success was numerically higher in the MV group but did not reach statistical significance.

Complications were uncommon in both groups (Table 4). Overall complication rates were 14.5% in the ML group and 3.6% in the MV group (p = 0.093). Lip injury was the most frequent event (7.3% ML vs 1.8% MV). Oral mucosal injury occurred in 5.5% and 1.8% respectively. Dental injury was observed in one patient (1.8%) in the ML group only. No laryngospasm, bronchospasm, sore throat or postoperative stridor was recorded in either group.

Table 4. Intubation related complications by group

Complication	ML n (%)	MV n (%)	p value
Any complication	8 (14.5)	2 (3.6)	0.093
Lip injury	4 (7.3)	1 (1.8)	—
Oral mucosal injury	3 (5.5)	1 (1.8)	—
Dental injury	1 (1.8)	0 (0.0)	—

Individual complication types were not tested separately due to small numbers. The dash (—) indicates Fisher exact test not performed.

Correlation analysis showed that the El Ganzouri risk score had a weak positive association with Cormack-Lehane grade (Spearman ρ = 0.196; p = 0.040) and that poorer Cormack-Lehane grades were associated with longer intubation times (ρ = 0.214; p = 0.025). The correlation between El Ganzouri score and intubation time was positive but did not reach significance (ρ = 0.179; p = 0.061).

IV. Discussion

The MAC style video laryngoscope produced better laryngeal views, shorter intubation times, fewer adjunct requirements and higher ease of intubation ratings than the Macintosh blade in this simulated difficult airway population. Poor Cormack-Lehane views were eliminated entirely in the video group. First attempt success was high with both devices and did not differ significantly. Complication rates were low in both arms. These findings support the use of MAC style video laryngoscopy when cervical immobilisation compromises the direct view.

The complete elimination of grade III and IV views in the MV group (0% vs 20.0% in ML) is clinically meaningful. Aziz et al. (2012), in a randomised trial of 300 patients with predicted difficult airways, reported grade I-II views in 93% with the C MAC versus 81% with direct laryngoscopy (p < 0.01).[21] The present study achieved 100% good views with the MAC style device, a result consistent with Kaur et al. (2020), who found 100% good views with both McGrath MAC and TruView video laryngoscopes versus 77.5% with the Macintosh blade in 120 elective patients.[22] Prekker et al. (2023) reported good views in 96.3% of video laryngoscopy cases versus 78.9% with direct laryngoscopy in 1417 critically ill adults.[16] The pattern is consistent across settings: MAC style video blades substantially reduce poor views and the magnitude of benefit in our study aligns with larger clinical trials.

The 6.7 second reduction in mean intubation time (35.33 vs 41.99 s; $p < 0.0001$) contrasts with Aziz et al. (2012), who found longer laryngoscopy times with the C MAC (46 s vs 33 s; $p < 0.001$).[21] The discrepancy may relate to differences in device familiarity, patient populations and measurement definitions. Our result is more closely aligned with Prekker et al. (2023), who reported a median difference of 8 seconds favouring video laryngoscopy in critically ill patients.[16] Kaur et al. (2020) found comparable total intubation durations across devices but noted that laryngoscopy time to best view was shortest with the McGrath MAC.[22] The time saving in our study probably stems from improved glottic exposure, which shortened tube delivery rather than prolonging it.

Bougie use fell from 21.8% with the Macintosh to 3.6% with the video device ($p = 0.008$). External laryngeal manipulation dropped from 38.2% to 18.2% ($p = 0.033$). Aziz et al. (2012) reported that combined adjunct use was 24% with the C MAC versus 37% with direct laryngoscopy ($p = 0.020$).[21] Kaur et al. (2020) similarly showed lower optimisation manoeuvre rates with both video devices.[22] The consistency of these findings across studies supports the interpretation that improved visualisation directly reduces the need for supplementary manoeuvres.

First attempt success was 94.5% in the MV group and 87.3% in the ML group ($p = 0.320$). The 7.2 percentage point difference did not reach significance in our 110 patient sample. Aziz et al. (2012) achieved significance with a 9 percentage point difference in 296 patients ($p = 0.026$).[21] Prekker et al. (2023) found a 14.3 percentage point difference ($p < 0.001$) in their larger trial and noted that operators with fewer than 25 intubations derived the greatest benefit.[16] Our experienced single operator design probably compressed the difference; a larger or multioperator trial might have shown significance. Kim et al. (2023) reported high success with the McGrath in an immobilised setting and linked gains to improved views and shared screen coaching.[17]

Complications were infrequent. The overall rate was 14.5% in the ML group and 3.6% in the MV group ($p = 0.093$). The predominant events were minor soft tissue injuries. Kaur et al. (2020) reported no trauma with the McGrath MAC versus 12.5% with the Macintosh, without reaching significance.[22] Hansel et al. (2022) noted in their Cochrane review that video laryngoscopy tends to reduce oesophageal intubations and airway trauma, particularly with channelled devices.[15] Our data are directionally consistent. The small absolute numbers in both groups limited statistical power for this endpoint.

Ease of intubation was rated easy in 89.1% of MV patients versus 54.5% in the ML group ($p < 0.001$). Kaur et al. (2020) reported easy intubation in 90% of McGrath cases versus 65% with the Macintosh.[22] This subjective measure tracked closely with the objective findings. Superior views translated into a simpler procedure; fewer adjustments were needed and tube delivery was faster. The alignment between objective and subjective data strengthens the conclusion that video laryngoscopy meaningfully simplifies the intubation process in compromised airways.

The weak positive correlations between El Ganzouri score and Cormack-Lehane grade ($\rho = 0.196$; $p = 0.040$) and between Cormack-Lehane grade and intubation time ($\rho = 0.214$; $p = 0.025$) support internal consistency. Patients with higher predicted difficulty tended to have worse views and longer intubation times. The correlation between the risk score and intubation time did not reach significance, which may indicate that the video device partially buffered the impact of predicted difficulty on procedural duration.

Cavus et al. (2011) studied 150 patients with normal airways and found that the C MAC improved laryngeal views in most patients who had suboptimal direct laryngoscopy grades.[23] Serocki et al. (2013) reported 100% intubation success with both the GlideScope and the C MAC D Blade versus 95.8% with direct laryngoscopy in anticipated difficult airways.[24] Kleine Brueggeney et al. (2016) tested six video laryngoscopes in 720 patients with simulated difficulty and showed that C MAC and GlideScope maintained high success despite collar induced restriction.[25] Taylor et al. (2013) demonstrated that novices using the McGrath achieved intubation rates comparable to experienced operators using direct laryngoscopy.[20] These results collectively indicate that MAC style geometry preserves the mechanical familiarity of the Macintosh blade while adding the safety margin of an indirect view.

Strengths of this study include the standardised simulation model, a single experienced operator (which minimised performance variability), prospective randomised design, comprehensive recording of primary and secondary outcomes and detailed reporting of individual complication types.

The study has several limitations. The single centre single operator design limits generalisability; results may differ with less experienced clinicians or in multicentre settings. The cervical collar was the sole difficulty modifier; combined constraints (tongue oedema inserts, secretion modules) might produce different device performance patterns. ASA physical status differed between groups (p = 0.027), with more ASA II patients in the MV arm; this could have introduced a small confounding effect, though ASA status alone does not directly influence laryngoscopic view. The sex distribution trended toward more males in the MV group (p = 0.068). The sample size was powered for the primary outcome (Cormack-Lehane grade) and may have been underpowered to detect differences in first attempt success or complications. The BPL VL 01 device used in this study may not generalise to all MAC style platforms.

Larger multicentre trials with stratification by operator experience are needed. Inclusion of combined difficulty modifiers, cost effectiveness analyses and longer-term outcome tracking would strengthen the evidence base. Comparative studies between different MAC style platforms would also help clinicians select the most appropriate device for their setting.

V. Conclusion

The MAC style video laryngoscope provided superior laryngeal visualisation, shorter intubation times, reduced bougie and external laryngeal manipulation requirements and improved operator rated ease of intubation compared with the Macintosh laryngoscope in patients with simulated difficult airways. Good Cormack-Lehane views were achieved in all patients with video laryngoscopy, and poor views were completely eliminated. First attempt success was high and comparable between devices. Complications were infrequent with both instruments. These findings indicate that the MAC style video laryngoscope can serve as an effective first line device when cervical immobilisation is anticipated, and they support its inclusion in difficult airway protocols and training programmes.

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