

**ORIGINAL RESEARCH**

# A prospective observational study to predict difficult endotracheal intubation using non-invasive tests

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## ABSTRACT

**Background:** Airway management is a fundamental aspect of anaesthetic practice. Difficult airway is considered as a nightmare. Failure to secure a definitive airway has led to catastrophic consequences. Such events are preventable with an adequate assessment, orientation, systematic preparedness. Cormack & Lehane's grading of direct laryngoscopic view is considered as benchmark for grading of difficult intubation. Taking Cormack & Lehane grading system to assess difficult intubation we evaluated few non-invasive tests as predictors of difficult airway. So we decided to conduct a prospective observational study, comparing the simple bedside screening tests that can help to accurately predict difficult endotracheal intubation. **Materials & Methods:** After obtaining institutional ethical committee clearance and written informed consent from every patient, a total of 362 patients were recruited as per the predetermined inclusion and exclusion criteria in this study. Preoperatively airway was assessed by Investigator in terms of Mallampatti score, ratio of height to thyromental distance, inter-incisor gap, upper lip bite test and hyomental distance and documented. And direct laryngoscopy was done by senior anaesthesiologist who was not apprised of the pre-operative measurements of the study tests during induction of anaesthesia and was graded according to Cormack & Lehane classification. The ability of the test to predict difficult intubation was calculated in terms of sensitivity, specificity, positive and negative predictive value and eventually accuracy of the tests were calculated. Statistical analysis was performed using SPSS Version 15.0. **Results:** Incidence of difficult intubation was 4.7% defined by Cormack & Lehane grade 3 and 4. RHTMD had the best 70.58% sensitivity, 99.13% specificity, 80.00% positive predictive value, 98.55% negative predictive value. With overall accuracy of 97.79%. Where as other non-invasive tests showed a better specificity and negative predictive value than sensitivity and positive predictive value. **Conclusion:** Ratio of height to thyromental distance was found to be better predictor of difficult endotracheal intubation. And the rest other non-invasive tests were not a better predictor of difficult intubation.

**Key words:** Difficult endotracheal intubation, non-invasive tests, thyromental distance

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## INTRODUCTION

Airway management is of prime importance to the Anesthesiologist. For securing airway, tracheal intubation using direct laryngoscopy remains the method of choice in most of the cases. No anesthetic is safe unless diligent efforts are made to secure and maintain an intact airway. Difficult airway is a potentially catastrophic incident. Difficult laryngoscopy and intubation causes increased risk of complications to the patient ranging from sore throat to airway trauma. In some cases, if anesthesiologist is not able to maintain a patent airway, it may lead to serious complications like hypoxic brain damage or death. Of all the anaesthetic deaths, 30% to 40% are

attributed to the inability to manage a difficult airway.<sup>1</sup>

Of the overall claims against anesthesiologist in closed claim projects, 17% involved difficult or impossible

intubation.<sup>2</sup> Although oxygenation/ventilation is always the primary goal in the management of a difficult airway, tracheal intubation remains the gold standard in securing the airway as it is the definitive airway, protecting the respiratory tract from aspiration.

The difficulty of tracheal intubation has been related with the direct laryngoscopic view classified by Cormack and Lehane (grades 1-4).<sup>3</sup> Many studies concluded that, laryngoscopy and intubation are

considered difficult in patients with a laryngoscopic view of Cormack-Lehane grade 3 or 4. <sup>4</sup>The reported incidence of difficult direct laryngoscopy ranges between 1.5% and 8.5% in patients receiving general anaesthesia. <sup>5</sup>The incidence of difficult intubation was 5.8% for the overall patient population<sup>4</sup>, in a meta-analysis of Shiga *et al.*

Failure to achieve endotracheal intubation causes considerable morbidity and mortality in patients under anaesthesia. To avoid this, prior prediction of difficult endotracheal intubation is important for the anesthesiologist. There are various techniques for the prediction of difficult airway which can be invasive, non-invasive or radiological imaging techniques. Among these, invasive techniques are time consuming and inconvenient for the patients. Radiological imaging techniques are expensive and inconvenient for the patients.<sup>6</sup> Therefore, few non-invasive bedside tests to predict difficult intubation such as ratio of height to thyromental distance, Mallampati test, hyomental distance, interincisor gap, upper lip bite test etc. are easy and informative and also carry no extra cost to the patients & also need little patient co-operation.

The aim of the present study is to assess certain anatomic features of the airway that can be measured pre-operatively with minimal patient co-operation and to evaluate their diagnostic value in predicting difficult direct laryngoscopy and endotracheal intubation.

## METHODOLOGY

### STUDY POPULATION

- The study included both rural and urban population, who met inclusion criteria.

### SAMPLE SIZE

- We have taken 362 cases in our study

## METHODOLOGY

After obtaining the approval from ethical committee, we identified patients posted for elective surgery under general anaesthesia with endotracheal intubation.

This was a prospective observational study. The details of four study were explained to the patient, in the language understood by them. Consent was obtained for airway assessment. Patient's identity and data collected was kept confidential.

All patients included in this study underwent a routine pre-anesthetic check up.

Airway assessment was done by Modified Mallampati test, Upper lip bite test, Hyomental distance, Inter incisor gap and Ratio of height to thyromental distance.

## INCLUSION CRITERIA

- Age Group  $\geq 18$  years and  $\leq 70$  years.
- ASA Grade I & II.
- Elective surgery under general anaesthesia requiring endotracheal intubation.

- Patients of either sex.

## EXCLUSION CRITERIA

- Edentulous patients.
- ASA grade III & IV.
- Patient refusal.
- Altered level of consciousness, unable to follow command.
- Inability to open the mouth.
- Pregnancy.
- Cervical spine pathology or limited movement of neck.
- Obesity (BMI  $> 30$  kg/m<sup>2</sup>).
- Oral/laryngeal tumour.
- Preexisting neck or facial deformity causing distortion of airway anatomy.
- Psychiatric illness.

The following five predictive test measurements were performed on each patient:

1. **MODIFIED MALLAMPATI TEST (MMT):** (Figure: 3, 16) Samsoon and Young's modification of the Mallampati test recorded oropharyngeal structures visible upon maximal mouth opening, with the patient in the upright position <sup>[10, 18, 61]</sup>.
  - a) **GRADE 1:** Faucial pillars, soft palate and uvula visible.
  - b) **GRADE 2:** Faucial pillars, soft palate visible, but uvula masked by the base of the tongue.
  - c) **GRADE 3:** Soft palate only visible.
  - d) **GRADE 4:** Soft palate not visible.
2. **RATIO OF HEIGHT TO THYROMENTAL DISTANCE (RHTMD):** Height of patient was measured in centimeters. The distance from the thyroid cartilage to the mental prominence with the neck fully extended and mouth closed was also taken. The ratio of height to thyromental distance was then calculated.
  - **GRADE 1:**  $< 23.5$ .
  - **GRADE 2:**  $> 23.5$ .
3. **HYOMENTAL DISTANCE:** Distance between mentum to hyoid bone
  - **Grade I:**  $> 6$  cm.
  - **Grade II:** 4-6 cm.
  - **Grade III:**  $< 4$  cm.
4. **INTERINCISOR GAP (IG):** Distance between the upper and lower incisors, measured with a pair of calipers, with the patient sitting in the neutral position and mouth maximally open.
  - **GRADE 1:**  $> 4$  cm
  - **GRADE 2:**  $\leq 4$  cm

**5. UPPER LIP BITE TEST (ULBT)****CLASS I:** Lower incisors can bite the upper lip above the vermilion line.**CLASS II:** Lower incisors can bite the upper lip below the vermilion line.**CLASS III:** The lower incisors fail to bite the upper lip.

(ULBT Class II and III are considered as difficult intubation).

**RESULTS****Table 1: Age wise distribution of patients in study population**

Age (Yrs)	No. of Patients	Percentage
<20	13	3.6
21 - 30	95	26.2
31 - 40	100	27.6
41 - 50	52	14.4
51 - 60	46	12.7
61 - 70	56	15.5
Total	362	100

Mean=40.86, SD=14.59, Minimum=19, Maximum=70

Above table shows age wise distribution of Patients. Out of 362 cases 13(3.6%) cases were  $\leq$  20 years, 95 (26.2%) cases were between age group of 21 to 30years. 100 (27.6%) cases were between age group

of 31 to 40 years, 52 (14.4%) cases were between age group of 41 to 50 years, 46 (12.7%) cases were between age group of 51 to 60 years, 56 (15.5%) cases were between age group of 61 to 70 years.

**Table 2: Gender wise distribution of patients in study population**

Gender	No. of Patients	Percentage
Male	202	55.8
Female	160	44.2
Total	362	100

Above Table shows gender wise distribution of cases. 202 (55.8%) patients were males and 160 (44.2%)

were females.

**Table 3: ASA grade wise distribution of patients in study population**

ASA grade	No. of Patients	Percentage
I	200	55.2
II	162	44.8
Total	362	100

200 Patients (55.2%) belonged to ASA class 1 and 162 Patients (44.8%) belonged to ASA class 2.

**Table 4: Sensitivity, Specificity, Positive predictive value, Negative predictive value and accuracy of airway parameters examined**

Airway parameters	Sensitivity	Specificity	Positive predictive value	Negative predictive value	Accuracy
MMC	64.71%	92.75%	30.56%	96.16%	91.44%
ULBT	41.18%	98.26%	53.85%	97.13%	95.58%
RHTMD	70.59%	99.13%	80.00%	98.56%	97.79%
IIG	58.82%	97.68%	55.56%	97.97%	95.86%
HMD	11.76%	98.55%	28.57%	95.77%	94.48%

**Table 5: Comparison of various airway assessment tests**

Criteria	Order of various airway assessment tests
Sensitivity	RHTMD>MMC>IIG>ULBT>HMD
Specificity	RHTMD>HMD>ULBT>IIG>MMC
PPV	RHTMD>IIG>ULBT>HMD>MMC
NPV	RHTMD>MMC>IIG>ULBT>HMD
Accuracy	RHTMD>IIG>ULBT>HMD>MMC

It can be observed that Ratio of Height to Thyro-Mental Distance has highest sensitivity, specificity,

positive predictive value (PPV) and negative predictive value and Accuracy. Modified Mallapati

Test has highest sensitivity and Negative Predictive Value, but least Specificity and Positive Predictive Value.

## DISCUSSION

### MODIFIED MALLAMPATI TEST

The Modified Mallampati Test has been criticized over the years for various limitations. It has been mentioned that the demarcation between classes II & III is unclear. It has also been pointed out that this test has a high inter-observer variability and a large number of false positives. Another limitation is that many patients involuntarily tend to phonate which affects the classification. Despite all its shortcomings, the MMT is still the most routinely used bedside test for the prediction of difficult intubation.

We evaluated the sensitivity, specificity, positive predictive value, negative predictive value & accuracy of Mallampati test by correlating it with Cormack and Lehane.

The association between MODIFIED MALLAMPATI TEST and CORMACK AND LEHANE Classification was done as per Fisher's exact test ( $P < 0.001$ ).

Sensitivity of MMT to predict difficult airway (CL CLASS 3 & 4) in our study was 64.71% which correlates with the study of Savva D *et al.*,<sup>7</sup> (1994) (64.7%), and Mohammadreza Safavi<sup>8</sup> (2014) (63.64%). It is slightly more than the study of Randell T *et al.*, (1996) (42%).<sup>9</sup>

Specificity of MMT in our study was observed to be 92.75% which correlates with the study of Merah NA.<sup>10</sup> It is more than E Allahyary *et al.*, (2008) (29.7%)<sup>11</sup>. This study was done in obstetric patients which might be one of the reason for variation.

Positive predictive value of MMT in our study was observed to be 30.56% which correlates with the study of Muhammad Asghar Ali *et al.*, (2012) (33.3%)<sup>12</sup>. It is less than the study of Merah NA<sup>10</sup>.

Negative predictive value was found to be 96.16% which correlates with the study of Khan Z H *et al.*, (2009) (95%).<sup>13</sup>

Khan Z H *et al.*, (2009) had done a prospective study. The negative predictive value of MMT was 95% and this is correlates with our study.

### UPPER LIP BITE TEST

The ULBT is classified according to the ability of the lower teeth to bite the upper lip. The ULBT not only takes into account the presence of buck teeth but also the range and freedom of movements of the mandible. Moreover, the 3 classes are clearly demarcated, making inter-observer variability highly unlikely.

We evaluated the sensitivity, specificity, positive predictive value, negative predictive value & accuracy of upper lip bite test by correlating it with Cormack and Lehane.

The association between UPPER LIP BITE TEST and CORMACK AND LEHANE Classification was done as per Fisher's exact test ( $P < 0.001$ ).

Sensitivity of ULBT to predict difficult airway (CL CLASS 3 & 4) in our study was 41.18% which is in correlation with the study of Mohammadreza Safavi *et al.*, (2011)<sup>8</sup> (47.1%). It is less than the study done by Khan *et al.*, (2009) (95%)<sup>13</sup>.

Specificity of ULBT in our study was found to be 98.26% which is in correlation with the study of Khan *et al.*, (2003) (91%).

Positive predictive value of ULBT was observed to be 53.85% which is quite similar to the study done by Zahid Khan *et al.*, (2013) (48%).<sup>13</sup> It is less than study done by Muhammad Asghar Ali *et al.*, (2012) (71.6%).<sup>12</sup>

Negative predictive value was found out to be 97.13% which is in correlation with the study of Muhammad Asghar Ali *et al.*,<sup>12</sup> (2012) (97.3%), and Khan *et al.*, (2009) (95%).<sup>13</sup>

Khan Z H *et al.*, in 2009, conducted a prospective study to test the diagnostic value of the upper lip bite test combined with sternomental distance, thyromental distance, and interincisor distance for prediction of easy laryngoscopy and intubation. Laryngoscopic view according to the Cormack and Lehane grading system was determined after induction of anesthesia and Grades 3 and 4 defined as "difficult intubation." The accuracy of ULBT was (91.05%), which is in correlation with our study (95.58%).<sup>13</sup>

In 2012, Muhammad Asghar Ali, Muhammad Qamar-ul-Hoda *et al.*, determined the accuracy of the Upper lip bite test and Mallampati test in predicting difficult endotracheal intubation. Laryngoscopic view was rated by using Cormack and Lehane laryngoscopic grading once the patient was fully anaesthetised using standard anaesthesia technique. Completed data sheets were analysed using SPSS version 10. Mc Nemar test and rank correlation coefficient were used to compare the upper lip bite test and the Mallampati test. They observed sensitivity (87.5%, 19.9%), specificity (92.9%, 91.8%), positive predictive value (71.6%, 33%) and negative predictive value (97.3%, 84.6%) of ULBT and MMC respectively.<sup>12</sup>

### RATIO OF HEIGHT TO THYROMENTAL DISTANCE

Thyromental distance was used for predicting difficult intubation from earlier days but its value as an indicator of difficult intubation was questionable, as it varies with patient size and body proportions. The RHTMD is based on precise measurement of patient's TMD and height, so making inter observer variations highly unlikely. The RHTMD has some limitations forces it depends on accurate measurement of patient's TMD and height. Also, the cutoff point of RHTMD for prediction of difficult laryngoscopy is race dependent. Ideally cut off points should be calculated separately for each population.

We evaluated the sensitivity, specificity, positive predictive value, negative predictive value & accuracy

of ratio of height to thyromental distance by correlating it with Cormack and Lehane.

The association between RATIO OF HEIGHT TO THYROMENTAL DISTANCE and CORMACK AND LEHANE Classification was done as per Fisher's exact test ( $P < 0.001$ ).

Sensitivity of RHTMD to predict difficult airway (CL CLASS 3 & 4) was 70.59% which is in correlation with the study of Mohammadreza Safavi *et al.*, (2011) (75.6%).<sup>8</sup>

Specificity of RHTMD to predict difficult airway (CL CLASS 3 & 4) in our study was found out to be 99.13%.

Positive predictive value of RHTMD to predict difficult airway (CL CLASS 3 & 4) in our study was found out to be 80.00%.

Negative predictive value of RHTMD to predict difficult airway (CL CLASS 3 & 4) in our study was found out to be 98.55% which is in correlation with the findings of Chara L *et al.*, (2014) (95.2%).<sup>14</sup>

Mohammadreza Safavi *et al.*, in 2011 conducted a comparative study of the ratio of patient's height to thyromental distance with the Modified Mallampati and the upper lip bite test in predicting difficult laryngoscopy. The laryngoscopy and grading (as per Cormack and Lehane's classification) was done by an experienced anaesthesiologist. Sensitivity for RHTMD obtained was 75.6% which is in correlation with our study.<sup>8</sup>

Chara L *et al.*, in 2014 assessed the diagnostic value of tests based on neck anatomy in predicting difficult laryngoscopy. They studied thyromental distance (TMD), sternomental distance (STMD), ratio of height to thyromental distance (RHTMD) and neck circumference (NC). The laryngoscopic view was compared according to the Cormack-Lehane Grade (1-4). The authors found that RHTMD had highest sensitivity (90.72%), specificity (80.39%), positive predictive value (91.53%), and negative predictive value (78.8%), which correlates with our study.<sup>14</sup>

### INTER INCISOR GAP

The IIG (distance between the upper and lower incisors at the midline) was measured by asking each patient to open the mouth to the maximum extent.

We evaluated the sensitivity, specificity, positive predictive value, negative predictive value & accuracy of inter-incisor gap by correlating with Cormack and Lehane.

The association between INTERINCISOR GAP and CORMACK AND LEHANE Classification was done as per Fisher's exact test ( $P < 0.001$ ).

Sensitivity of IIG to predict difficult airway (CL CLASS 3 & 4) in our study was found out to be 58.82% which is in correlation with the findings of Srinivasa S, Vrinda Oza, Vasantha Kumar *et al.*, (2014) (60.0%). It is less than the findings of Cattano *et al.*, (2004) (70%).

Specificity of IIG in our study was found out to be 97.68% which is in correlation with the study of Merah NA, Wong DT.

Positive predictive value of IIG in our study was found out to be 55.56% which is in correlation with other studies.

Negative predictive value of IIG in our study was found out to be 97.97% which is in correlation with the study of Merah NA, Wong DT *et al.*

### HYOMENTAL DISTANCE

The HMD was measured in supine position with the head fully extended and with the mouth closed as the straight distance from the lower border of the mandibular mentum to the superior border of the hyoid bone in centimetres.

We evaluated the sensitivity, specificity, positive predictive value, negative predictive value & accuracy of hyomental distance by correlating it with Cormack and Lehane.

The association between HYOMENTAL DISTANCE and CORMACK AND LEHANE Classification was done as per Fisher's exact test ( $P = 0.038$ ).

Sensitivity of HMD to predict difficult airway (CL CLASS 3 & 4) in our study was found out to be 11.76%.

Specificity of HMD to predict difficult airway (CL CLASS 3 & 4) in our study was found out to be 98.55%.

Negative predictive value of HMD to predict difficult airway (CL CLASS 3 & 4) in our study was found out to be 95.77%.

Positive predictive value of HMD in our study was observed to be 28.57%.

Dr. Sumesh T. Rao *et al.*, in 2013, studied hyomental distance ratio as a diagnostic predictor of difficult laryngoscopy. The study has been done to evaluate the usefulness of the Hyomental Distance Ratio (HMD) for accurately predicting difficult visualization of the larynx (DVL) in apparently normal patients in comparison with other predictors. Glottic visualisation was assessed by using modified Cormack and Lehane's classification without external laryngeal manipulation. The sensitivity of HMDR for predicting Difficult Laryngoscopy was 27.78% and specificity was 98.89%. The test has a Negative predictive value of 93.19%. This is in correlation with our study.<sup>15</sup>

In 2009 Huh J, evaluated the usefulness of the hyomental distance (HMD) ratio (HMDR), defined as the ratio of the HMD at the extreme of head extension to that in the neutral position, in predicting difficult visualization of the larynx (DVL) in apparently normal patients. They examined the following preoperative airway predictors, alone and in combination: the modified Mallampati test, HMD in the neutral position, HMD and thyromental distance at the extreme of head extension and HMDR. DVL was defined as a Grade 3 or 4 view. The HMDR with the optimal cutoff point of 1.2 had greater diagnostic accuracy than other single predictors, and it alone

showed a greater diagnostic validity profile (sensitivity, 88%; specificity, 60%) than any other test combinations.<sup>16</sup>

## CONCLUSION

1. No single bedside airway parameters can accurately predict difficult intubation.
2. All the studied bedside tests are poor to moderate predictor of a difficult intubation.
3. Among the tests performed in this study, RHTMD was found to have highest Sensitivity, Specificity, Positive predictive value and Negative predictive value, indicating that it might be a better predictor of difficult intubation if used alone.
4. Except RHTMD all the tests had poor Positive Predictive Value and high Negative Predictive Value, suggesting that they can not be more useful predictor of difficult intubation.
5. Various combinations of these tests should be assessed and applied for better prediction of difficult intubation.

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