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**Research Article**

# Assessment of difficult airway predictors for predicting difficult laryngoscopy and intubation

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## Abstract

**Objectives:** The aims and objectives of this study was to study and compare the sensitivity, specificity, positive predictive value, negative predictive value, odds ratio, relative risk, likelihood ratio and accuracy of the following parameters, modified Mallampati grading, interincisor gap, thyromental distance (TMD), ratio of height to thyromental distance (RHTMD), sternomental distance, neck movements, mandibular length and mentohyoid distance for predicting difficult laryngoscopy and/or intubation.

**Methods**: A single blinded prospective observational study involving 100 patients of both gender between 20-70 years of age belonging to ASA physical status I, II and III scheduled to undergo elective surgery under general anaesthesia with endotracheal intubation were recruited for the study. All patients were subjected to the preoperative airway assessment and the above 8 airway parameters were recorded and analysed. The number of intubation attempts was noted. Use of intubation aids was also noted.

**Conclusion:** Upper lip bite test can be used as a simple bedside screening test for prediction of difficult laryngoscopy/intubation but it should be combined with other airway assessment tests. RHTMD is a more accurate test than TMD. Inspite of various airway assessment tests no single test is 100% accurate. So it is advisable to use combination of different tests or the use various scoring systems for predict predicting difficult laryngoscopy/intubation.

**Keywords:** Difficult airway, general anaesthesia, endotracheal intubation

## 1. Introduction

Anaesthesia is a unique speciality. From the earliest period of our training, the importance of the airway is emphasized and every anaesthesiologist has felt the cold panic when he or she first realizes that usual anatomic structures cannot be visualized. In such situations a more scientific approach to airway evaluation and management becomes necessary. Some airway may be difficult to maintain under mask anaesthesia but are easily intubated, other airways are difficult to intubate but may be maintained with mask anaesthesia for the duration of operation and some are difficult to manage in both the aspects.[1]

The fundamental responsibility of anaesthesiologists is to maintain adequate gas exchange.[2] Therefore the airway must be managed in such a way that it is always patent. The risk of failed intubation is approximately 1 in 200 in the general population.[3] This risk is approximately 1:300 in the obstetric patient.[4] Inability to provide a life-sustaining amount of gas exchange in a situation in which neither ventilation by mask nor intubation can be achieved is responsible for up to 30% of deaths totally attributable to anesthesia.[5,6] This makes it the most important cause of major anaesthesia related morbidity and mortality. There are several studies comparing different airway parameters with varying results. There is no single airway assessment test which can alone predict difficult laryngoscopy/ intubation. In our study we compared various predictors of difficult laryngoscopy/intubation in an attempt to find out the best possible difficult airway predictor.

The aims and objectives of this study was to study and compare the sensitivity (Sn), specificity (Sp), positive predictive value (PPV), negative predictive value (NPV), odds ratio (OR), relative risk (RR), likelihood ratio (LHR) and accuracy for the following parameters, modified Mallampati grading ( MPG), interincisor gap (IIG), thyromental distance (TMD), ratio of height to thyromental distance (RHTMD), sternomental distance (SMD), neck movements, mandibular length (ML), mentohyoid distance (MHD) for predicting difficult laryngoscopy and/or intubation.

## 2. Material and methods

The present study was carried out in P.D.U. Medical college, Rajkot during the year 2012-13 after institutional ethical committee approval (ethical committee approval no. PDUMCR/IEC/21818/2013, dated 21/10/2013) and written informed consent, 100 patients of both gender between 20-70 years of age belonging to ASA physical status I, II and III scheduled to undergo elective surgery under general anaesthesia with endotracheal intubation were recruited for the study. It was a single blinded prospective observational study. Patients with neck burns contracture, midline neck swelling, intraoral surgery, emergency surgical procedure, pregnant patients, edentulous patients, age < 18 years, obvious malformations of the airway, limitation of temporomandibular /atlantoaxial joint mobility and history of neck surgery were excluded from the study.

All patients were subjected to the preoperative airway assessment by the same anaesthesiologist to avoid inter observer variability. The parameters which were measured & their cut off value for difficult laryngoscopy and intubation include patient weight (kgs), patient height (meters), Body mass index ($kg/m^2$), Mallampati classification (III), upper lip bite test (II, III), interincisor gap (cms): $\leq$ 3.5 cm, thyromental distance (cms): $\leq$ 6 cm, ratio of height to thyromental distance (RHTMD): $\geq$ 23.5, sternomental distance (cms): $\leq$ 12.5 cm, horizontal length of mandible (cms): < 9 cm, mentohyoid distance (cms): < 4 cm, buck teeth : present / absent and neck extension : $\leq 80^0$.

All patients were advised nil by mouth for 10 hours. After taking patients preoperative vitals a standard anaesthetic protocol was followed. Premedication was given with inj. glycopyrollate 0.004 mg/kg, ondansetron 0.8 mg/kg, ranitidine 1 mg/kg and inj. fentanyl 1 mcg/kg i.v. Preoxygenation was done with 100% $O_2$ for 3 minutes. Induction was done with inj. thiopentone 5mg/kg i.v. after checking mask ventilation inj. succinylcholine 1.5 mg/kg i.v was given. After ventilating for 1 min patient was put in ideal intubating position. Laryngoscopy was done,

Cormack and Lehane laryngoscopic view was noted. Then number of intubation attempts was noted. Use of intubation aides like stylet, bougie, and laryngeal mask airway was noted. Patient vitals were monitored intraoperatively & in the postoperative period.

We used Fisher's exact test for statistical analysis and P value ≤ 0.05 was considered statistically significant. All statistical analysis was done using GraphPad Prism 6.

## 3. Results

**Table 1: Demographic characteristics**

| | **Mean ± SD** |
|---|---|
| Age (years) | 41.4± 14 |
| Weight (kgs) | 60.1± 13.8 |
| Height (metres) | 1.58± 0.08 |
| Body mass index (kg/m$^2$) | 24.1± 5.09 |

**Table 2: Percentage of easy and difficult intubation**

| Intubation predicted | | Actual outcome | |
|---|---|---|---|
| Easy | Difficult | Easy | Difficult |
| 21 | 79 | 65 | 35 |

**Table: 3: shows sensitivity, specificity, positive predictive value, negative predictive value, relative risk, Odds ratio**

| **Airway parameters** | **Sn (%)** | **Sp (%)** | **PPV (%)** | **NPV (%)** | **RR** | **OR** | **95% CI** | **LHR** | **P value** | **Accuracy** |
|---|---|---|---|---|---|---|---|---|---|---|
| MPG III/IV | 68.57 | 60 | 48 | 78 | 2.2 | 3.27 | 1.37-7.80 | 1.71 | 0.0113 | 63 |
| ULBT III | 77.14 | 98.46 | 96.43 | 88.89 | 8.67 | 216 | 25.73-181 | 50.1 | < 0.0001 | 91 |
| IIG ≤ 3.5 cm | 60 | 75.38 | 56.76 | 77.78 | 2.55 | 4.5 | 1.9-11.09 | 2.43 | 0.001 | 70 |
| TMD ≤ 6.5 cm | 71.43 | 90.77 | 80.65 | 85.51 | 5.56 | 24.5 | 8.05-74.99 | 7.73 | < 0.0001 | 84 |
| RHTMD ≥ 23.5 | 74.29 | 93.85 | 86.67 | 87.14 | 6.74 | 44 | 12.44-156 | 12 | < 0.0001 | 87 |
| SMD ≤ 12.5 cm | 57.14 | 84.62 | 66.67 | 78.57 | 3.1 | 7.33 | 2.83-18.96 | 3.71 | < 0.0001 | 75 |
| ML < 9 cm | 45.71 | 76.92 | 51.61 | 72.46 | 1.8 | 2.8 | 1.16-6.77 | 1.98 | 0.0246 | 66 |
| MHD < 4 cm | 31.43 | 87.69 | 57.89 | 70.37 | 1.95 | 3.26 | 1.16-9.13 | 2.55 | 0.0312 | 68 |
| NE ≤ 80$^0$ | 17.14 | 86.15 | 40 | 65.8 | 1.17 | 1.28 | 0.41-3.97 | 1.23 | 0.77 | 62 |

**Table 4: Comparison of various airway assessment tests**

| **Criteria** | **Order of various airway assessment tests** |
|---|---|
| Sensitivity | ULBT>RHTMD>TMD>MPG>IIG>SMD>ML>MHD>NE |
| Specificity | ULBT>RHTMD>TMD>MHD>NE>SMD>ML>IIG>MPG |
| PPV | ULBT>RHTMD>TMD>SMD>MHD>IIG>ML>MPG>NE |
| NPV | ULBT>RHTMD>TMD>SMD>MPG>IIG>ML>MHD>NE |
| Relative risk | ULBT>RHTMD>TMD>SMD>IIG>MPG>MHD>ML>NE |
| Odds ratio | ULBT>RHTMD>TMD>SMD>IIG>MPG>MHD>ML>NE |
| Likelihood Ratio | ULBT>RHTMD>TMD>SMD>MHD>IIG>ML>MPG>NE |
| Accuracy | ULBT>RHTMD>TMD>SMD>IIG>MHD>ML>MPG>NE |

Table 1 shows distribution of demographic characteristics. Mean age was 41 years and Sex ratio was almost equal. Mean weight was 60kg and mean height was 1.58 meters. Mean Body mass index was 24 Kg/m$^2$. We found no correlation between demographic data (patient's age, weight and Body mass index) and the incidence of difficult intubation in the present study.

Table 2 shows distribution/percentage of difficult intubation in the study. We found that 35 patients had difficult intubation out of 79 patients who were predicted to have difficult laryngoscopy and intubation.

Table 3 shows sensitivity, specificity, positive predictive value, negative predictive value, relative risk, Odds ratio, 95% confidence interval, likelihood ratio, p value and accuracy of above 9 airway parameters. The p value was found to be significant with MPG, IIG, TMD, RHTMD, SMD, ML, and MHD except in neck extension where it was statistically insignificant. Upper lip bite test was found to be highly accurate test.

Table 4 shows comparison of various airway assessment tests. Upper lip bite test showed highest sensitivity, specificity, positive predictive value, negative predictive value, relative risk, Odds ratio, likelihood ratio and accuracy followed by RHTMD and TMD. Mallampati test showed lowest specificity. Neck extension showed lowest sensitivity, positive predictive value, negative predictive value, relative risk, Odds ratio, likelihood ratio and accuracy.

## 4. Discussion

Most life threatening clinical problems that involve a difficult airway occur infrequently. A difficult intubation occurs in approximately one in 200 patients in the general surgical population[3], but one in 300 obstetric patients.[4]

The demographic characteristics in the present study was comparable to studies done by Krobbuaban *et al*[8], Leopold *et al*[10], Krishna *et al*[11]and Huh *et al*.[14] Safavi *et al*[17] in their study found significant correlation between old age, obesity, high BMI with the incidence of difficult intubation in contrast to the present study.

In the present study – The sensitivity, specificity, positive predictive value and negative predictive value of modified Mallampati test were 68.57%, 60%, 48%, 78% respectively. We found low sensitivity, specificity & PPV, with an acceptable NPV. The present study was comparable to the studies done by Krobbuaban *et al*[8], Leopold *et al*[10] and Krishna *et al*[11] on Mallampati score.

In the present study – The sensitivity, specificity, positive predictive value and negative predictive value of inter-incisor gap were 60%, 75.38%, 56.76%, 77.78% respectively. We found low sensitivity, PPV and an acceptable specificity, NPV. The sensitivity was less than MPG but specificity is more than MPG. The present study was comparable to the studies done by Krobbuaban *et al*[8] and Khan *et al*.[13]

The ULBT, evaluates a combination of jaw subluxation and the presence of buck teeth concurrently. The ULBT score of predicting difficult laryngoscopy has also some limitations. It is not appropriate for edentulous patients. In addition, the anthropological literature emphasized that there is ethnic variation in craniofacial configuration of populations. In the present study- The sensitivity, specificity, positive predictive value and negative predictive value of Upper lip bite test were 77.14%, 98.46%, 96.43%, 88.89% respectively. We found that ULBT has highest sensitivity, specificity, positive predictive value & negative predictive value when compared to the MMT, IIG, TMD, RHTMD, SMD, HMD, ML and neck extension in the study. The ULBT has also shown highest relative risk, odds ratio, likelihood ratio and accuracy (91%). The p value was highly significant (< 0.0001). The present study was comparable to the studies done by Leopold *et al*[10] and Khan *et al*.[16]

In the present study – The sensitivity, specificity, PPV and NPV of TMD were 71.43%, 90.77%, 80.65%, 85.51% respectively. The sensitivity was more than MMT but less than RHTMD. The p value was statistically highly significant (< 0.0001). The present study was comparable to the studies done by Krishna *et al*[11], Khan *et al*[13] and Krobbuaban *et al*.[8]

Thyromental distance was used for predicting difficult intubation from earlier days but it's value as an indicator of difficult intubation was questionable, as it varies with patient size and body proportions.[12] The RHTMD is based on precise measurement of patient's TMD and height, so making inter observer variations highly unlikely (on the contrary to significant inter observer variations found with the MMT).The RHTMD has some limitations, 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. So cut off points should be calculated separately for each population.[17] The sensitivity, specificity, PPV and NPV of RHTMD were 74.29%, 93.85%, 86.67%, 87.14% respectively and were greater than respective parameters of TMD but less than ULBT. This was comparable to the studies done by Krobbuaban *et al*[8], Safavi *et al*[17] and Shah *et al*.[18]

SMD can be an indicator of head and neck mobility.[9] In the present study- The sensitivity, specificity, PPV and NPV were 57.14%, 84.62%, 66.67%, 78.57% respectively. The present study was comparable to the studies done by Savva[7] and Khan *et al*.[13]

The sensitivity, specificity, PPV and NPV of ML were 45.71%, 76.92%, 51.61%, 72.46% respectively. The Sensitivity was quite low. The accuracy of the test was 66%. The p value was found to be statistically significant (0.024). The present study was comparable to the study done by Khan ZH *et al*[16] in 2011. They concluded that ML < 9 cm as a marker of a potentially difficult intubation and ML > 9 cm as a good predictor of negative difficult intubation. The sensitivity, specificity, PPV and NPV of HMD were 31.43%, 87.69%, 57.89%, 70.37% respectively. The Sensitivity was low but has high specificity. The accuracy was 68%. The p value was statistically significant (0.031). The present study was comparable to the study done by Khan ZH *et al*[16] in 2011. They concluded that HMD < 3.5 cm as a marker of a potentially difficult intubation and HMD > 3.5 cm as a good predictor of negative difficult intubation.

Limited Neck extension hinders the proper alignment of three axis making laryngoscopy and intubation difficult. It was measured using goniometer in our study. In the present study sensitivity, specificity, PPV and NPV were 17.14%, 86.15%, 40% and 65.8% respectively. The accuracy was 62%. We found that limited neck extension has least sensitivity, PPV, NPV, relative risk, Odds ratio, likelihood ratio and accuracy when compares to all the remaining 7 airway predictors used in the study. The specificity was quite high. The p value was found to be statistically insignificant (0.77). The present study was comparable to the studies done by Orozco-Diaz *et al*[15] and Krobbuaban *et al*.[8]

## 5. Conclusion

Based on the results of the study, the following conclusions were drawn:

- The Upper lip bite test has highest Sensitivity, specificity, PPV, NPV, odds ratio, relative risk, likelihood ratio and accuracy. So ULBT can be used as a simple bedside screening test for prediction of difficult laryngoscopy/ intubation but it should be combined with other airway assessment tests.
- RHTMD is a more accurate test than TMD and probably the 2nd important test for prediction of difficult laryngoscopy/ intubation.
- TMD is less accurate than RHTMD and probably the 3nd important test for prediction of difficult laryngoscopy/ intubation.
- MPG has moderate sensitivity and least specificity and should never be used as a single bedside screening test and it should be combined with other airway assessment tests for prediction of difficult laryngoscopy/ intubation.
- SMD and ML can be good predictors of difficult laryngoscopy/ intubation when combined with other airway assessment tests.
- Inspite of various airway assessment tests no single test is 100% accurate. So it is advisable to use combination of different tests or the use various scoring systems for predict predicting difficult laryngoscopy/ intubation.

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