

# Predictive value of bedside tests for difficult intubations

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**Abstract. – OBJECTIVE:** The aim of this study is to find the ideal test(s) for the prediction of difficult laryngoscopic intubation.

**PATIENTS AND METHODS:** One hundred and twenty patients were selected at random for this prospective observational study. The patients' preoperative exams include the assessment of Mallampati classification, thyromental, sternomental, interincisor distances and neck circumference. The laryngoscopy was evaluated with using the Cormack Lehane classification. The sensitivity, specificity, positive and negative predictive values and accuracy of tests, alone and in combination, were assessed.

**RESULTS:** No statistically significant difference was found between the difficult and easy intubation cases. Sternomental distance showed the highest sensitivity (76%) and positive predictor value (54%). As the critical value of neck circumference was set to 35 cm and above, the sensitivity was 74% and positive predictive value, 53%. For the neck circumference and sternomental distance combination, which is determined to be the most reliable and accurate criteria, the sensitivity was 62% and positive predictive value, 42%.

**CONCLUSIONS:** The findings suggest that the sternomental distance and neck circumference combination may be a more accurate predictor of difficult intubation.

*Key Words:*

General anaesthesia, Difficult intubation, Difficult laryngoscopy, Mallampati classification, Thyromental distance, Sternomental distance, Interincisor distance, Neck circumference.

## Introduction

Difficult laryngoscopies are the most significant cause of mortality in anesthetised patients<sup>1</sup>. Preoperative evaluation is important to reduce the risk of difficult airway management. The frequency of difficult laryngoscopy ranges from

1.5% to 20%<sup>2</sup>. Prediction of difficult airways will enable an effective preoperative anaesthetic plan and safe intubation, which will decrease complications and mortality rates. Mallampati classification, sternomental distance, thyromental distance, mouth opening, neck circumference are some preoperative tests that can be done to predict difficult airways. Several studies question the accuracy of these predictive tests; however, they are not adequate as the only predictor when used for predicting difficult airways<sup>3</sup>.

This study was designed to determine the accuracy of bedside tests and to discover the safest method to predict difficult airways.

## Patients and Methods

This prospective observational study was conducted after obtaining approval from the Ethics Committee and informed consent from all the patients. One hundred and twenty adult male and female patients (ASA I-III) aged 18-70 years, requiring general anaesthesia and direct laryngoscopy, were enrolled in the study. Patients who underwent emergency operations, who needed awake intubations, or who have congenital anomalies were excluded. All demographic properties of patients (age, sex, weight, height, and body mass index) were recorded in the preoperative assessment.

The following predictive test measurements were obtained by an anaesthesiologist who did not conduct the laryngoscopy assessment:

**Modified mallampati test (MMT):** The oropharyngeal view are graded into four different classes<sup>4</sup>:

- Class I – soft palate, fauces, uvula, and pillars visible
- Class II – soft palate, fauces, and uvula visible

- Class III – soft palate and base of the uvula visible
- Class IV - soft palate not visible at all.

The patients were classified while they were seated upright, with mouths maximally opened, tongues protruded, and without phonation. A modified Mallampati score class of 3 and 4 are considered predictive of difficult laryngoscopy.

**Thyromental distance (TMD):** It is defined as the distance from the mentum to the thyroid notch with the head fully extended. A TMD  $\leq$  6.5 cm is considered predictive of difficult laryngoscopy<sup>5</sup>.

**Sternomental distance (SMD):** It is defined as the distance from the suprasternal notch to the mentum and is measured with the head fully extended on the neck and the mouth closed. A SMD  $\leq$  13.5 cm is considered predictive of difficult laryngoscopy<sup>6</sup>.

**Neck circumference (NC):** It is measured at the level of the cricoid cartilage. The critical value of neck circumference is set to 35 cm and above.

**Inter-incisor distance (ID):** It is the distance between the upper and lower incisors. An ID  $>$  3.8 cm is considered predictive of a difficult airway.

**Airway risk index (ARI):** It is defined as the sum of several clinical criteria (i.e., mouth opening, Mallampati classification, head/neck movement, ability to prognath, thyromental distance, body weight, and previous history of difficult intubation). The presence of five or more criteria is considered predictive of difficult laryngoscopy<sup>7</sup>.

Each patient was monitored routinely with a pulse oximetry, electrocardiogram and non-invasive arterial pressure. Patients breathed 100% oxygen through a face mask for more than 3 minutes. Anaesthesia was then induced with propofol (2 mg/kg). After an easy ventilation with face mask, muscle relaxation was achieved with rocuronium (0.7 mg/kg). The laryngoscopy was performed 3 minutes after rocuronium injection using a Macintosh #3 blade with the patient's head in the "sniffing position". If there was no laryngeal view, cricoid pressure with Sellick manoeuvre was applied<sup>8</sup>. All tracheal intubations were performed by the same anaesthetist with more than 2 years of experience who was unaware of the patients' assignment. The laryngoscopic view was graded according to Cormack and Lehane's scale (C-L)<sup>9</sup>:

- Grade I, the vocal cords were completely visible
- Grade II, only the arytenoids were visible
- Grade III, only the epiglottis was visible
- Grade IV, the epiglottis was not visible

C-L grades I and II were classified as "easy," whereas C-L grades III and IV were designated as "difficult."

The type of blade, number of attempts, C-L grade and any difficulties encountered were documented after each successful direct laryngoscopy. If the proper insertion of the tracheal tube with conventional laryngoscopy required multiple attempts, it was defined as difficult intubation (DI).

### **Statistical Analysis**

Statistical analysis was performed with The Statistical Package for Social Sciences version 10 software (SPSS Inc., Chicago, IL, USA). The sensitivity, specificity, positive and negative predictive values, and accuracy were calculated, and the data were analysed by using the Student's t test, Mann-Whitney U test and logistic regression tests. The results were assessed in the 95% safety interval and statistical significance was assumed when  $p < 0.05$ .

## **Results**

One hundred twenty ASA physical status I and II patients (67 women and 53 men), with a mean age of  $47.5 \pm 15$  years, participated in the study. In 94 patients, tracheal intubation was achieved under direct laryngoscopy. The intubation was easy in 27 of the 94 patient while the remaining 67 patients experienced difficult intubation. Among these 67 patients, 3 were pregnant and 15 were morbid obese. Direct laryngoscopic intubation was completely unsuccessful in 8 of the 67 patients.

5 of these 8 patients went through blind intubation using fast-track; laryngeal mask airway was used in 2 patients; while tracheostomy was performed on only 1 patient. The risk factors for difficult intubation in 67 patients are shown in Table I, the results of predictive tests in these patients are shown in Table II, and the accuracy of risk factors in predicting difficult tracheal intubation is shown in Table III.

The remaining 26 of the total 120 patients' intubation were performed directly by fiberoptic-guided tracheal intubation. Seven of these pa-

**Table I.** Risks factors for difficult intubation.

	N= 67	%
Morbid obesity	15	22
Micrognathia	15	22
Limited cervical extension	10	14.9
Maxillofacial anomaly	2	2.9
Torticollis	2	2.9
Ankylosing spondylitis	1	1.4
Ankylosing of temporomandibular joint	1	1.4
Micrognathia + limited cervical extension	11	16.4
Micrognathia + morbid obesity	3	4.4
Morbid obesity + thyroid mass	1	1.4
History of difficult intubation	8	11.9
Intraoral pathology	7	10.4
Modified Mallampati Score III-IV	38	56.7

tients had a history of difficult intubation in their previous operations. Ten patients had serious cervical extension limitations, 7 had limited inter incisor distance, 1 experienced maxillofacial trauma, while 1 patient had congenital micrognathia and high palate. Regional anaesthesia was performed successfully on 1 patient.

No statistically significant difference was found between the difficult and easy intubation cases. Sternomental distance showed the highest sensitivity (76%) and positive predictor value (54%). As the critical value of neck circumference was set to 35 cm and above, the sensitivity was 74% and positive predictive value, 53%. For the neck circumference and sternomental distance combination, which is determined to be the most reliable and accurate criteria, the sensitivity was 62% and positive predictive value, 42%.

**Table II.** Results of the 94 patients' prediction tests.

	N: 67 (difficult intubation)	N: 27 (easy intubation)	p
BMI	28.1 ± 6.2	28.8 ± 5.9	> 0.05
NC (cm)	37 ± 5.5	36.4 ± 5.6	> 0.05
ID (cm)	3.8 ± 1.1	3.5 ± 1.3	> 0.05
TMD (cm)	7.4 ± 2.3	7.8 ± 1.9	> 0.05
SMD (cm)	11.2 ± 2	11.7 ± 1.7	> 0.05
Number of attempts	3.6 ± 2.4	1.2 ± 0.5	< 0.05
Time for intubation (min)	7.8 ± 8.4	2 ± 2	< 0.05
ARI	4.9 ± 1.9	4.5 ± 1.6	> 0.05
MMT I-II	29	10	
MMT III-IV	38	17	

BMI = Body mass index; NC = Neck circumference; ID = Inter-incisor distance; TMD = Thyromental distance; SMD = Sternomental distance; ARI = Airway risk index; MMT = Modified Mallampati test.

## Discussion

The prediction of difficulties in maintaining airway plays a vital role in patient safety and the prevention of complications. Several tests and classifications are employed for the assessment of intubation conditions and airway management. However, those tests exhibit high specificity but low sensitivity. Ideally, any test to predict difficult airway should have high sensitivity, specificity, and minimal false positive and false negative values<sup>10</sup>. Difficult airway is a multifactorial problem, and no single test can be used on its own to predict difficulty. As such, combinations of individual tests or risk factors are used as they may add some incremental diagnostic value<sup>11</sup>. Among all the clinical tests available to predict difficult intubation, the Mallampati test is the most popular and commonly used. Thyromental distance measurement, sternomental distance measurement, neck circumference and interincisor distance measurement are the other simple bedside tests that can also be used. They have all been found to be limited in predicting difficult airway if used alone<sup>12</sup>.

According to Savva et al<sup>13</sup>, the Mallampati test has low sensitivity, and as interventional observation can affect the results, this test should be combined with other bedside tests in order to be effective. In our study, the Mallampati test alone had 56% sensitivity and the positive predictive test is calculated as 40%. The sensitivity and positive predictive value were lower when the Mallampati test was combined with other bedside tests. Butler et al<sup>14</sup> also found the sensitivity of Mallampati to be 56% in their study. This study concurs with Savva et al with regards to combining Mallampati with other bedside tests to accurately predict difficulty.

**Table III.** Accuracy of risk factors in predicting difficult intubation.

	Sensitive (%)	Positive predictive value (%)
BMI > 26	67	47
NC > 35 cm	74	53
ID < 4 cm	37	26
TMM < 6 cm	46	32
SMM < 12 cm	76	54
MMT 3-4	56	40
ARI > 5	59	42
TMM + MMT	20	14
SMM + MMT	31	21
TMM + SMM	38	27
NC + MMT	38	27
MMT + ID	37.5	26
BMI + NC	60	41
BMI + MMT	39	26
NC + SMM	62	42

BMI = Body mass index; NC = Neck circumference; ID = Inter-incisor distance; TMD = Thyromental distance; SMD = Sternomental distance; ARI = Airway risk index; MMT = Modified Mallampati test.

Savva et al<sup>13</sup> found the sensitivity of sternomental distance (82.4%) and specificity (88.6%), to be the highest test results. In a meta-analysis, Shiga et al<sup>3</sup> mentioned that among all single-factor tests, the sternomental distance is the best single test with moderate sensitivity and specificity for ruling out difficult intubation. The findings in this study reveal that the sensitivity of SMD as 82.4%, and positive predictive value as 54%, and concluded that sternomental distance is the safest bedside test.

Merah et al<sup>15</sup> found that sensitivity, specificity, and positive predictive value of TMD were 15.4%, 98.1%, and 22.2% respectively. Their sensitivity results were lower than the other studies; which suggested that this difference may be due to anthropometric specialties in the study population. Frerk et al<sup>16</sup> reported the sensitivity of thyromental distance as 90.9%, the specificity as 81.5%, and the negative predictive value as 10%. The combination of thyromental distance measurement and the Mallampati test resulted in a lower false positive value in their study. However, Jimson et al<sup>17</sup> found the sensitivity of the thyromental test as 32%, positive predictive value as 20%, and reported that the sensitivity and specificity were very much lower when TMD was used with Mallampati. Asik et al<sup>18</sup> reported the sensitivity as 45%, the sensitivity of TMD as 46%, and positive predictive value as 32%. The

sensitivity was 20%, and the positive predictive value was 14% when TMD was used with Mallampati in this study. The difference between these studies could have occurred because Frerk accepted all guide aided intubation as difficult intubation; which may have resulted in high sensitivity results.

Wilson et al<sup>19</sup> suggested that difficult intubation risk is increased in patients who have limited mandibular protrusion and interincisor gap lower than 5 cm. However, Savva et al<sup>13</sup>, Kararmaz et al<sup>20</sup>, and Krobbuaban et al<sup>5</sup> found no correlation between the interincisor gap and the view on laryngoscopy. This study also did not find any association between difficult laryngoscopy and the interincisor gap. The patients in this study were generally in the obesity category (BMI 28.4 ± 6), and this study did not reveal any correlation between difficult laryngoscopy and increased BMI.

El Ganzouri et al<sup>7</sup> analysed 10,507 patients that received general anaesthesia prospectively, and developed an airway risk index. They described seven risk factors in predicting difficult intubation, including mouth opening < 4 cm, thyromental distance < 6 cm, Mallampati classification III, neck movement < 80°, inability to prognath, body weight > 110 kg, and positive history of difficult intubation. Compared to Mallampati, they reported high sensitivity (59.4%) and specificity (93.6%) when there was a risk factor of ≥ 4. This study discovered the sensitivity of the airway risk index as 59%, and positive predictive value as 42%. The application of such multifactorial indices for predicting difficult laryngoscopy gave new perspectives to the results, but certainty is never possible.

As mentioned before, the effective prediction of difficult laryngoscopy requires a combination of tests<sup>12</sup>. Frerk et al<sup>16</sup> reported that combination of Mallampati and thyromental distance measurement offers the highest sensitivity and specificity results. Asik et al<sup>18</sup> concurs with this finding. In this study, it was discovered that sternomental distance measurement has the highest sensitivity (76%), and positive predictive value (54%). The increased neck circumference (NC) is reported to be associated with difficult intubation, especially in obese patients. However, in this study, the critical value of neck circumference was set to 35 cm and above. The patients who have a neck circumference more than 35 cm had a sensitivity of 74% and positive predictive value of 53%. The results suggest that the combi-

nation of sternomental distance measurement and neck circumference is the safest and best method to predict difficult laryngoscope with 62% sensitivity and 42% positive predictive value.

### Conclusions

The combination of sternomental distance measurement and neck circumference is the most accurate and safest bedside test for the prediction of difficult laryngoscopy.

### Conflict of Interest

The Authors declare that there are no conflicts of interest.

### References

- 1) BRAZ DG, CRUZ DS, FERNANDES LA, MÓDOLO NS, BRAZ JR. Mortality in anaesthesia: a systematic review. *Clinics* 2009; 64: 999-1006.
- 2) ETEZADI F, AHANGARI A, SHOKRI H, NAJAFI A, KHAJAVI MR, DAGHIGH M, MOHARARI RS. Thyromental height: a new clinical test for prediction of difficult laryngoscopy. *Anesth Analg* 2013; 117: 1347-1351.
- 3) SHIGA T, WAJIMA Z, INOUE T, SAKAMOTO A. Predicting difficult intubation in apparently normal patients a meta-analysis of bedside screening test performance. *Anesthesiology* 2005; 103: 429-437.
- 4) SAMSOON GL, YOUNG JR. Difficult tracheal intubation: a retrospective study. *Anaesthesia* 1987; 42: 487-490.
- 5) KROBBUABAN B, DIREGPOKE S, KUMKEAW S, TANOMSAT M. The predictive value of the height ratio and thyromental distance: four predictive tests for difficult laryngoscopy. *Anesth Analg* 2005; 101: 1542-1545.
- 6) AL RAMADHANI S, MOHAMED LA, ROCKE DA, GOUWS E, RAMADHANI SA. Sternomental distance as the sole predictor of difficult laryngoscopy in obstetric anaesthesia. *Br J Anaesth* 1996; 77: 312-316.
- 7) EL-GANZOURI AR, MCCARTHY RJ, TUMAN JK, TANCK EN, IVANKOVICH AD. Preoperative airway assessment: Predictive value of a multivariate risk index. *Anesth Analg* 1996; 82: 1197-1204.
- 8) SELICK BA. Cricoid pressure to control regurgitation of stomach contents during induction of anaesthesia. *Lancet* 1961; 2: 404-406.
- 9) CORMACK RS, LEHANE J. Difficult tracheal intubation in obstetrics. *Anaesthesia* 1984; 39: 1105-1111.
- 10) ARNE J, DESCOINS P, FUSCIARDI J, INGRAND P, FERRIER B, BOUDIGUES D, ARIES J. Preoperative assessment for difficult in general and ENT surgery: predictive value of a clinical multivariate risk index. *Br J Anaesth* 1998; 80: 140-146.
- 11) KIM WH, AHN HJ, LEE CJ, SHIN BS, KO JS, CHOI SJ, RYU SA. Neck circumference to thyromental distance ratio: a new predictor of difficult intubation in obese patients. *Br J Anaesth* 2011; 106: 743-748.
- 12) NAGUIB M, SCAMMAN FL, O'SULLIVAN C, AKER J, ROSS AF, KOSMACH S, ENSOR JE. Predictive performance of three multivariate difficult tracheal intubation models: A double blind case controlled study. *Anesth Analg* 2006; 102: 818-824.
- 13) SAVA D. Prediction of difficult tracheal intubation. *Br J Anaesth* 1994; 73: 149-153.
- 14) BUTTER B, EZRI T, WARTERS RD, SZMUK P. The incidence of class 'zero' airway and the impact of Mallampati Score, age, sex and body mass index on prediction of laryngoscopy grade. *Anesth Analg* 2001; 93: 1073-1075.
- 15) SALIMI A, FARZANEGAN B, RASTEGARPOUR A, KOLAHI AA. Comparison of the upper lip bite test with measurement of thyromental distance for prediction of difficult intubations. *Acta Anaesthesiol Taiwan* 2008; 46: 61-65.
- 16) FRERK CM. Prediction difficult intubation. *Anaesthesia* 1991; 46: 1005-1008.
- 17) TSE JC, RIMM EB, HUSSAIN A. Predicting difficult endotracheal intubation in surgical patients scheduled for general anesthesia: a prospective blind study. *Anesth Analg* 1995; 81: 254-258.
- 18) ASIK I, GOKTUG A, CANAKCI N. The relation of different intubation assessment tests with difficult intubation. *Aneztezi Dergisi* 2000; 8: 188-192.
- 19) WILSON ME, SPIEGELHALTER D, ROBERTSON JA, LESSER P. Predicting difficult intubation. *Br J Anaesth* 1988; 61: 211-216.
- 20) KARARMAZ A, TURHANOGLU S, KAYA S, OZYILMAZ MA. Comparison of different predictive tests for predicting difficult intubation. *Turk J Anaesth Reanim* 2003; 31: 303-308.