

# A Prospective Study to Predict difficult intubation using Simple Non-Invasive Tests

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## ABSTRACT

**Introduction:** Failure to achieve endotracheal intubation causes considerable morbidity and mortality in anaesthetised patients. Preoperative identification of such patients would help the Anesthesiologist to be prepared for such a difficult situation. The purpose of our study was to determine the ability to predict difficult visualization of larynx using the Upper Lip Bite Test (ULBT), Hyomental distance (HMD), Thyrosternal distance (TSD), and the Mandibular length (ML).

**Material and methods:** Study group included 100 patients undergoing elective surgical procedures under general anaesthesia with endotracheal intubation. ULBT, HMD, TSD and ML measurements were performed on all patients preoperatively. ULBT class III, HMD <3.5cm, TSD < 6.5cm and ML < 9cm were considered potentially difficult intubation. An experienced anesthesiologist, unaware of preoperative airway evaluation, performed the laryngoscopy and graded the glottic view (as per Cormack and Lehane's (CL) classification). CL Grade III and IV were considered as difficult intubation. We calculated the Sensitivity, specificity, accuracy, positive and negative predictive values of upper lip bite test and Modified Mallampati test.

**Results:** ULBT had a sensitivity, specificity, PPV and NPV of 45.45%, 100%, 100% and 93.68%, respectively. HMD showed a Sensitivity, Specificity, PPV and NPV of 9.09%, 97.75%, 33.33% and 89.69%, respectively. TSD showed a Sensitivity and PPV came of 0% while the Specificity and NPV of the test to be 97.75% and 88.78%, respectively. ML showed Sensitivity, Specificity, PPV and NPV and found of 18.18%, 98.88%, 66.67% and 90.72%, respectively.

**Conclusion.** ULBT comes out to be a better predictor of Difficult Intubation over HMD, TSD and ML. Though, ULBT appears to be better amongst the four tests, none of them is a foolproof test. None of them can be used as a reliable screening test as no one had a sensitivity even more than 50%. But, ULBT is better predictor amongst above parameters.

**Keywords:** Difficult Intubation, Cormack Lehane Grading, Upper lip Bite Test, Hyomental Distance, Thyrosternal Distance, Mandibular Length

## INTRODUCTION

Failure to achieve endotracheal intubation causes considerable morbidity and mortality in anaesthetised patients. Of all the anaesthetic deaths, 30% to 40% are attributed to the inability to manage a difficult airway.<sup>1</sup> Preoperative identification of such patients would help the Anesthesiologist to be prepared for such a difficult situation. Various techniques like Radiographs and Airway Imaging have been advocated to predict difficult intubation but are too expensive and inconvenient for patients to undergo as screening tests.<sup>2</sup> Highly specialized techniques such as Acoustic Reflectometry are of dubious reliability.<sup>3</sup> More quantitative, non-invasive measurements such as those with the laryngeal indices calliper<sup>4</sup> and bubble inclinometer<sup>5</sup>

offer the potential for accurate measurements but have never found their way into clinical practice. In contrast, the various simple bedside predictors of difficult airway like Mallampati class, Atlanto-occipital extension, Upper Lip Bite Test, Thyromental, Hyomental, Thyrosternal and Sternomental distances, Mandibular length, Neck Circumference, etc. are easy to perform, with no extra cost or inconvenience to patient. However, no single test alone has been found to be a foolproof predictor of difficult visualization of larynx.

The purpose of our study was to determine the ability to predict difficulty in visualization of larynx using the Upper Lip Bite Test (ULBT), Hyomental distance (HMD), Thyrosternal distance (TSD), and the Mandibular length (ML). We wished to determine whether there was a direct correlation between each of these parameters and the laryngoscopic view i.e. Cormack Lehane grading and difficult intubation and the diagnostic value i.e. which test predicts the difficult visualization better than others with the help of sensitivity, specificity, positive predictive value and negative predictive value of each test.

## MATERIAL AND METHODS

After obtaining institutional ethics committee clearance and taking written informed consent, this prospective study was conducted in 100 patients of either sex, aged between 25 years and to 60 years, ASA physical status I/II and BMI 18.5 to 24.9, undergoing elective surgical procedures under general anaesthesia with endotracheal intubation at a tertiary care hospital (NAIR Hospital, Mumbai). All patients included in this study underwent a routine pre anesthetic check up. Apart from Mouth Opening and Modified Mallampati Test (MMT), which are routinely done, airway assessment included Upper Lip Bite Test (ULBT), Hyomental distance (HMD), Thyrosternal distance (TSD) and Mandibular length (ML). Edentulous patients, patients with BMI > 30, uncooperative and patients with altered consciousness, patients unable to open the mouth, patients requiring Rapid sequence induction of anaesthesia, patients with cervical spine fractures and deformities, those with restricted mobility of neck and mandible, any oropharyngeal, airway abnormality or obvious neck pathology, pregnancy, temporomandibular joint and atlanto-axial joint dislocation were excluded from the study. A power analysis was conducted

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assuming a moderate effect, a power of 80% and type I error of 5% and using two sided alternative hypothesis, a sample size of 100 was determined to be appropriate for the study. All the patients were explained about the procedure in detail preoperatively and all the patient's airway was evaluated using ULBT.

Description of the airway assessment tests is as follows:

**Upper Lip Bite Test (ULBT):** It is a scale indicating range of motion of bite of lower teeth onto upper lip. ULBT was assessed with the participant in sitting position at the eye level and graded as follows.

Class 1: Lower incisors can bite the upper lip above the vermilion border.

Class 2: Lower incisors can bite the upper lip below the vermilion border.

Class 3: Lower incisors cannot bite the upper lip (potentially difficult intubation).

**Hyomental distance (HMD) Test:** HMD was measured in supine position with head in full extension and mouth closed. The straight distance from the lower border of the mandibular mentum to the superior border of hyoid bone was measured in centimeters.

HMD is graded as:

≥3.5 cm- expected easy intubation

<3.5 cm-potentially difficult intubation

**Thyrosternal distance (TSD) Test:** TSD was measured in supine position with head in full extension and mouth closed. The straight distance between the prominent laryngea of the thyroid cartilage and incisura jugularis of the sternal bone was measured in centimeters.

TSD is graded as:

≥6.5 cm- expected easy intubation

<6.5 cm- potentially difficult intubation

**Mandibular length (ML):** ML was measured from the angle of mandible to the tip of the chin with the patient in sitting position.

ML is graded as:

≥9 cm- expected easy intubation

<9 cm- potentially difficult intubation

All the distances were measured with the help of a flexible plastic material scale so as to measure the distances accurately. Consent and NBM status were confirmed. Monitoring included the Non Invasive Blood Pressure (NIBP), Electrocardiography, Pulseoximetry and Capnography, Baseline heart rate, SpO<sub>2</sub>, Systolic and Diastolic Blood Pressure, Mean arterial Blood Pressure were recorded. Peripheral line was taken with 18G IV cannula (standard protocol). Patient was preoxygenated and pre Medication was given as per routine protocol.

Propofol 2mg/kg was used as intravenous induction agent. Ventilation was confirmed. Intravenous Vecuronium 0.1mg/kg was given as muscle relaxant and patient was ventilated for 3 minutes. Laryngoscopy was performed with No.3 or No.4 Macintosh blade by an experienced anesthesiologist (who has completed atleast 3 years of postgraduate training in Anesthesia).

CORMACK and LEHANE'S grading system is the gold standard parameter in diagnosing level of difficulty in INTUBATION.

Laryngoscopy view was graded according to Cormack and Lehane scale as follows:

Grade 1: Full view of glottis seen.

Grade 2: Anterior commissure not visible, Glottis seen partially.

Grade 3: Only epiglottis is seen.

Grade 4: Epiglottis is not seen.

Grade 3 and 4 are considered as potentially difficult intubations.

Intubation was declared difficult if a second experienced anaesthesiologist failed to visualize the larynx even after using conventional measures of changing the head position, blade and application of external laryngeal pressure.

#### Outcome measures

*Predicted easy intubation:*

a) Thyrosternal distance ≥6.5

b) ULBT: class 1 and 2

c) Hyomental distance ≥3.5cm

d) Mandibular length ≥9cm

#### Predicted difficult intubation

a) Thyrosternal distance <6.5cm

b) ULBT: class 3

c) Hyomental distance <3.5cm

d) Mandibular length <9cm

#### Actual easy intubation

Cormack Lehane grade 1 and 2

#### Actual difficult intubation

Cormack Lehane grade 3 and 4

### STATISTICAL ANALYSIS

The completed data sheets were analysed by SPSS version 17 software (SPSS Inc.). The preoperative assessment data and the laryngoscope findings were used to evaluate the predictive value of each test for difficult laryngoscopy. As ULBT class, HMD, TSD, ML are categorical variable, we used a 2 × 2 table to assess the validity parameters i.e sensitivity, specificity, positive and negative predictive values, and accuracy. Calculations were performed using Excel 2013 for Windows. Qualitative data is represented in form of frequency and percentage. Quantitative data is represented using mean±sd and Median and IQR (Interquartile range). Predictiveness of various variables towards CL was assessed using Linear Regression analysis. Results were graphically represented wherever required. Diagnostic efficacy was calculated through Sensitivity, Specificity, Positive Predictive Value and Negative Predictive Value.

### RESULTS

Our study included 100 patients, 51 males and 49 females. 75 patients came under ASA status I and 25 under ASA II. Mean age was 34.27 years and mean BMI was 22.23. Difficult intubation was seen in 11 (11%) patients. Cormack Lehane (CL) Grades I and II were included in Easy Cormack Lehane grading, whereas Grades III and IV were included in Difficult Cormack Lehane. All of our patients with difficult intubation had CL grading III and none had CL grade IV. There was no failure to intubate the trachea in any of the patients in our study. External Laryngeal pressure or Gum elastic Bougie was used to intubate patients with CL grade III patients. Remaining patients were intubated at the first attempt.

We studied the validity of ULBT, HMD, TSD and ML on the basis of sensitivity, specificity, positive predictive value and negative predictive value. In our study we found Sensitivity of

Upper Lip Bite Test (ULBT) to be 45.45%, specificity of 100%, positive predictive value of 100% and negative predictive value of 93.68% (Table-1). This means ULBT is less sensitive but highly specific and has very good positive predictive value with good negative predictive value. Hyomental distance (HMD) showed a Sensitivity, Specificity, Positive Predictive Value and Negative Predictive Value of 9.09%, 97.75%, 33.33% and 89.69%, respectively (Table-2). Thyrosteral distance showed a Sensitivity and Positive Predictive Value came of 0% while the Specificity and Negative Predictive value of the test to be 97.75% and 88.78%, respectively (Table-3). Mandibular length. showed Sensitivity, Specificity, Positive Predictive Value and Negative Predictive Value and found of 18.18%, 98.88%, 66.67% and 90.72%, respectively (Table-4).

**DISCUSSION**

Securing an airway is the most important part of general anaesthesia. Difficult Intubation is a nightmare for every anaesthesiologist. Being prepared for a difficult intubation reduces the adverse events due to difficulty in or failure to intubate. To be prepared for Difficult Intubation, it is vital to predict the difficult airway correctly before induction of anaesthesia. There has been an extensive research on the predictors for difficulty in intubation, right from radiological imaging to external anatomical factors, but there’s no single test which is easy to perform, highly sensitive, highly specific and which possess high positive predictive value with few false negative predictions, i.e. an ideal test.

A test to predict difficult intubation should have high sensitivity, so that it identifies most patients in whom intubation will truly be difficult. It should also have a high Positive Predictive Value, so that only few patients with airways actually easy to intubate are subjected to the protocol for management of a difficult airway. Similarly, a test should have a high specificity and Negative Predictive Value to correctly predict the ease of laryngoscopy and intubation.

This study was designed to evaluate the efficacy of Upper Lip Bite Test, Hyomental distance, Thyrosteral distance and Mandibular length in terms of Sensitivity, Specificity, positive Predictive Value and Negative Predictive Value in forecasting a difficult intubation, and to draw a possible relation between the Tests/ Parameters and Cormack–Lehane grades which was used as the gold standard in our study.

Upper Lip Bite Test proposed by Khan et al in 2002<sup>6</sup> is a simple assessment method in predicting difficulty in intubation. It tests the range and freedom of mandibular movement and the architecture of the teeth. ULBT is easy to demonstrate to patients and very convenient to perform as a bedside test.

We have studied ULBT along with Hyomental distance(HMD), Sternothyroid distance (STD) and Mandible length (ML).

In our study, the sensitivity of ULBT was found out to be 45.45%. The sensitivity we found is in contrast with the findings of Zahid khan, et al<sup>6</sup>, 2003, who found the sensitivity of 76.5% and Eberhart et al<sup>8</sup> who got sensitivity to be 28%. Lower sensitivity of ULBT in Eberhart, et al study can be explained due to higher incidence of difficult intubation in the study with

ULBT		Cormack Lehane Grading		Total
		Difficult	Easy	
Predicted Difficult	No.	5	0	5
Predicted Easy	No.	6	89	95
Total	No.	11	89	100
Diagnostic tests		Estimate	Lower 95% CI	Upper 95% CI
Sensitivity		45.45%	16.75%	76.62%
Specificity		100.00%	95.94%	100.00%
Predictive value of positive test		100.00%	47.82%	100.00%
Predictive value of negative test		93.68%	86.76%	97.65%

**Table-1:** Association between ULBT and Cormack Lehane Grading among the cases

TSD (cm)		Cormack Lehane Grading		Total
		Difficult	Easy	
Predicted Difficult	No.	0	2	2
Predicted Easy	No.	11	87	98
Total	No.	11	89	100
Diagnostic tests		Estimate	Lower 95% CI	Upper 95% CI
Sensitivity		0.00%	0.00%	28.49%
Specificity		97.75%	92.12%	99.73%
Predictive value of positive test		0.00%	0.00%	84.19%
Predictive value of negative test		88.78%	80.80%	94.26%

**Table-3:** Association between TSD and Cormack Lehane among the cases

HMD (cm)		Cormack Lehane Grading		Total
		Difficult	Easy	
Predicted Difficult	No.	1	2	3
Predicted Easy	No.	10	87	97
Total	No.	11	89	100
Diagnostic tests		Estimate	Lower 95% CI	Upper 95% CI
Sensitivity		9.09%	0.23%	41.28%
Specificity		97.75%	92.12%	99.73%
Predictive value of positive test		33.33%	0.84%	90.57%
Predictive value of negative test		89.69%	81.86%	94.94%

**Table-2:** Association of HMD and Cormack Lehane among the study population

ML (cm)		Cormack Lehane Grading		Total
		Difficult	Easy	
Predicted Difficult	No.	2	1	3
Predicted Easy	No.	9	88	97
Total	No.	11	89	100
Diagnostic tests		Estimate	Lower 95% CI	Upper 95% CI
Sensitivity		18.18%	2.28%	51.78%
Specificity		98.88%	93.90%	99.97%
Predictive value of positive test		66.67%	9.43%	99.16%
Predictive value of negative test		90.72%	83.12%	95.67%

**Table-4:** Association between ML and Cormack Lehane among the cases

large proportion of false negative results (6%).

Zahid Khan et al<sup>6</sup> in 2003 found the specificity of 88.7% against 100% what we found which can be explained by no false positive obtained in our study with ULBT as compared to Khan's study (10.6%). E Allahyary et al<sup>9</sup> and Khan ZH et al<sup>7</sup>, found the specificity for ULBT to be 97.6% and 91.69%, respectively, which were close to what was found in present study.

The positive predictive value and negative predictive value of ULBT were found to be 100% and 93.68%, respectively. E Allaharay et al<sup>9</sup>, found the positive predictive value of 89.7% which is quite close to present study findings.

We also studied Hyomental distance and found its sensitivity to be very low as 9.09% which was in accordance with study of Khan et al in 2011,<sup>7</sup> who found the sensitivity of HMD to be 8.8%. Huh J et al<sup>10</sup> in 2009 assessed Modified Mallampati Test, HMD, HMD ratio and Thyromental distance and found the sensitivity of HMD to be 23% which was again not a very good predictor in terms of screening test which requires a good sensitivity. The Specificity, Positive Predictive Value and Negative Predictive Value in our study for HMD were 97.75%, 33.33% and 89.69%, respectively. Khan et al<sup>2</sup> found the Specificity, Positive Predictive Value and Negative Predictive Value of HMD to be 98.9%, 50% and 89.5%, respectively which were almost similar to what we found in our study. Huh J et al<sup>10</sup> found the Specificity, Positive Predictive Value and Negative Predictive Value of HMD to be 95%, 40% and 90%, respectively which were also similar to what we found in our study.

Cattano et al<sup>11</sup> studied Hyomental distance and found its sensitivity to be 16%, specificity of 91%, Positive Predictive Value of 4% and Negative Predictive Value of 98%. All other results were comparable to our study except the very low positive predictive value they found which might be due to not calculating the Hyomental distance in full extension of neck and taking the cut off point for predicting difficult intubation by Hyomental distance as 4.5cm against our study and also the other studies conducted by Khan et al<sup>2</sup> and Huh J et al.<sup>10</sup>

We also studied Thyrosternal distance (TSD) and found its Sensitivity and Positive Predictive Value came to be 0%. We found the specificity and Negative Predictive value of the test to be 97.75% and 88.78%, respectively. So it appears that TSD has a poor sensitivity and Positive Predictive value and hence a bad predictor of difficult intubation as a screening test.

Mandibular length had the Sensitivity, Specificity, Positive Predictive Value and Negative Predictive Value of 18.18%, 98.88%, 66.67% and 90.72%, respectively. E Allahyary et al<sup>9</sup> also studied Mandibular length along with other five parameters and found the sensitivity to be 62.2% which was comparatively higher as compared to our study result. Specificity of their study was 43.14% which was quite low as compared to our study. The positive predictive value and negative predictive value of were 19.7% and 83.7%. The difference in the finding might be due to difference in the population composition.

In our study, we found the sensitivity of ULBT to be higher compared to HMD, STD and ML. Sensitivities of ULBT, HMD, TSD and ML were 45.45%, 9.09%, 0% and 18.18%, respectively. Thus the overall sensitivity of ULBT is low but it is better than other tests compared in our study. The specificity

of ULBT, HMD, TSD and ML were 100%, 97.75%, 97.75% and 98.88%. Thus we found a very a specificity of all the tests but even in them ULBT had the highest specificity of 100%, which means the predictions on the basis of ULBT were every time correct. The high specificity of ULBT means it is a good test to predict easy intubations. So, comparing the above parameters, ULBT comes out to be a better predictor of Difficult Intubation over HMD, TSD and ML. Also we found out that ULBT is easy to perform and very convenient to use as a bedside test. The classes are clearly demarcated making inter observer variability highly unlikely while using this test. But, during the study, we found that repeated demonstrations were required for patients to perform ULBT and a few failed to understand the procedure inspite of our repeated efforts. Another interesting observation was the reflex movement of the upper lip in the reverse direction over the upper teeth. This movement may alter the point of meeting of vermilion line with the lower incisors. So, proper explanation and comfortable environment are required for the patients to be cooperative to do the test. However, ULBT on its own fails to take into account relative tongue and pharyngeal size, mandibular space and a narrow high arched palate. Also, ULBT requires patient's cooperation, ability to move the teeth and the presence of teeth.

## CONCLUSION

Though, ULBT appears to be better amongst the four tests, none of them is a foolproof test. None of them can be used as a reliable screening test as no one had a sensitivity even more than 50%. So, negative test doesn't rule out a difficult intubation and we need to be prepared with the Difficult Intubation cart all the time.

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