


# Comparison of the C-MAC D-blade video laryngoscope and the McCoy laryngoscope for double-lumen endotracheal tube intubation

## A prospective randomized controlled study

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### Abstract

**Background:** Inserting a double-lumen endotracheal tube (DLT) poses more challenge than inserting a single-lumen tube. The C-MAC D-blade videolaryngoscope is a useful alternative to the direct laryngoscope. However, no study has compared its performance with that of the McCoy laryngoscope, which has a hyperangulated blade tip similar to that of the C-MAC D-blade. We aimed to compare the performance of the C-MAC D-blade videolaryngoscope with that of the McCoy laryngoscope in DLT intubation.

**Methods:** In this prospective randomized controlled study, 90 patients requiring DLT intubation were randomly allocated to either the C-MAC D-blade videolaryngoscope group (group C, n = 47) or McCoy laryngoscope group (group M, n = 43). During intubation, the percentage of glottic opening, modified Cormack–Lehane grade, time taken for intubation, malposition of the bronchial lumen, and hemodynamic parameters were recorded. After intubation, we assessed the intubation difficulty scale score and, a postoperative sore throat in the recovery room.

**Results:** The time taken for intubation was  $35.85 \pm 10.77$  seconds and  $33.18 \pm 11.97$  seconds in groups C and M, respectively ( $P = .269$ ). The modified Cormack–Lehane grade was significantly lower in group C than in group M ( $P = .000$ ). Percentage of glottic opening was significantly higher in group C ( $79.36 \pm 13.42\%$ ) than in group M ( $53.49 \pm 29.83\%$ ) ( $P = .000$ ). The intubation difficulty scale score was significantly lower in group C than in group M ( $P = .030$ ). There were no significant differences between the 2 groups in terms of malposition status, hemodynamic parameters, or visual analog scale score for a postoperative sore throat.

**Conclusion:** Although the time taken for intubation was comparable between the 2 intubation devices, the C-MAC D-blade videolaryngoscope facilitated glottis visualization and reduced the intubation difficulty scale better than the McCoy laryngoscope in patients undergoing DLT intubation.

**Abbreviations:** BURP = backward, upward, and rightward pressure maneuvers, DLT = double-lumen endobronchial tube, Fr = French, HR = heart rate, IDS = intubation difficulty scale, MAP = mean arterial pressure, POGO = percentage of glottic opening, SPI = surgical pleth index, SpO<sub>2</sub> = peripheral oxygen saturation, T0 = baseline, T1 = immediately before intubation, T2 = immediately after intubation, T3 = 3 minutes after intubation, VAS = visual analog scale.

**Keywords:** C-MAC video laryngoscope, double lumen tube, hemodynamic changes, intratracheal, intubation, McCoy laryngoscope

## 1. Introduction

In thoracic surgery, one-lung ventilation is often required to collapse the surgical side lung to secure a better surgical field of view and reduce secondary lung damage. For this purpose, a

double-lumen endotracheal tube (DLT) is commonly used for endotracheal intubation. The DLT has a larger outer diameter than a single-lumen endotracheal tube, and a portion of the bronchial lumen is flexed to one side. DLT intubation can be technically more difficult and requires longer intubation time

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than a single-lumen tube. Therefore, many studies have been conducted on the intubation success rate and usefulness of various endotracheal intubation devices during DLT intubation.<sup>[1,2]</sup>

The McCoy laryngoscope has a movable hinged tip at the laryngoscope blade to lift the epiglottis easily during endotracheal intubation.<sup>[3]</sup> Compared to the Macintosh laryngoscope, the McCoy laryngoscope improves operators' visual field with less force and attenuates changes in hemodynamic parameters during endotracheal intubation.<sup>[4]</sup> The McCoy laryngoscope also decreases the incidence of difficult intubation in patients with simulated cervical spine injuries.<sup>[5]</sup> However, the usefulness of the McCoy laryngoscope in DLT intubation has not been well studied.

The video laryngoscopes have a built-in camera at the tip of the blade that allows improved visualization of the larynx and vocal cords through a monitor during intubation.<sup>[6]</sup> Among video laryngoscopes, the C-MAC D-blade video laryngoscope has a strong curvature at the distal end of the blade similar to the McCoy laryngoscope, which faces markedly upward.<sup>[7]</sup> Therefore, a view of the glottis is feasible even without alignment of the orotracheal axes and requires less cervical spine movement than conventional direct laryngoscopy.<sup>[6]</sup> The performance of the C-MAC D-blade video laryngoscope has been reported in various clinical situations.<sup>[8–10]</sup> However, most studies were performed to compare it with the Macintosh laryngoscope, and advantages of video laryngoscopes compared to direct laryngoscope in DLT intubation is controversial.<sup>[4,11,12]</sup> In addition, comparative studies on the performance of the McCoy laryngoscope and C-MAC D-blade video laryngoscope during DLT intubation are still limited.

Therefore, in this study, we aimed to investigate the performance of the McCoy laryngoscope and the C-MAC D-blade video laryngoscope in DLT intubation with respect to the time taken for intubation, intubation difficulty, and hemodynamic changes.

## 2. Materials and methods

### 2.1. Ethics statements

The present study protocol was approved by the Institutional Review Board of Hallym University Sacred Heart Hospital (approval number: 2018-01-009) and registered in the Clinical Trial Registry of the Korea National Institute of Health (CRIS, <http://cris.nih.go.kr>; identification number: KCT 0004535). Written informed consent was obtained from all patients the day before surgery.

### 2.2. Study design and population

This prospective randomized controlled study enrolled patients aged 20 to 80 years with American Society of Anesthesiologists physical status classes I to III scheduled for elective video-assisted

thoroscopic surgery under general anesthesia. This study was performed at Hallym University Sacred Heart Hospital, which is a tertiary university hospital. Patients were excluded if they had an anticipated difficult endotracheal intubation (Mallampati score IV and thyromental distance  $\leq 6$  cm), a history of difficult endotracheal intubation, uncontrolled lung disease, morbid obesity (body mass index  $\geq 35$  kg/m<sup>2</sup>), cervical spine instability, cervical myelopathy, or a known allergy to any drug used in the protocol.

### 2.3. Randomization

All patients were randomly assigned to one of the 2 groups in a 1:1 ratio using a computer-generated random numbers table ([www.randomizer.org](http://www.randomizer.org)) the day before the operation. Randomization was performed by an anesthesiologist who was not involved in the data recording or anesthetic management. Endotracheal intubation of the DLT was conducted using the C-MAC D-blade video laryngoscope (Karl Storz, Tuttlingen, Germany) in group C and the McCoy laryngoscope (Optima, Timesco Ltd., London, England) in group M. All patients were blinded to their group assignment.

### 2.4. Anesthesia protocol

All patients were premedicated with intramuscular glycopyrrolate (0.2 mg) 40 minutes before anesthesia induction. Prior to patients' arrival in the operating theater, an attending anesthesiologist performed an airway examination that included an assessment of the thyromental distance, interincisor distance, loose teeth, the modified Mallampati score, and angle of atlanto-occipital joint extension ( $>30^\circ$ ).<sup>[13]</sup> Upon arrival in the operating theater, patients were placed in the supine position with their head on an 8-cm-high pillow, and basic monitoring including noninvasive blood pressure measurement, electrocardiography, and pulse oximetry was performed.

A DLT (Mallinckrodt™ endobronchial tube, left; Covidien, Mansfield, MA) with internal diameters of 37-Fr for men and 35-Fr for women was prepared for endotracheal intubation. For male patients  $< 160$  cm tall, a 35-Fr DLT was used. The curvature of the DLT was molded along the C-MAC D-blade convexity or McCoy blade convexity with a malleable stylet by the operator prior to anesthesia induction, as shown in Fig. 1.

Five minutes after preoxygenation, anesthesia was induced with intravenous administration of propofol (1.5–2.5 mg/kg) and remifentanyl (0.1–0.2  $\mu$ g/kg/min). After assessing the ability to ventilate, rocuronium (1 mg/kg) was administered intravenously to facilitate DLT intubation, and the patient's lungs were manually ventilated with 2 to 4% sevoflurane in 100% oxygen. After 3 minutes, DLT intubation was performed using the assigned device by a single experienced anesthesiologist,



**Figure 1.** Modelling of the distal concavity of the double-lumen tube along the C-MAC D-blade and McCoy laryngoscope.

who had conducted > 100 successful DLT intubations using the McCoy laryngoscope and C-MAC D-blade video laryngoscope. After inserting the tip of the bronchial lumen of the DLT into the glottis, the stylet was withdrawn 5 cm distal to the upper border of the blue cuff, and the DLT was inserted with the distal concavity facing forward until the blue cuff disappeared into the glottis. Thereafter, the stylet was removed completely, and the DLT was rotated 90° counterclockwise and inserted so that the bronchial lumen entered the left main bronchus.

After induction, anesthesia was maintained with 50% air in oxygen, sevoflurane (2.0–3.5%), and remifentanyl (continuous infusion), and correct positioning of the DLT was confirmed with a flexible fiberoptic bronchoscope. Fentanyl (0.5 µg/kg) was administered for postoperative analgesia 15 minutes prior to the completion of surgery.

**2.5. Data collection**

The primary outcome variable was intubation time, which was defined as the time from the passage of the laryngoscope between the patient’s lips and the connection of the DLT to the circuit of the anesthesia workstation. If more than one intubation attempt was required, only successful endotracheal intubation was included in the data analysis. Secondary outcomes included the visual analog scale (VAS) score for face mask ventilation difficulty (0: very easy or no difficulty; 10: major difficulty, impossible to ventilate the patients’ lungs), modified Cormack–Lehane grade,<sup>[14]</sup> percentage of glottic opening (POGO) (0–100%),<sup>[15]</sup> and intubating conditions, such as ease of laryngoscope and tube advancement and the intubation difficulty scale (IDS) score.<sup>[16]</sup> According to a previous study, POGO represented the degree of the glottic opening along the linear span from the anterior commissure to the inter-arytenoid notch.<sup>[15]</sup> POGO of 100% was defined as a full view of the glottis from the anterior commissure to the inter-arytenoid notch, whereas POGO of 0% indicated that even the inter-arytenoid notch was invisible. The ease of insertion of the laryngoscope was graded as follows: easy, easy to insert once; moderate, requires slight manipulation or has slight resistance; and difficult, has moderate resistance or 2 or more laryngoscope insertion attempts. The ease of tube advancement into the glottis was graded as follows: easy, smooth passage of the DLT into the trachea; moderate, slight DLT manipulation required (changes in the DLT tip direction); and difficult, moderate DLT manipulation or more than 2 tube advancement attempts (re-modeling the curvature of DLT). To score the intubating conditions after completion of intubation, an IDS was used (Table 1).<sup>[16]</sup> During intubation, if the DLT tip failed to align with the glottic inlet, POGO for the glottic view was < 80%, or modified

Cormack–Lehane grade was ≥ 2, a lifting force and/or external pressure was applied to the larynx (backward, upward, and rightward pressure maneuvers [BURP]) to facilitate insertion of the DLT into the vocal cord. The number of patients who underwent BURP was recorded.

Mean arterial pressure (MAP), heart rate (HR), and surgical pleth index (SPI) were recorded immediately before anesthetic induction (baseline, T0), immediately before intubation (T1), immediately after intubation (T2), and 3 minutes after intubation (T3). The lowest peripheral oxygen saturation (SpO<sub>2</sub>) during the intubation period (from propofol administration to 3 minutes after intubation) was recorded. Five minutes after DLT intubation, a separate anesthesiologist who was unaware of the group allocation confirmed the position of the DLT with a bronchoscope and assessed for oropharyngeal bleeding by inspecting the laryngoscope blade and the patient’s oral cavity for mucosal bleeding.

Failure to intubate was defined as an inability to intubate the patient’s trachea within 120 seconds, within 3 intubation attempts, or if the patient’s SpO<sub>2</sub> decreased to < 95% during intubation. Those cases were excluded from the present study, and other operators performed the intubation. If necessary, the patient was awakened and intubated using a fiberoptic bronchoscope.

Complications related to intubation, including hoarseness and tooth, lips, or oral cavity injury were evaluated in the post-operative recovery room. Sore throat was assessed using VAS (0, no pain; 10, worst pain).

**2.6. Sample size**

The number of patients required in each group was calculated with a power analysis based on our pilot study in which the mean time taken for DLT intubation with C-MAC D-blade video laryngoscope was 32 seconds compared with 38 seconds with McCoy laryngoscope. To detect a mean (± standard deviation) difference in the time taken for DLT of 6 ± 10 seconds, power estimation analysis suggested that 43 patients per group would be required to obtain a power of 80%, considering a type I error of 0.05. To compensate for unexpected dropouts, recruitment was increased by 10%, and we determined that 94 patients were required.

**2.7. Statistical analyses**

All quantitative variables including age, weight, height, thyromental distance, inter-incisor distance, intubation time, VAS score for facemask ventilation difficulty, POGO score, VAS score for sore throat, and hemodynamic parameters, were analyzed using descriptive statistics and summarized as mean ± standard deviation. Quantitative parameter normality was tested using the Shapiro–Wilk test. These outcomes were assessed using the Student’s *t* test or Mann–Whitney *U* test for independent groups, as appropriate. All qualitative variables (e.g., sex, American Society of Anesthesiologists class, Mallampati score, and IDS score) were presented as frequencies. Qualitative data were analyzed using chi-square or Fisher exact test. For analysis of repeated measures including MAP, HR, and SPI, a repeated measure analysis of variance with adjustment for multiple comparisons and the *t* test via Bonferroni post hoc correction was performed (corrected *P* value < .125). To analyze changes in hemodynamic parameters within each group, paired *t* tests were used to compare T0 values with the rest of the time points (T1–T3).

All statistical analyses were conducted using the SPSS software for Windows (version 26.0 (IBM Corp., Armonk, NY)). *P*-values < .05 were considered statistically significant for all parameters.

**Table 1**  
**Intubation Difficulty Scale.<sup>[16]</sup>**

Parameter	Score
Number of attempts > 1	N <sub>1</sub> (every additional attempt adds 1)
Number of operators > 1	N <sub>2</sub> (every additional operator adds 1)
Number of alternative techniques	N <sub>3</sub> (each alternative technique adds 1)
Cormack–Lehane Grade—1	N <sub>4</sub> (apply grade for 1st oral attempt)
Lifting force required	
Normal	N <sub>5</sub> = 0
Increased	N <sub>5</sub> = 1
Laryngeal pressure	
Not applied	N <sub>6</sub> = 0
Applied	N <sub>6</sub> = 1
Vocal cord mobility	
Abduction	N <sub>7</sub> = 0
Adduction	N <sub>7</sub> = 1
Total = Sum of scores	N <sub>1</sub> - N <sub>7</sub>

### 3. Results

#### 3.1. Patient characteristics

A total of 120 patients were screened, of whom 27 were excluded from the study (Fig. 2). Eighteen patients did not meet the study inclusion criteria and 9 declined to participate. The remaining 93 eligible patients were randomized and enrolled (48 in Group C and 45 in the Group M). One patient in group C and 2 patients in group M were excluded because their intubation times exceeded 120 seconds. Ninety patients completed the study, according to the protocol. As shown in Table 2, there were no significant differences between the 2 groups in terms of demographic and preoperative data.

#### 3.2. Intubation parameters

The results of intubation parameters are presented in Table 3. Regarding the modified Cormack–Lehane grade, in group C, all except one patient were grade 1 or 2, whereas in group M, approximately 34.88% (n = 15) were grade 3; thus, there was a significant difference between the 2 groups (P = .000). POGO was significantly higher in group C than in group M by approximately 26%, which indicated greater glottic visualization in group C than in group M. Ease of laryngoscope insertion and tube advancement were comparable between the 2 groups. However, more than a moderate level of tube advancement occurred in approximately 38.3% (n = 18) and 27.91% (n = 12) of the patients in groups C and M, respectively. Two or more intubations were attempted in 12.77% (n = 6) and 6.98% (n = 3) of the patients in groups C and M, respectively, but there was no statistical difference in the overall number of intubation attempts between the groups. Regarding the IDS score, all patients except 6 (12.77%) in group C scored 1 or 2, whereas 37.21% of patients (n = 16) scored ≥ 3 in group M. Although the difference between the 2 groups was significant (P = .030), all patients had an IDS score ≤ 5. The time taken for DLT intubation was not significantly different between the groups

(P = .269). BURP was performed in all the patients. No other operator or intubation device was required, and no DLT was intubated into the esophagus in any of the patients in this study. Oral bleeding or tooth damage was not observed in the recovery room. There was no difference between the groups in the VAS score for sore throat after anesthesia (Table 3).

#### 3.3. Hemodynamic parameters

The changes in hemodynamic parameters are shown in Table 4. According to the changes in time, there was no significant difference in MAP and SPI changes between the 2 groups (P = .206 and .111, respectively), but the change in HR was significantly different between the groups (P = .045). In the post hoc analysis for the comparison of data between each time point, there was no time point at which a statistical difference in HR was reached (all corrected P > .125, Table 4). Compared to T0, MAP significantly decreased at T1 and T3 (P = .000, both), and HR significantly increased at T2 (P < .001) in group C. In group M, compared with T0, MAP significantly decreased at T1 and T3 (P = .000, both), and HR significantly increased at T2 and T3 (P = .000 and P = .004, respectively). SPI significantly decreased at the rest of the time points compared with T0 in both groups (group C: P = .000, .025, and .008 for T1, T2, and T3, respectively; group M: P < .001, .006, and = .000 for T1, T2, and T3, respectively). The lowest SpO<sub>2</sub> values were 98.30 ± .98 in group C and 98.33 ± 1.27 in group M (P = .907) during the intubation period.

### 4. Discussion

This study demonstrated that the C-MAC D-blade video laryngoscope could not reduce the time taken for intubation, but it lowered the IDS score with the advantage of better glottic visualization than the McCoy laryngoscope in patients undergoing DLT intubation for elective lung surgery.

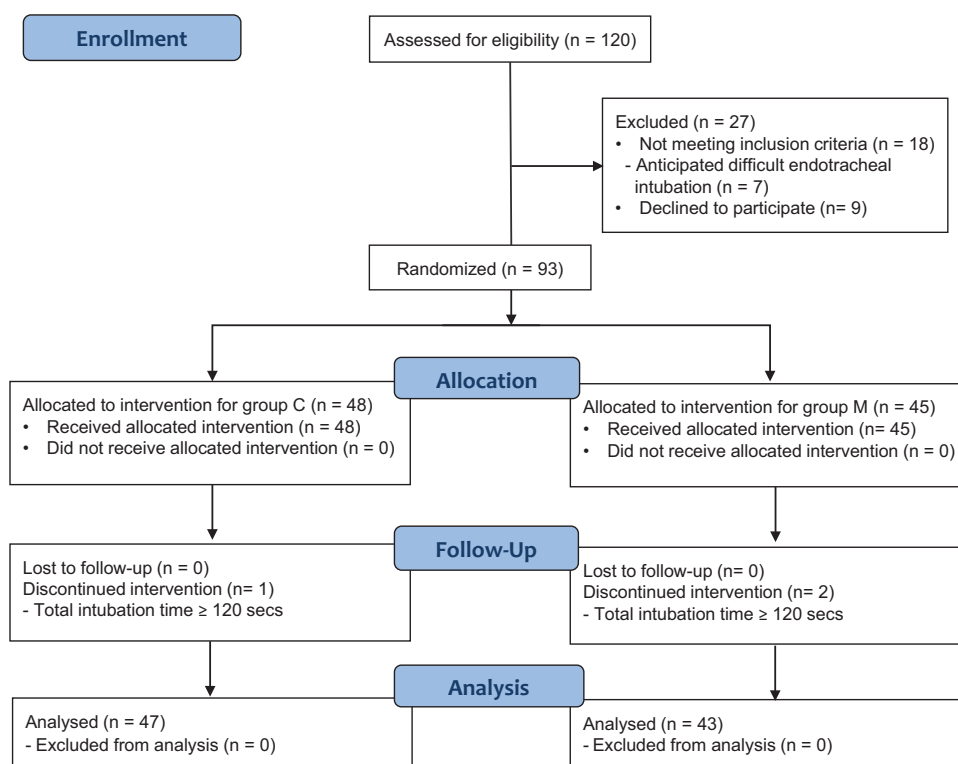


Figure 2. CONSORT flow diagram of recruitment and assessment of study participants.

**Table 2**  
**Demographic and preoperative data.**

	Group C	Group M	P
	(n = 47)	(n = 43)	
Gender (M/F)	31/16	27/16	.754
Age (yr)	49.13 ± 20.78	52.00 ± 17.07	.478
Height (cm)	165.54 ± 10.10	164.53 ± 9.27	.656
Weight (kg)	59.87 ± 10.53	61.87 ± 9.67	.355
ASA class			.724
I	8	5	
II	19	20	
III	20	18	
Mallampati score			.363
I	7	11	
II	32	23	
III	8	9	
Thyromental distance (cm)	7.25 ± 1.24	7.13 ± 1.79	.721
Interincisional distance (cm)	4.37 ± 1.28	4.72 ± 1.63	.260
loose teeth (-/+)	40/7	39/4	.419
Atlanto-occipital Joint Extension > 30°	47	43	N/A
Double lumen tube size 35/37 Fr	17/30	17/26	.742

Mean ± Standard deviation or number of patients. ASA = American Society of Anesthesiologists physical status, Fr = French, N/A = not applicable, VAS =visual analog scale.

Prolonged intubation time causes several complications, such as airway injury, aspiration, hypoxia, and sore throat. Patients undergoing thoracic surgery requiring DLT intubation usually have pulmonary comorbidities and are vulnerable to hypoxemia owing to prolonged intubation time. In this study, although the C-MAC D-blade video laryngoscope improved glottic visualization, the intubation time was slightly longer than that with the McCoy laryngoscope. Video laryngoscopes

with a highly angulated blade, such as the GlideScope, McGrath Series 5, or C-MAC D-blade, may result in difficulty in advancing the DLT into the vocal cord.<sup>[17,18]</sup> Since the concave curvature of the bronchial lumen can easily impinge on the arytenoids or ventral tracheal wall when the distal part of the tracheal lumen of the DLT is molded like blade curvature, previous reports recommended a sequential rotation maneuver when DLT intubation was performed with a hyperangulated video laryngoscope.<sup>[17,18]</sup> We molded the distal angle of the tracheal and bronchial lumen to facilitate the insertion of the DLT into the oropharyngeal cavity and conducted a sequential rotation maneuver in this study. Nevertheless, 38.3% of the patients in group C and 27.9% in group M required DLT manipulation to pass the DLT through the vocal cord, which could have prolonged the DLT intubation time in group C. This may be because the McCoy blade tip angle can be adjusted by the operator on a case-by-case basis, but the C-MAC D-blade tip is half-moon-shaped and fixed at a 40° angle. Most previous studies reported that the DLT intubation time was not significantly different between video laryngoscopes and the Macintosh laryngoscope.<sup>[8-10,18]</sup> However, some researchers reported that video laryngoscopes require a longer or shorter intubation time than the Macintosh laryngoscope.<sup>[12,19,20]</sup> This heterogeneity of previous findings might be explained by different definitions of the intubation time, type of video laryngoscope, and operators' experience.<sup>[18,19]</sup> A previous meta-analysis indicated that novice operators may require more time to perform DLT intubation with video laryngoscopes than with the Macintosh laryngoscope.<sup>[18]</sup> In this study, a single experienced anesthesiologist performed intubation, and the intubation time was defined as passage of the intubation device through the lips to connect the DLT and a circuit of anesthesia workstation to measure the time taken only for the intubation technique.

**Table 3**  
**Intubation data of the C-MAC D-blade and McCoy laryngoscopes.**

	Group C	Group M	P
	(n = 47)	(n = 43)	
VAS of facemask ventilation difficulty	3.06 ± 1.46	3.56 ± 2.03	.186
Cormack–Lehane grade			.000
1	17 (36.17%)	5 (11.63%)	
2	29 (61.71%)	23 (53.49%)	
3	1 (2.12%)	15 (34.88%)	
POGO (%)	79.36 ± 13.42	53.49 ± 29.83	.000
Ease of laryngoscope insertion			.101
Ease	39 (82.98%)	32 (74.42%)	
Moderate	8 (17.02%)	7 (16.28%)	
Difficult	0 (0%)	4 (9.30%)	
Ease of tube advancement			.523
Ease	29 (61.70%)	31 (72.09%)	
Moderate	12 (25.53%)	7 (16.28%)	
Difficult	6 (12.77%)	5 (11.63%)	
Number of intubation attempt			.570
1	41 (87.23%)	40 (93.02%)	
2	5 (10.64%)	2 (4.65%)	
3	1 (2.13%)	1 (2.33%)	
Intubation Difficulty Scale			.030
1	15 (31.91%)	5 (11.63%)	
2	26 (55.32%)	22 (51.16%)	
3	5 (10.64%)	13 (30.23%)	
4	0 (0%)	2 (4.65%)	
5	1 (2.13%)	1 (2.33%)	
Malposition			.716
Yes	5 (10.64%)	3 (6.98%)	
No	42 (89.36%)	40 (93.02%)	
DLT intubation time (sec)	35.85 ± 10.77	33.18 ± 11.97	.269
VAS of severity of sore throat	3.28 ± 1.75	3.51 ± 1.79	.531

Mean ± standard deviation or number of patients (%). Group C = C-MAC D-blade laryngoscope group, group M = McCoy laryngoscope group, DLT = double lumen intubation, POGO = percentage of glottis opening, VAS = visual analogue scale.

**Table 4**  
**Changes in hemodynamic parameters.**

	T0	T1	T2	T3
Mean arterial pressure (mm Hg)				
Group C	103.32 ± 14.75	76.28 ± 10.49	108.64 ± 21.03	91.49 ± 13.71
Group M	108.093 ± 13.71	77.56 ± 10.59	112.00 ± 18.56	93.37 ± 12.95
P value	.116	.566	.425	.506
Heart rate (beats/min)				
Group C	82.66 ± 17.89	81.72 ± 16.21	96.21 ± 15.03	85.98 ± 13.72
Group M	76.44 ± 16.02	76.14 ± 12.83	89.67 ± 16.02	82.98 ± 14.66
P value	.087	.075	.049	.318
Surgical pleth index				
Group C	63.09 ± 18.26	43.43 ± 14.93	51.00 ± 18.45	46.46 ± 19.52
Group M	58.41 ± 15.21	38.41 ± 12.69	47.14 ± 14.90	38.77 ± 13.34
P value	.275	.382	.932	.409

Mean ± standard deviation. T0 = baseline (before intubation), T1 = immediately before intubation, T2 = immediately after intubation, T3 = 3 min after intubation. Group C = C-MAC D-blade laryngoscope group, group M = McCoy laryngoscope group.

As operator experience could have affected the intubation time in this study, the intubation time was not statistically different between the 2 devices.

The IDS is often reclassified as a difficulty grade of intubation, where 0 indicates easy intubation, 1–5 indicates slightly difficult intubation, >5 indicates moderately difficult intubation, and infinity indicates inability to intubate.<sup>[11,16]</sup> In this study, distributions of the IDS score were significantly different, but no patient had an IDS score > 5 in either group. These findings indicate that DLT intubation using McCoy or C-MAC D-blade video laryngoscopes is not difficult in patients with normal airway. Yoo et al demonstrated that the IDS score was significantly lower with the McGrath video laryngoscope than with the Macintosh laryngoscope for DLT intubation in patients who underwent manual in-line stabilization, with the median IDS scores of 1 and 3, respectively. Jain et al reported that the median IDS scores for the C-MAC D-blade video laryngoscope and McCoy laryngoscope were 1 and 4, respectively, in patients with simulated cervical spine injury for single-lumen tube intubation.<sup>[21]</sup> According to the results of this study and previous studies, the C-MAC D-blade video laryngoscope would be more helpful for DLT intubation than the McCoy laryngoscope in patients with cervical spine injuries, limited head and neck range of motion, or morbid obesity. Further studies on patients with difficult airways for DLT are still required.

Glottic visualization is critical for endotracheal intubation. In this study, the C-MAC D-blade video laryngoscope provided a lower Cormack–Lehane grade and approximately 26% higher POGO than the McCoy laryngoscope did. Most previous studies have reported that the video laryngoscope is superior to the Macintosh laryngoscope in terms of the Cormack–Lehane grade because of the wider view of the camera in DLT intubation for patients with normal or difficult airways.<sup>[8,10,12]</sup> Yoo et al demonstrated that the McGrath video laryngoscope provides a higher POGO than the Macintosh laryngoscope by 50% in patients with manual in-line stabilization.<sup>[10]</sup> However, to our knowledge, no study has compared the McCoy laryngoscope with other intubation devices in patients undergoing DLT intubation. The McCoy laryngoscope has a hinged tip similar to the C-MAC D-blade laryngoscope, which improves the Cormack–Lehane grade by 1–2 grades compared to the Macintosh laryngoscope in patients with cervical spine injury.<sup>[5]</sup> A few studies comparing the McCoy laryngoscope and C-MAC D-blade video laryngoscope for single-lumen tubes have been conducted in patients with simulated cervical injuries, demonstrating that the C-MAC D-blade video laryngoscope provided approximately 30% higher POGO and a lower Cormack–Lehane grade than the McCoy laryngoscope.<sup>[21,22]</sup> Taken together, the video laryngoscope improved the glottic view compared to a direct laryngoscope, including the McCoy laryngoscope.

For DLT intubation, a more satisfactory laryngeal view does not usually guarantee more successful intubation.<sup>[9,12]</sup> According to a meta-analysis by Liu et al, the incidence of bronchial lumen malposition was higher with the video laryngoscope than with the Macintosh laryngoscope, as the odds ratio was 2.23, and the success rate at first attempt was lower with the video laryngoscope than with the Macintosh laryngoscope when the operators were novice.<sup>[18]</sup> The findings of this study also showed that a better glottic view of the C-MAC D-blade video laryngoscope did not result in fewer intubation attempts or lower incidence of malposition. In this study, the bronchial lumen and distal part of the DLT were flexed as the angled tip and curvature of the blades to facilitate insertion of the DLT into the oropharyngeal cavity; however, the bronchial lumen tip was impinged at the glottis in some cases, and intubation failed during the first attempt in group C. In cases of malposition, after removing the stylet, rotating the DLT 90° counterclockwise may have guided the bronchial lumen to the wrong bronchus. These results may be because the C-MAC D-blade video laryngoscope facilitated a view of the glottis without alignment of the oral, pharyngeal, and tracheal axes, whereas the McCoy laryngoscope requires alignment of these 3 axes during intubation.

The long duration of intubation and force delivered to the tongue base can trigger a stress response during endotracheal intubation.<sup>[9]</sup> Although hemodynamic changes during endotracheal intubation are affected by various factors, previous studies indicated similar hemodynamic changes between video laryngoscopes and the Macintosh laryngoscope.<sup>[8,10]</sup> The McCoy laryngoscope has been reported to induce less hemodynamic changes than the Macintosh laryngoscope.<sup>[3]</sup> In a manikin study, the force applied to the manikin during intubation with the McCoy laryngoscope was weaker than that of the Macintosh laryngoscope but greater than that of the Airtraq video laryngoscope.<sup>[4]</sup> However, no clinical study has compared hemodynamic changes during DLT intubation between video laryngoscopes and the McCoy laryngoscope. In addition, most previous studies reported only hemodynamic parameters, such as blood pressure and HR.<sup>[9,10,23]</sup> In this study, we recorded changes in SPI, which reflect the patients' responses resulting from sympathetic activity changes for nociceptive stimuli. Although the HR significantly increased until 1 and 3 min after intubation in groups C and M, respectively, the SPI did not significantly increase even after intubation compared to the baseline value in each group. Changes in the SPI in both groups were comparable, which might have been due to the similar intubation time and ease of laryngoscope insertion, regardless of the better glottic visualization of the C-MAC D-blade video laryngoscope. Postoperative sore throat was also affected by intubation stimulation; therefore, the VAS scores of the 2 groups were similar.

## 5. Limitations

First, the operator and investigators could not be blinded to group allocation during the measurement and recording of data. Therefore, a bias may have affected the results of this study. Second, a single experienced anesthesiologist performed DLT intubation in all enrolled patients. If several operators with different experiences had performed intubation in a larger number of patients, the result could have been more objectively assessed and might have been different in terms of intubation time, POGO, and IDS score. Third, we enrolled patients with normal airway. If patients who were expected to have difficult intubation were included in the study, there could have been a difference in intubation time between the 2 laryngoscopes. Additional studies on patients with difficult airways are required. Finally, we did not record the duration of intubation by dividing 2 stages, the time from laryngoscope insertion to exposure of the glottis and from exposure of the glottis to the entry of the tube into the trachea. As previous studies have reported, advancement of the DLT into the oropharyngeal space requires more delicate manipulation with a video laryngoscope than with a conventional direct laryngoscope.<sup>[8,20]</sup> If the intubation time had been assessed in 2 stages, we may have objectively revealed the difference in DLT advancement into the glottis in the 2 devices.

## 6. Conclusions

The C-MAC D-blade video laryngoscope facilitated glottis visualization and had a lower IDS score than the McCoy laryngoscope. However, it did not reduce intubation time in patients undergoing DLT intubation. For DLT intubation, the C-MAC D-blade video laryngoscope may be more useful than the McCoy laryngoscope in patients with normal airways.

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