

Comparison of Thyromental Distance and Upper Lip Bite Test with Other Airway Assessment Parameters to Predict Difficult Endotracheal Intubation

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Abstract

Background: The incidence of difficult intubation in the operating room is 1.2–3.8% and that of failed intubation is 0.13–0.3%. Complications of multiple attempts at intubation and failure of airway management include hypoxia, responsible for 50–75% of cardiac arrests, hypercarbia and airway trauma. Pre-anaesthetic airway assessment can predict potential problems and decrease the rate of anaesthesia-related adverse respiratory events.

Aim: To compare the predictability and accuracy of various commonly used airway assessment parameters in adult patients with no apparent anatomical airway abnormalities.

Materials and Methods: In this prospective observational study, 120 adult patients of either gender, aged 18–65 years, belonging to ASA grades I and II, undergoing elective surgical procedures under general anaesthesia, were included. Airway indices such as the Upper Lip Bite Test (ULBT), Ratio of Height to Thyromental Distance (RHTMD), Modified Mallampati Test (MMT) and Thyromental Distance (TMD) were assessed pre-operatively and correlated with the Cormack–Lehane (CL) grading during laryngoscopy under general anaesthesia.

Results: The incidence of difficult laryngoscopy was 17.5% (21 of 120 patients). Among the four tests, MMT was the most effective diagnostic test, demonstrating the highest sensitivity (95.24%), specificity (97.98%), positive predictive value (PPV, 90.91%), negative predictive value (NPV, 98.98%) and diagnostic accuracy (97.5%). Combining all the indices yielded 100% sensitivity and specificity.

Conclusion: MMT stands out as the most effective individual pre-operative test for predicting difficult laryngoscopy. However, combining tests enhances both sensitivity and specificity, improving discriminatory capability. Hence, a combination of indices is recommended for the pre-operative airway assessment of adult patients.

Keywords: Difficult Endotracheal Intubation; Airway Assessment Tests; Thyromental Distance; Upper Lip Bite Test; Modified Mallampati Test; Ratio of Height to Thyromental Distance.

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Introduction

Airway management is an essential skill in anaesthesiology and critical care medicine. According to the American Society of Anesthesiologists (ASA) practice guidelines, [8] the incidence of difficult and failed intubation in the operating room is 1.2–3.8% and 0.13–0.3%, respectively. Complications of multiple attempts at intubation and failure of airway management include hypoxia, which is responsible for 50–75% of cardiac arrests, hypercarbia and airway trauma

resulting in laryngospasm and haemodynamic responses to instrumentation. Closed-claim analysis has shown that the incidence of Cormack–Lehane grades II and III views requiring multiple attempts, different blades or both is relatively high. The pre-anaesthetic airway assessment should, therefore, be able to predict potential problems that might be encountered peri-operatively, allowing us to design a management plan ahead of time and decrease the rate of anaesthesia-related adverse respiratory

events. Several pre-operative bedside airway assessment tests are available; which anatomical landmark or index is the best predictor remains debatable. The present study was conducted to compare four commonly used airway assessment tests — the Upper Lip Bite Test (ULBT), Ratio of Height to Thyromental Distance (RHTMD), Modified Mallampati Test (MMT) and Thyromental Distance (TMD) — with the Cormack–Lehane (CL) grading at laryngoscopy, in order to identify the most accurate predictor of difficult endotracheal intubation.

Materials and Methods

Source of Data: Adult patients between 18 and 65 years of age, of either sex, requiring general anaesthesia with endotracheal intubation for elective surgical procedures at KVG Medical College and Hospital, Sullia, a tertiary-care hospital, were included in the study.

Study Design: Prospective, observational study.

Duration of Study: One year.

Inclusion criteria

- Patients of both genders aged 18–65 years
- Patients who gave informed written consent
- Patients of ASA grades I and II
- Patients scheduled for elective surgery under general anaesthesia

Exclusion criteria

- Pregnant females
- History of airway surgery
- History of burns or trauma involving the head and neck
- Patients requiring awake intubation
- Patients unable to sit
- Restricted mobility of the neck and mandible
- Edentulous patients
- Body mass index (BMI) > 35 kg/m²
- Uncooperative and unwilling patients

Sample Size: The sample size was calculated using the formula: $n = [Z\alpha^2 \times Sn \times (100 - Sn)] / (d^2 \times p)$, where Z = standard normal value at the 95% confidence level, Sn = sensitivity (53.3%), $100 - Sn$ = 46.7%, d = desired absolute precision (4%) and p = proportion of difficult laryngoscopy. The calculated sample size was 120 patients.

Statistical Analysis: Data were entered in a Microsoft Excel spreadsheet and analysed using SPSS version 22. All categorical data were expressed as counts (percentages). The association between categorical variables was tested using the chi-square test, and $p < 0.05$ was considered statistically significant. Sensitivity, specificity, positive and negative predictive values and diagnostic accuracy were calculated.

Methodology: After approval from the Institutional Ethics Committee, all patients received oral premedication with pantoprazole 40 mg and tablet alprazolam 0.5 mg on the night before surgery.

In the pre-anaesthetic room, the weight, height and BMI of each patient were recorded. Patients with BMI > 35 kg/m² were excluded from the study. Baseline pulse rate, blood pressure and oxygen saturation were recorded. The procedure was explained to the patient and informed consent was obtained. After obtaining signed informed consent, the following anatomical markers were measured.

Pre-operative Data Recording: After ruling out any dental and airway pathology, the following pre-operative bedside airway assessment tests were performed:

- Upper Lip Bite Test (ULBT)
- Ratio of Height to Thyromental Distance (RHTMD)
- Modified Mallampati Test (MMT)
- Thyromental Distance (TMD)

The findings were correlated with the Cormack–Lehane grading during laryngoscopy. Difficult visualisation was defined as grades III and IV, and easy visualisation as grades I and II.

Thyromental Distance (TMD): measured from the bony point of the mentum to the thyroid notch with the head fully extended and the mouth closed, using a rigid ruler. Class 1: > 6.6 cm; Class 2: 6–6.6 cm; Class 3: < 6 cm. TMD < 6 cm was considered to predict difficult laryngoscopy.

Upper Lip Bite Test (ULBT): Performed by assessing the ability of the patient to bite the upper lip with the lower incisors. Class 1: the lower incisors bite the upper lip above the vermilion line; Class 2: the lower incisors bite the upper lip below the vermilion line; Class 3: the lower incisors cannot bite the upper lip.

Ratio of Height to Thyromental Distance (RHTMD): calculated as height (cm) / TMD (cm). Grade 1: < 23.5; Grade 2: > 23.5. RHTMD > 23.5 was considered to predict difficult laryngoscopy.

Modified Mallampati Test (MMT): performed with the patient seated, head in neutral position, mouth maximally opened and tongue protruded. Grade 1: soft palate, fauces, uvula and tonsillar pillars visible; Grade 2: tonsillar pillars obscured by the base of the tongue, but soft palate, fauces and uvula visible; Grade 3: soft palate and base of the uvula visible; Grade 4: soft palate not visible. Grades III and IV were considered to predict difficult laryngoscopy.

Table 1: Cut-off values of the various predictors of difficult laryngoscopy

Predictor	Cut-off value
Modified Mallampati test	Grades III and IV
Upper lip bite test	Class 3
Thyromental distance	< 6 cm
Ratio of height to thyromental distance	> 23.5

Cormack–Lehane grading: Grade I: vocal cords visible; Grade II: only the posterior commissure or arytenoids visible; Grade III: only the epiglottis visible; Grade IV: none of the above visible.

Anaesthesia Technique: Patients were kept nil per os for 8–10 h pre-operatively. In the operating theatre, an intravenous line was secured with a 20-gauge IV cannula and Ringer lactate infusion was started.

Non-invasive blood pressure, electrocardiogram and oxygen saturation were monitored continuously. Premedication was administered with inj. glycopyrrolate 0.01 mg/kg, inj. midazolam 0.05 mg/kg and inj. fentanyl 2 µg/kg intravenously. Patients were pre-oxygenated with 100% oxygen.

Anaesthesia was induced with inj. propofol 2 mg/kg intravenously once mask ventilation was confirmed, followed by inj. vecuronium 0.1 mg/kg intravenously. Laryngoscopy was performed using a Macintosh blade of size 3 or 4 by an experienced anaesthesiologist, and the laryngoscopic view was classified according to the Cormack–Lehane scale without any external laryngeal manipulation.

Difficult visualisation was defined as grades III and IV, and easy visualisation as grades I and II.

Tracheal intubation was performed with endotracheal tubes of appropriate size. Confirmation of intubation was done by bilateral auscultation of the lung fields and capnography. Maintenance of anaesthesia was carried out with oxygen, nitrous oxide and isoflurane. The patient was extubated after administration of the reversal agents inj. neostigmine and inj. glycopyrrolate, once all extubation criteria were met, and was shifted to the post-anaesthesia care unit.

Parameters observed

- Pre-operative airway assessment tests
- Laryngoscopic view classified by the Cormack–Lehane scale
- Number of attempts for intubation
- Any manoeuvres performed or use of difficult-airway assisting devices in cases of difficult laryngoscopy

Results: The incidence of difficult laryngoscopy (Cormack–Lehane grades III and IV) was 17.5% (21 of 120 patients).

Table 2: Sex distribution of patients in relation to Cormack–Lehane grading

Sex	CL grade I	CL grade II	CL grade III	CL grade IV	Total
Female	36 (50.7)	17 (60.7)	8 (42.1)	2 (100)	63 (52.5)
Male	35 (49.3)	11 (39.3)	11 (57.9)	0 (0)	57 (47.5)

Figures in parentheses are column percentages. There was no statistically significant association between sex and Cormack–Lehane grade.

Table 3: ASA grade distribution of patients in relation to Cormack–Lehane grading

ASA grade	CL grade I	CL grade II	CL grade III	CL grade IV	Total
I	37 (52.1)	14 (50.0)	10 (52.6)	1 (50.0)	62 (51.7)
II	34 (47.9)	14 (50.0)	9 (47.4)	1 (50.0)	58 (48.3)

Figures in parentheses are column percentages. There was no statistically significant association between ASA grade and Cormack–Lehane grade.

Table 4: Age distribution of patients in relation to Cormack–Lehane grading

Age (years)	CL grade I	CL grade II	CL grade III	CL grade IV	Total
< 20	5 (7.0)	1 (3.6)	1 (5.3)	0 (0)	7 (5.8)
21–30	21 (29.6)	6 (21.4)	4 (21.1)	0 (0)	31 (25.8)
31–40	25 (35.2)	11 (39.3)	7 (36.8)	0 (0)	43 (35.8)
41–50	15 (21.1)	5 (17.9)	1 (5.3)	0 (0)	21 (17.5)
51–60	4 (5.6)	4 (14.3)	4 (21.1)	2 (100)	14 (11.7)
> 60	1 (1.4)	1 (3.6)	2 (10.5)	0 (0)	4 (3.3)

Figures in parentheses are column percentages. There was a statistically significant association between age and Cormack–Lehane grade; difficult intubation increased with increasing age.

Table 5: Findings of the predictive tests compared with Cormack–Lehane grading

Predictor	Prediction	CL grade III/IV (Difficult) n = 21	CL grade I/II (Easy) n = 99	p-value
MMT	Difficult	20 (95.2%)	2 (2.0%)	< 0.001
	Easy	1 (4.8%)	97 (98.0%)	
TMD	Difficult	8 (38.1%)	0 (0%)	< 0.001
	Easy	13 (61.9%)	99 (100%)	
ULBT	Difficult	1 (4.8%)	1 (1.0%)	0.223
	Easy	20 (95.2%)	98 (99.0%)	
RHTMD	Difficult	19 (90.5%)	5 (5.1%)	< 0.001
	Easy	2 (9.5%)	94 (94.9%)	

MMT: modified Mallampati test; TMD: thyromental distance; ULBT: upper lip bite test; RHTMD: ratio of height to thyromental distance. P-values were derived using the chi-square test; $p < 0.05$ was considered statistically significant.

Table 6: Validity of the predictive tests in predicting difficult intubation compared with Cormack–Lehane grading

Test	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
MMT	95.24	97.98	90.91	98.98	97.50
TMD	38.10	100	100	88.39	89.17
ULBT	4.76	98.99	50.00	83.05	82.50
RHTMD	90.48	94.95	79.17	97.92	94.17

PPV: positive predictive value; NPV: negative predictive value.

Discussion

In the present study, the incidence of difficult laryngoscopy (Cormack–Lehane grades III and IV) was 17.5%.

Among the four airway assessment tests studied, MMT had the highest sensitivity (95.24%),

specificity (97.98%), PPV (90.91%), NPV (98.98%) and diagnostic accuracy (97.5%) for predicting difficult laryngoscopy, followed by RHTMD, TMD and ULBT, in that order (MMT > RHTMD > TMD > ULBT). Tables 7–10 compare the validity of each test in the present study with previously reported values. [1,3,5–7]

Table 7: Comparison of the validity of MMT grading in predicting difficult intubation with previous studies

Parameter	Our study	Srinivasa S et al.	Shobha et al.	Badheka JP et al.	Tamire T et al.	Philip S et al.
Sensitivity	95.24	68.57	53.33	78.99	58.3	65
Specificity	97.98	60	90.43	68.63	90.9	65.7
PPV	90.91	48	42.11	85.45	25	26.5
NPV	98.98	78	93.69	58.33	97.6	90.8
Accuracy	97.5	63	86.15	–	74.6	66

Values are percentages. –: not reported. MMT: modified Mallampati test.

Table 8: Comparison of the validity of TMD grading in predicting difficult intubation with previous studies

Parameter	Our study	Srinivasa S et al.	Shobha et al.	Badheka JP et al.	Tamire T et al.	Philip S et al.
Sensitivity	38.1	71.43	3.33	70.59	58.3	70
Specificity	100	90.77	96.96	68.63	82.2	90.5
PPV	100	80.65	12.5	84	14.6	58.3
NPV	88.39	85.51	88.49	50	97.4	94.1
Accuracy	89.17	84	86.15	–	29.7	87

Values are percentages. –: not reported. TMD: thyromental distance.

Table 9: Comparison of the validity of ULBT grading in predicting difficult intubation with previous studies

Parameter	Our study	Srinivasa S et al.	Shobha et al.	Badheka JP et al.	Philip S et al.
Sensitivity	4.76	77.14	66.67	96.64	45
Specificity	98.99	98.46	99.13	82.35	99
PPV	50	96.43	90.91	92.74	90
NPV	83.05	88.89	95.8	91.3	90.4
Accuracy	82.5	91	95.38	—	90

Values are percentages. —: not reported. ULBT: upper lip bite test.

Table 10: Comparison of the validity of RHTMD grading in predicting difficult intubation with previous studies

Parameter	Our study	Srinivasa S et al.	Shobha et al.	Badheka JP et al.	Philip S et al.
Sensitivity	90.48	74.29	63.33	90.76	90
Specificity	94.95	93.85	89.57	80.39	82.9
PPV	79.17	86.67	44.19	91.53	50
NPV	97.92	87.14	94.93	78.85	97.8
Accuracy	94.17	87	86.54	—	84

Values are percentages. —: not reported. RHTMD: ratio of height to thyromental distance.

Considering the sensitivity, specificity, PPV, NPV and accuracy of all the airway assessment tests (TMD, MMT, ULBT and RHTMD) in the present study, and their comparison with previous studies,^{1,3,5-7} MMT was the most accurate test for predicting difficult endotracheal intubation pre-operatively. The MMT grading was closest to the Cormack–Lehane grading compared with the other scores. The overall ranking of the tests was MMT > RHTMD > TMD > ULBT.

The predictive values reported in the literature vary widely across studies, which may reflect differences in study populations, definitions of difficult laryngoscopy and the cut-off values used. Although no single bedside test is perfectly predictive on its own, combining multiple indices improves sensitivity and specificity, and is therefore recommended for pre-operative airway assessment.

Conclusion

MMT stands out as the most effective individual pre-operative test for predicting difficult endotracheal intubation. However, employing a combination of tests enhances both sensitivity and specificity, resulting in improved discriminatory capability. Hence, it is recommended to utilise a combination of indices during the pre-operative airway assessment of adult patients.

References

- Shobha D, Adiga M, Rani DD, Kannan S, Nethra SS. Comparison of upper lip bite test and ratio of height to thyromental distance with other airway assessment tests for predicting difficult endotracheal intubation. *Anesth Essays Res.* 2018 Jan-Mar;12(1):124-9.
- Kaniyil S, Anandan K, Thomas S. Ratio of height to thyromental distance as a predictor of difficult laryngoscopy: a prospective observational study. *J Anaesthesiol Clin Pharmacol.* 2018 Oct-Dec;34(4):485-9.
- Srinivasa S, Oza V, Kumar V, Parmar V, Chhaya VA. Assessment of difficult airway predictors for predicting difficult laryngoscopy and intubation. *Int J Biomed Adv Res.* 2014;5(7):340-2.
- Koh W, Kim H, Ro YJ, Yang HS. Encountering unexpected difficult airway: relationship with the intubation difficulty scale. *Korean J Anesthesiol.* 2016 Jun;69(3):244-9.
- Badheka JP, Doshi PM, Vyas AM, Kacha NJ, Parmar VS. Comparison of upper lip bite test and ratio of height to thyromental distance with other airway assessment tests for predicting difficult endotracheal intubation. *Indian J Crit Care Med.* 2016;20(1):3-8.
- Philip S, Nizar F. Prediction of difficult laryngoscopy in patients undergoing endotracheal intubation: a comparative study of various airway assessment tests. *Astrocyte.* 2016 Apr-Jun;3(2):90.
- Tamire T, Demelash H, Admasu W. Predictive values of preoperative tests for difficult laryngoscopy and intubation in adult patients at Tikur Anbessa Specialized Hospital. *Anesthesiol Res Pract.* 2019;2019:1790413.
- Apfelbaum JL, Hagberg CA, Connis RT, Abdelmalak BB, Agarkar M, Dutton RP, et al. 2022 American Society of Anesthesiologists practice guidelines for management of the difficult airway. *Anesthesiology.* 2022;136(1):31-81.