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Short Thyromental Distance: A Predictor of Difficult Intubation or an Indicator for Small Blade Selection?

Mukesh Tripathi, M.D., M.N.A.M.S., Mamta Pandey, M.D., P.G.D.H.H.M.†*

Background: **Short thyromental distance (TMD; < 5 cm) has been correlated with difficult direct laryngoscopic intubation in adult patients. The authors hypothesized that a smaller Macintosh curved blade (No. 2 MCB) would improve the predicted difficult laryngoscopy in short-TMD patients over that with a standard Macintosh curved blade (No. 3 MCB).**

Methods: **In a preliminary study of 11 consenting adults (7 females and 4 males), American Society of Anesthesiologists physical status I and TMD ≤ 5 cm, lateral neck radiographs were recorded during laryngoscopy with a No. 2 and No. 3 MCB in sequential fashion. In a prospective clinical study, laryngoscopy and tracheal intubation were evaluated in 83 adult patients with TMD ≤ 5cm by randomly assigning them to two groups for the blade used at first intubation. Those who failed intubation with the first blade were switched to the alternate blade. In total 100 laryngoscopies and intubations were performed: the No. 2 MCB (n = 50) and the No. 3 MCB (n = 50).**

Results: **Lateral neck radiographs recorded at the best laryngeal view revealed that the tip of the No. 2 MCB was proximal to the hyoid body with the No. 2 MCB and distal to it with the No. 3 MCB. The intubation distance (C5 to blade tip) on neck radiographs with the No. 2 MCB was significantly greater than it was with the No. 3 MCB for similar anterior jaw displacement. In the clinical study, the laryngoscopic grade with the No. 2 blade was considered easy (median, 2B), better than the grade with the No. 3 MCB (median, 3). When the No. 2 MCB was used, external laryngeal pressure improved the laryngoscopic grade (1, full glottic view) in 46% of patients. In contrast, when the No. 3 MCB was used, pressure improved the grade in only 10% of the patients. Intubation time with the No. 2 MCB was significantly (*P* < 0.05) less than it was in patients with No. 3 MCB. Overall, 14 patients who failed intubation with the No. 3 MCB were switched to the No. 2 MCB, and intubation was successful with an easy laryngoscopic grade. Three patients who failed intubation with the No. 2 MCB were switched to the No. 3 MCB.**

Conclusions: **The predicted difficult laryngoscopy and intubation with the use of the adult No. 3 MCB in standard adult patients with a TMD ≤ 5cm is significantly easier with use of the smaller No. 2 MCB.**

DIRECT laryngoscopy and intubation of the trachea within the framework of safe apnea are crucial during anesthesia and resuscitation. Identification of patients who are at risk for a difficult tracheal intubation has always been an area of interest for anesthesiologists and airway interventionalists. A number of markers for predicting a difficult intubation have been proposed including anatomical landmarks and noninvasive clinical tests such as radiographic assessment of the head and neck,[1] oropharyngeal structure,[2] external anatomical airway structures,[3] and the size of the mandibular space.[4] However, some of these individual markers have been critiqued,[5] and scoring systems including multiple variables have been proposed,[6,7] with increased complexity of assessment in clinical practice. Small thyromental distance (TMD) ≤ 6 cm is a simple, clinically used parameter that has been shown to correlate with a difficult laryngoscopy and tracheal intubation.[8] However, some have questioned whether a small TMD, in isolation, is a reliable predictor of a difficult laryngoscopy.[9–11] In fact, both large and small TMDs have been shown to predict difficult intubation.[12] Modifications such as the ratio of patient height to TMD,[13] combining the TMD with Mallampati grades (3 and 4), and redefining the TMD cutoff at 4 cm or less are reported to predict difficult intubation with greater specificity.[14] Until now, much of the emphasis has focused on predicting difficult intubations. Because of the limitations in predicting a difficult airway in an emergency,[9] it would be useful to develop a plan to convert a difficult intubation into an easy one. We hypothesized that because pediatric patients have short TMDs (< 5 cm) and the pediatric blade is short from its tip to the body of the blade, the use of a smaller Macintosh curved blade (MCB) might make a predicted difficult intubation easier. With this background, the aim of the current study was to compare the performance of the standard adult No. 3 MCB with that of the No. 2 MCB in patients with short TMD.

Materials and Methods

Approval from the institutional ethics committee (Sanjay Gandhi Postgraduate Institute of Medical Sciences, Lucknow, India) for human study was received, and written informed consent was obtained from each patient. In the preliminary study, patients were examined in the sitting position during preanesthetic assessment, opening the mouth fully for the Mallampati score (1 = soft palate, fauces, uvula, pillars; 2 = soft palate, fauces, uvula; 3 = soft palate, base of uvula; and 4 = soft palate not visible at all)[2] and extending the neck maximally for measurement of the TMD. Eleven adult patients (38 yr [median]; range, 28–54 yr) of both sexes (seven women and four men), American Society of Anesthesiologists physical status I and TMD < 5 cm who were scheduled to undergo general anesthesia were selected. Patients with restricted mouth opening (less than two fingers), buck teeth, neck swelling, or cervical spine abnormality, or with any history of difficult intubation, were excluded.

* Additional Professor, † Medical Officer.

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Address correspondence to Dr. Tripathi: Type IV-21, Campus, Sanjay Gandhi Postgraduate Institute of Medical Sciences, Lucknow-226014, India. mukesh_tripathi@yahoo.com. Individual article reprints may be purchased through the Journal Web site, www.anesthesiology.org.

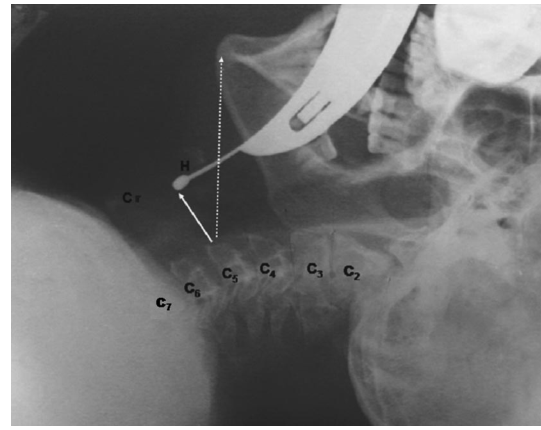

Fig. 1. Lateral radiograph of the head and neck taken at the best laryngoscopic view with a No. 3 Macintosh curved blade (MCB) (*solid arrow*). Larynx visualization space from C5 to MCB tip marked. Mentovertebral distance (*dotted arrow*) from C5 to mentum to measure anterior displacement of the jaw during laryngoscopy. C = cervical vertebrae; Cr = cricoid cartilage; H = hyoid body.

Patients were positioned supine on the operating table, with their heads resting on a 10-cm-thick foam pillow to achieve extension of the atlantoaxial joint and flexion of the cervical spine (sniffing position). General anesthesia was induced with intravenous fentanyl (1 μg/kg) and propofol (1–2 mg/kg), and muscle relaxation was effected with vecuronium (0.1 mg/kg). Anesthesia was maintained with an isoflurane–nitrous oxide mixture in oxygen delivered *via* face mask and the oropharyngeal airway, as needed.

Direct laryngoscopy was performed using both a No. 3 MCB (usable length [from the tip of the blade to the end of the inner curve at the base of the blade] = 11 cm; radius of the inner blade curvature = 5.6 cm; blade web = 2.6 cm) and a No. 2 MCB (usable length = 9.4 cm; radius of the inner blade curvature = 4.5 cm; blade web = 2.2 cm) in a random order in each patient. The No. 2 MCB was shorter (by 1.6 cm), more curved (smaller radius of the curve), and less broad at the web (by 0.5 cm) than was the No. 3 MCB.

A lateral radiograph of the neck was taken when the point of the best laryngoscopic view was obtained. To overcome the bias resulting from use of a single operator, two experienced physicians performed each laryngoscopy, using two blades in the same patient. Real-time visualization of the skull base, craniovertebral junction, rostral cervical spine, anterior aspect of the neck including the hyoid bone, and the tip of the MCB were recorded continually using fluoroscopy which was positioned on the patient's right side, at the level of the head and perpendicular to the long axis of the body. The fluoroscopy was stationary throughout the entire intubation sequence with both blades. In both laryngoscopies, head and neck positions were fixed, and the occiput remained in contact with the pillow. X-ray images were printed by adjusting the dose of radiation for good visualization of soft tissue and bony tissue (figs. 1 and 2).

The optimal laryngoscopic view was graded using the five-grade modified Cormack and Lehane system: grade 1 = full view of the vocal cords; grade 2A = partial view of the vocal cords; grade 2B = only the arytenoids and epiglottis seen; grade 3 = only the epiglottis visible; and grade 4 = neither the epiglottis nor the glottis seen.[15] On the lateral neck radiograph, the positions of the tips of the blades in relation to the hyoid bone were noted and the distance from the midpoint of the anterior margin of the fifth cervical (C5) vertebral body to the tips of both of the blades were measured (figs. 1 and 2). It depicted the glottis-visualizing oropharyngeal space to negotiate the endotracheal tube into the larynx, and we termed this the "intubation distance." We also measured the mentovertebral distance (from the mentum to C5 as described) to compare the anterior jaw displacement during laryngoscopy using the two blades (figs. 1 and 2).

To determine the sample size for the clinical study, data from the preliminary study were used. With a 27% incidence of easy intubation grades (1–2B) with the No. 3 MCB, the minimum incidence of easy intubation was assumed to be 25% and the minimum significant difference between groups to be 35%. With a 90% confidence level (β value of 0.10) and a two-sided α value of 0.05, a minimum of 46 patients in each group was required. Therefore, in the second part of the study, which consisted of a prospective clinical analysis of laryngoscopy and intubation in patients with short TMDs, 100 orotracheal intubations were prospectively performed in a randomized fashion.

For measurement of the TMD, each patient was positioned supine with a 10-cm pillow under his or her head, and asked to extend his or her neck. Thus, the patient was instructed to extend his or her neck toward the anesthesiologist who was positioned at the head of the

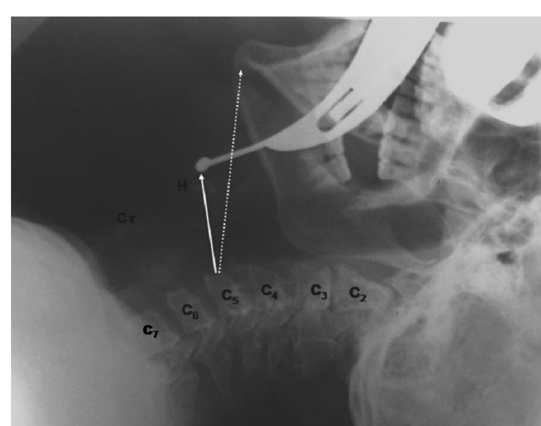

Fig. 2. Lateral radiograph of the head and neck taken at the best laryngoscopic view with the No. 2 Macintosh curved blade (MCB) (*solid arrow*). Larynx visualization space from C5 to MCB tip marked. Mentovertebral distance (*dotted arrow*) from C5 to mentum to measure anterior displacement of the jaw during laryngoscopy. C = cervical vertebrae; Cr = cricoid cartilage; H = hyoid body.

Table 1. Preliminary Study: Observations of Laryngoscopy and Intubation with Use of Two Blades in Patients with Short (< 5 cm) Thyromental Distance

								Laryngeal View Grade		Intubation Time, s		Intubation Distance, cm		Mentovertebral Distance, cm	
Patient No.	Age, yr	Sex	Weight, kg	Height, cm	BSA, m^2	Mallampati Grade	TMD, cm	No. 3 MCB	No. 2 MCB	No. 3 MCB	No. 2 MCB	No. 3 MCB	No. 2 MCB	No. 3 MCB	No. 2 MCB
1	38	F	74	142	1.63	3	4.5	4	2A	42	16	3.5	5.6	13.5	14.3
2	47	F	57	148	1.50	3	4	4	3	40	18	5.2	6.3	15.6	16.3
3	28	M	40	152	1.32	3	5	2B	2A	16	18	4.0	6.5	18.2	17.8
4	38	F	58	154	1.56	2	4.6	4	2A	38	09	5.3	7.5	13.4	12.8
5	57	M	54	155	1.52	2	5	2B	2A	12	20	4.5	6.3	10.8	11.2
6	23	F	47	150	1.40	2	4	4	1	45	15	3.7	5.0	12.7	14.8
7	55	F	61	152	1.57	3	4	4	2A	55	17	4.5	6.5	10.3	10.8
8	18	M	50	148	1.56	2	3.6	4	2A	45	08	6.0	7.0	10.2	10.9
9	40	M	62	158	1.63	2	4.5	2B	1	26	18	5.0	5.5	10.6	11.0
10	58	F	66	149	1.60	2	5	3	3	36	21	4.5	6.8	11.4	10.5
11	46	F	66	145	1.57	3	4.6	4	2A	46	23	5.8	7.5	11.2	10.2
Mean	39.8	M = 4, F = 7	58	152	1.53	2.5	4.4	4†	2A†	36.5	16.6*	4.7	6.4*	12.5	12.8
SD	14.8		9.7	6.9	0.10	0.5	0.48	2.0†	0.01†	13.24	4.61	0.81	0.80	2.5	2.6

* $P < 0.05$, compared with No. 3 MCB, Student t test. † Median; $P < 0.001$, compared with No. 3 MCB, Wilcoxon rank sum test.

BSA = body surface area; MCB = Macintosh curved blade; TMD = thyromental distance.

table. The distance from the thyroid notch to the inner margin of the mental prominence, the effective TMD during optimal head position for laryngoscopy and intubation, was measured with a hard-plastic bond ruler.[5] Adult patients of both sexes, American Society of Anesthesiologists physical status I and short TMD (≤ 5 cm) who were scheduled to undergo surgery during general anesthesia were included. All patients were anesthetized with 2 μg/kg fentanyl, 1–2 mg/kg propofol, 0.12 mg/kg vecuronium. Direct laryngoscopy and intubation were performed by an experienced anesthesiologist using a No. 2 or No. 3 MCB, according to the randomization assignment. Patients were randomized by computer-generated numbers that were placed in sealed and opaque envelopes until immediately before induction of anesthesia. If intubation was impossible (failure to pass the endotracheal tube after three attempts), the patient was crossed over to use the other blade.

The Mallampati score modified Cormack and Lehane laryngoscopic view grade, the effect of external laryngeal pressure on the laryngoscopic view, the intubation time (from the start of laryngoscopy to passing the endotracheal tube), the number of attempts at tracheal intubation, and the need to use aids (stylet or bougie) for intubation were recorded. The laryngoscopic intubation technique was also scored on the basis of three factors: ease of MCB insertion and its positioning to displace the tongue, need for external laryngeal pressure to insert the endotracheal tube, and need for aids (stylet or bougie). Scoring was as follows: 1 = easy MCB placement and no external laryngeal pressure or aids; 2 = mild struggling to achieve MCB placement and use of external pressure to pass tube, but no aids; 3 = moderate difficulty in placing the MCB, no improvement with external laryngeal pressure, and aids used to pass endotracheal tube; and 4 = failure to visualize the glottis or to place the endotracheal tube in three attempts.

Statistical analysis was performed using SPSS 9.0 (SPSS Inc., Chicago, IL). Demographic data were compared using the Student t test. One-way analysis of variance was used to compare parametric data, Fisher's exact test for nominal data, and the Wilcoxon rank sum test for nonparametric data. $P < 0.05$ was accepted as statistically significant.

Results

In the preliminary study, the best direct laryngoscopic view was graded in 11 patients with short TMD (< 5 cm). The laryngoscopic view with the No. 2 MCB (median, 2A; range, 1–3) was significantly better than that with the No. 3 MCB (median, 3; range, 2B–4). The lateral neck radiographs showed that the tip of the No. 2 MCB was proximal to the hyoid body and the tip of the No. 3 MCB was distal in all patients (figs. 1 and 2). The intubation distance from the C5 body to the tip of the MCB on the lateral neck radiographs with the No. 2 MCB (6.4 ± 0.8 cm) was significantly ($P < 0.05$) greater than with the No. 3 MCB (4.7 ± 0.81 cm) at the best laryngoscopic view. The mentovertebral distances on the lateral neck radiographs were similar for the two studied blades (table 1).

In the clinical study, demographical data, including age, sex, height, weight, body surface area, and TMD, were similar in the two groups (group 1, laryngoscopy and intubation with No. 3 MCB, and group 2, with No. 2 MCB) (table 2). Of the 47 patients who were enrolled in group 1, 14 failed intubation and were switched to group 2. Of the 36 who were enrolled in group 2, 3

Table 2. Demographic Data of the Clinical Study of Laryngoscopy and Intubation of Patients with Short Thyromental Distance

	Group 1: No. 3 MCB (n = 50)	Group 2: No. 2 MCB (n = 50)
Sex, M:F	27:23	26:24
Age (range), yr	54 ± 6.9 (43–70)	53 ± 8.3 (35–72)
Weight (range), kg	59 ± 13 (34–85)	58 ± 12 (34–85)
Height (range), cm	151 ± 6.6 (143–164)	152 ± 6.9 (142–165)
Body surface area (range), m^2	1.56 ± 0.2 (1.43–1.60)	1.55 ± 0.17 (1.42–1.58)
Body mass index (range), kg/m^2	24 ± 5.7 (22–36)	24 ± 5.3 (21–36)

Data are presented as mean ± SD (range).

MCB = Macintosh curved blade.

failed and were switched to group 1. Thus, of the 83 patients who were enrolled, there were 50 attempted laryngoscopies with each of the No. 2 and 3 MCBs. The laryngoscopic view with the No. 2 MCB (median, 2B) was superior to the laryngoscopic view with the No. 3 MCB (median, 3) (table 3). The laryngeal view was graded as easy (1, 2A, or 2B) in a significantly greater number of patients (60%) with the No. 2 MCB (group 2) than in 14% with the No. 3 MCB (fig. 3A). External laryngeal pressure improved the laryngoscopic view by one or two grades in patients in both groups; the laryngoscopic view was grade 1 in 46% of patients with No. 2 MCB and 10% of patients with No. 3 MCB use (fig. 3B and table 3).

The median laryngoscopy and intubation technique score with No. 2 MCB; (median, 2) was significantly ($P <$ 0.05) less than it was with No. 3 MCB; median, 3 (table 3). A significantly ($P < 0.05$) greater number of patients with the No. 3 MCB (14 [28%]) with failed intubations were successfully intubated with the No. 2 MCB, compared with the 3 patients (6%) with failed intubations

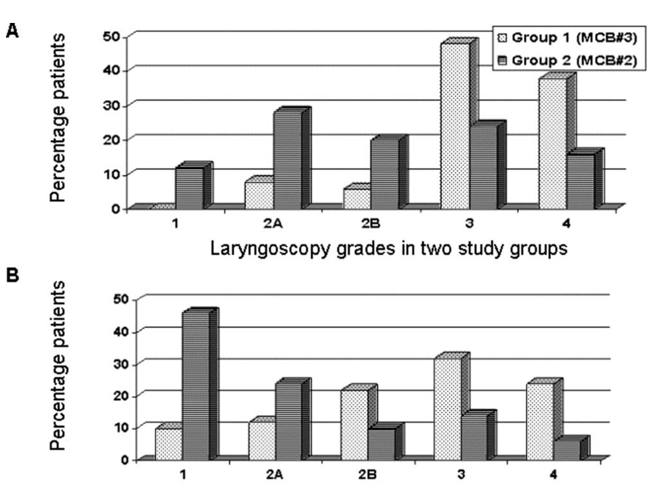

Fig. 3. (*A*) Distribution of best laryngoscopic grades for the two blades used in the study groups. (*B*) Change in laryngeal view grades in the two study groups resulting from the use of external laryngeal pressure. MCB = Macintosh curved blade.

with the No. 2 MCB who were crossed over to No. 3 MCB. Use of the No. 3 MCB was successful in these patients because the smaller blade did not reach beyond the base of the tongue. The intubation time with the No. 2 MCB was significantly ($P < 0.05$) less than with the No. 3 MCB. The number of attempts to intubate patients with the No. 2 MCB was less than in the No. 3 MCB. The use of intubation aids with the No. 3 MCB was significantly ($P < 0.01$) greater (stylet, 60%; bougie, 48%) than it was with the No. 2 MCB (stylet, 32%; bougie, 22%) (table 3).

Discussion

The results of this study demonstrated that the use of the regular adult No. 3 MCB in patients with short TMD ($\leq$ 5 cm during full neck extension) was associated with a poor laryngoscopic view (median, 3), and the frequent use of aids (stylet or bougie) to intubate the trachea, prolonged time to intubation and more attempts than with the No. 2 MCB. In contrast, the smaller blade (No. 2 MCB) provided better visualization of the glottis (median, 2B) and a full view of the vocal cords (grade 1) in 46% of patients with application of external laryngeal pressure, with easy and more rapid tracheal intubation. Lateral neck radiographs demonstrated that in short-TMD patients, when the smaller blade (No. 2 MCB) with more curve and a smaller tip-to-body distance was used, the tip of the blade fell just short of the hyoid body in the preepiglottic fold. The No. 2 MCB allowed more intubation space than the regular adult blade (No. 3 MCB), which, being longer and less curved, reached beyond the hyoid body to stretch the thyrohyoid membrane and restricted laryngeal manipulation.

In clinical practice, physical characteristics are evaluated to make sensible decisions in airway management to ensure patient safety.[16] Short TMD is one of the clinical parameters used to predict a difficult intubation, although reports of the cutoff distance in the literature vary. Patil *et al.*[8] suggested the normal value of the TMD in adults is 6.5 cm or greater. If the distance is 6.0–6.5 cm without other anatomical abnormalities, laryngoscopy and intubation are difficult but usually possible. However, in the presence of anatomical difficulties, a TMD between 6.0 and 6.5 cm may make intubation impossible. A TMD of less than 6 cm suggests that laryngoscopy may be impossible. Frerk[17] reported that intubation is likely to be difficult in patients with a TMD less than 7 cm in whom the posterior pharyngeal wall could not be visualized during inspection of the oropharynx. These tests have limitations with different sensitivities (Mallampati classification, 42–81%; TMD, 62–91%) and specificities (Mallampati classification, 66–84%; TMD, 25–82%).[11] The TMD cutoff value that discriminates best between patients with easy and difficult glottic visualization has been reported to be 4 cm. With a TMD cutoff of

Table 3. Clinical Study: Observations on Laryngoscopy and Intubation

	Group 1: No. 3 MCB (n = 50)	Group 2: No. 2 MCB (n = 50)
Thyromental distance, mean ± SD, cm	4.1 ± 4.9	3.9 ± 4.2
Mallampati score	3; (2–4)	3; (2–4)
Laryngoscopic view grade	3; (3–4)	2B; (2A–3)*
Laryngoscopic view with external pressure	3; (2B–3)	2A; (1–2B)†
Laryngoscopy and intubation technique score	3; (2–4)	2; (1–2)*
Intubation time, s	25; (21–33)	20; (16–30)*
No. of intubation attempts	2; (1–3)	1; (1–2)*
Incidence of aids used in intubation, No. of patients (%)		
Stylet use	30 (60%)	16 (32%)†
Bougie	24 (48%)	11 (22%)
Complications, No. of patients (%)		
Esophageal intubation	5 (10%)	2 (4%)
Trauma during blade placement	13 (26%)	3 (6%)
Broken teeth	2 (4%)	1 (2%)

Values are presented as median; interquartile range (25th–75th percentile), unless otherwise specified.

* $P < 0.05$, † $P < 0.01$, compared with group 1.

MCB = Macintosh curved blade.

4 cm or less, 48% of patients with a Mallampati score of 1 or 2 and 79% of patients with a Mallampati score of 3 or 4 had difficult intubation.[14] Factors such as reduced head extension, short deep mandible, and high anterior larynx may all influence TMD and contribute to difficult laryngoscopy.[18] Therefore, the clinical significance and implication of the cephalocaudad separation of the mandible and hyoid deserves redefinition.

Harton *et al.*[19] emphasized the importance of control of the hyoid bone with the tip of the curved Macintosh laryngoscope blade and reported that the hyoid was drawn forward and its body was tilted downward during laryngoscopy and intubation. In the preliminary study, lateral neck radiographs demonstrated that the tip of the No. 3 MCB was placed distal to the hyoid bone and tended to stretch the thyrohyoid membrane as the laryngoscope was pulled up to visualize the vocal cords. As a result, external laryngeal pressure did not improve the laryngoscopic view with the No. 3 MCB. In contrast, when the tip of the No. 2 MCB lay proximal to the hyoid body, laryngoscopy pulled up the hyoepiglottic membrane and the soft tissue in the mandibular space. This allowed tilting of the body of the hyoid bone to allow full view of the glottis. Because the smaller blade did not stretch the thyrohyoid membrane, external laryngeal pressure easily displaced the larynx posteriorly to improve the laryngeal view grade (1–2B) for an easy intubation in the majority of patients.

The smaller blade (No. 2 MCB), with a shorter usable distance and greater curvature (smaller radius of the inner curvature), was positioned with its tip short of the hyoid body in the preepiglottic fold. The smaller web of the No. 2 MCB might have further allowed its tip to be pulled more anteriorly to yield a larger intubation distance. In contrast, the No. 3 MCB, with its longer usable blade, flatter curvature, and wider breadth, limited the anterior lift of the neck tissue and thus restricted the intubation space.

The narrower intubation distance (from the tip of the blade to the anterior margin of C5) with the No. 3 MCB not only obscured vision of the glottis but also restricted endotracheal tube movement. In these cases, we frequently required a stylet to orient the tip of the tracheal tube toward the larynx. Without a stylet, the endotracheal tube tended to slip posteriorly into the esophagus and persistently failed to come up on its natural curve. The frequent need to use a stylet or bougie increased the time to intubation and increased the number of attempts to complete intubation with the No. 3 MCB compared with the No. 2 MCB. Because the larynx could easily be pushed posteriorly when the No. 2 MCB was used, tracheal intubation was accomplished more rapidly and with fewer attempts than with the No. 3 MCB.

In the current study, we attempted to explore a possible solution to overcome anticipated difficult intubations due to short TMDs by appropriate instrumentation, *i.e.*, use of a smaller blade (No. 2 MCB). The laryngoscopic and intubation technique grades were better for the No. 2 MCB than for the No. 3 MCB, with significantly less time required to complete intubation. In three patients (6%) with a TMD of 5 cm but a Mallampati grade of 4, the No. 2 MCB was associated with a poor laryngoscopic view because the tip of the blade failed to reach the base of the tongue. Intubation was easily accomplished with the No. 3 MCB. Therefore, use of the short blade cannot be recommended in patients with a TMD of 5 cm or greater who have a large tongue (*i.e.*, Mallampati grade 4).

The current study objectively demonstrated the differences between the positions of the two curved blades during direct laryngoscopy in patients with short TMDs. Our incidence of difficult intubation grades (3 and 4) in

82% of patients was similar to the incidence of difficult intubation of 79% of patients with short TMD reported by Ayoub *et al.*[14] with regular blade use. However, the limitation of being aware of the type of blade being used for laryngoscopy during intubation could not be removed.

In conclusion, the use of the No. 2 MCB provides better laryngoscopic view grades (1–2B) and improved visualization of the vocal cords (grade 1) after external laryngeal pressure in patients with a short TMD ($<$ 5 cm) than the No. 3 MCB. In patients in whom a short TMD ($<$ 5 cm) is present and a difficult intubation is anticipated, a No. 2 MCB should be available and combined with external laryngeal pressure to facilitate laryngoscopy and tracheal intubation.

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