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# A CORRELATION OF ULTRASONOGRAPHY-GUIDED VERSUS CLINICALLY MEASURED AIRWAY PARAMETERS IN PREDICTING DIFFICULT LARYNGOSCOPY – A PROSPECTIVE OBSERVATIONAL STUDY

Anaesthesiology

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## ABSTRACT

**Background and aims:** Airway management is one of the routine tasks in practicing anaesthesiologist life on a day-to-day basis ranging from intubation for elective surgical cases to emergency intubation for cardiac arrest patients. Ranging between 1.5- 13% is the incidence of unexpected difficult laryngoscopy and tracheal intubation. To determine whether skin to epiglottis thickness aids in predicting difficult laryngoscopy in patients with unanticipated difficult airway and to determine the correlation between ratio of height to thyromental distance and skin to epiglottis thickness. The study also focuses in predicting a cut off value of skin to epiglottis in the study population. **Methods:** After ethical approval and trial registration, 225 participants were enrolled in the study and ratio of height to thyromental distance and ultrasound guided skin to epiglottis distance were measured along with other airway parameters. The Pearson correlation test was used to corelate clinical and USG parameter in airway. The level of significance was set at $P < 0.05$ **Results:** Demographic data were equally distributed. All patients were successfully intubated in the study. The cut off value derived from ROC for US-SED was 2.45 cm with 82.2% sensitivity and 76.7% specificity. So above 2.45 cm one should anticipate difficult laryngoscopy. Cut-off value for RHTMD in predicting difficult laryngoscopy observed in our trial was > 24.7 but lacks greater sensitivity (57.8%) and specificity (69.4%). **Conclusion:** Cut off value of skin to epiglottis distance above which one can anticipate a difficult laryngoscopy is 2.45 cm Even though ratio of height to thyromental distance above 24.7 can predict difficult laryngoscopy, it lacks greater sensitivity and specificity

## KEYWORDS

## INTRODUCTION

Airway management is one of the routine tasks in practicing anaesthesiologist life on a day-to-day basis ranging from intubation for elective surgical cases to emergency intubation for cardiac arrest patients. Ranging between 1.5- 13% is the incidence of unexpected difficult laryngoscopy and tracheal intubation. This incidence can lead to morbidity and mortality and can compromise patient health care.

Prediction of a difficult laryngoscopy will help us to plan a safer technique to intubate a patient and also be more prepared to manage complications. The routine clinical assessment and the commonly used tests fail to predict this difficulty probably due to high interobserver variability, so this led to the path of combining both clinical and radiological assessment in terms of predicting difficult laryngoscopy and better outcome.

Ultrasound is a non-invasive, simple, portable tool that can be used in trauma, operating room, and critical care units to measure various airway parameters preoperatively for detecting incidence of difficult laryngoscopy. Various parameters like skin to epiglottis distance, hyo-mental distance, tongue thickness can be measured and helps in predicting difficult airways, through various values but not standardized yet.

The objectives of this study are to demonstrate the efficacy of combining clinical and radiological measures in forecasting difficult laryngoscopy and to obtain a threshold value for ultrasound guided pre-epiglottic space thickness in difficult laryngoscopy in our study population.

Airway is defined as "the passage through which the air passes during respiration."[1] Management of an airway is a vital skill in daily practice "especially for anaesthesiologists, critical care physicians and emergency physicians". [2]

The term "difficult airway" refers to a broad range of clinical situations, including difficulty or inability to intubate the trachea and difficulty or inability to provide mask ventilation. [3]. The ability to ventilate the patient with a sufficient chest rise and keep the oxygen saturation level above 90% is known as bag and mask ventilation.

When using conventional laryngoscopy, difficult laryngoscopy indicates the inability to visualise any part of the true vocal cords. [4]

Prevalence of difficult laryngoscopic intubation varies from 1.5 to 20% and unanticipated airway always remain a concern for the practicing anaesthesiologist.[5]

## METHODOLOGY

In this prospective observational study, we enrolled 225 patients after receiving approval from the institutional ethics committee and clinical trials registry.

**Study Period:** June 2021 – October 2022

**Study Setting:** Department of Anaesthesiology, KMC, Manipal

**CTRI No:** CTRI/2021/06/034008

### Inclusion Criteria

- Patients above the age of 18 scheduled for elective surgery under GA and endotracheal intubation
- Patients with ASA PS I–III (American Society of Anesthesiologists physical status)

### Exclusion Criteria

Patients

- Refused to take part in the study
- Anticipated difficult airway
- Age < 18 years
- Head and neck malignancy and diseases involving TMJ / C-spine
- Pregnant women
- Previous history of difficult airway from previous medical records

**OBSERVERS** There were three observers in our study

**Observer 1:**

Postgraduate in anaesthesiology, who performed the preoperative evaluation and clinical airway assessment including mouth opening, thyromental distance, modified Mallampati grading and ratio of height to thyromental distance along with baseline vitals one day before surgery, took informed written consent and also explained the study in a language which was understandable to the patient.

**Observer 2:**

Consultant, trained in airway ultrasound measured the skin to epiglottis thickness in the preoperative holding area

**Observer 3:**

Consultant anaesthesiologist who performed the laryngoscopy intraoperatively and assess the ease of laryngoscopy and intubation

On the day of surgery, after confirming the identity, NPO status and premedication, Observer 2 performed airway sonography in the preoperative room and measured the skin to epiglottis thickness by placing the linear probe transversely over the thyrohyoid membrane with neck in neutral position. Following USG evaluation, the patient was sent to the operating room, where the consultant anesthesiologist administered general anaesthesia as per standard protocol.

**Conduct of Anaesthesia**

Patients were continually monitored using an ECG, a pulse oximeter, a capnograph, and noninvasive blood pressure. IV fentanyl 2 mcg/kg was administered and 3 minutes of preoxygenation was done with 100% oxygen. 2.5 to 3 mg/kg of IV propofol was used for induction. The endpoint of induction was considered when verbal contact ceased. Adequacy of bag-mask ventilation was checked and Observer 1 will also document the following parameters

Ease of bag and mask ventilation (Han's and colleagues' grading) Use of airway adjuncts (Oropharyngeal, nasopharyngeal airway)

**Han's mask ventilation grading*** [6]

Grade 1 - Ventilated by mask
Grade 2 - Ventilated by mask plus oral airway ± muscle relaxant
Grade 3 - Difficult to mask ventilate despite above, "inadequate or requiring" two providers
Grade 4 - Unable to mask ventilate with or without the use of relaxants
Grade 3 & 4 represents difficult face mask ventilation

After confirming that the ventilation was adequate, 1.5%-2% isoflurane in oxygen was used to deepen the anaesthesia and reach a MAC of 1.2. Adequate neuromuscular blockade was achieved with IV vecuronium at a dose of 0.1 mg/kg. The ulnar nerve was stimulated using a peripheral nerve stimulator that was set up to deliver a train of four (TOF) stimulus at a 40-mA current. Ventilation was continued until the TOF count of zero was achieved. Study subjects underwent direct laryngoscopy using appropriate Macintosh laryngoscope blades, and observer 3 communicated the Cormack-Lehene grading to observer 1. Intubation was performed on both male and female patients using size 8 mm ID and size 7 mm ID portex ETT respectively.

**Observed Parameters**

- Patient's height (cm)
- Interincisor distance – Mouth opening (cm)
- Thyromental distance (cm) – A firm scale was used to measure the distance between the thyroid notch and the mentum while the subject was seated with their lips closed and their neck completely extended.

**Ratio of height to thyromental distance (RHTMD) = Height of the patient (cm)**
**Thyromental distance (cm)**

- Skin to epiglottis distance (cm) calculated using ultrasound and noted by observer 1.
- Inside the operating room, ease of bag mask ventilation, use of adjuvant airway devices, laryngoscopic view for intubation and use of stylet or bougie or change in airway management plan like use of video laryngoscope were also documented.

**Statistical Analysis**

Data were collected during study proforma and analysed by a biostatistician at the end of the study. Data entered in Microsoft Excel spread sheet, analyzed statistically using appropriate software SPSS20 (version 22 released in 2013).

All values were expressed in mean ± standard deviation. Independent student's t-test and Pearson correlation test were used to obtain the cut-off value and to establish correlation between RHTMD and US-SED respectively.

**RESULTS**

**A. Demographic data**

| Table 1: Patient Characteristics | | |
|---|---|---|
| Variable | Category | n = 225 |
| Age (Years) | ≤ 20 / 21-40 / 41-60 / > 60 | 11 / 75 / 103 / 36 |
| Gender | Males / Females | 102 / 123 |
| BMI Status (kg/m2) | Underweight/Normal / Overweight | 21 / 131 / 73 |
| ASA Status | PS I / PS II | 155 / 70 |

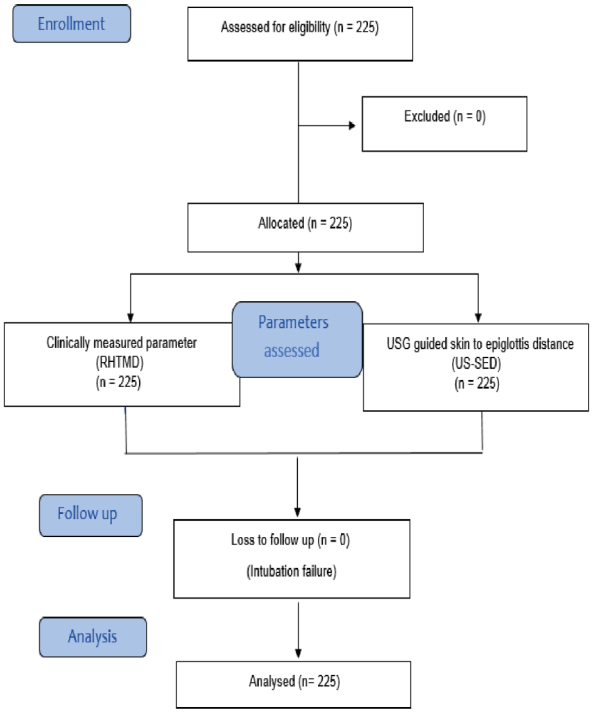



**Figure 1: CONSORT Flow diagram**
RHTMD – Ratio of height to thyromental distance
US-SED – Ultrasound guided skin to epiglottis distance

BMI – Body mass index, ASA PS – American society of Anesthesiologist physical status

The age, gender, body mass index (BMI) and ASA PS among the participants are displayed

**B. Distribution of airway parameters**

| Table 2: Distribution of Airway Parameters | | |
|---|---|---|
| Variable | Category | n = 225 |
| MMP Class | Class I / Class II / Class III | 34 / 138 / 53 |
| BMV Grade | Grade 1/ Grade 2/ Grade 3/ Grade 4 | 153 / 59 / 13/ 0 |
| Intubation Adjunct | Yes / No | 72 / 153 |
| Laryngoscopy | Easy / Difficult | 180 / 45 |
| Cormack-Lehane Grade | Grade 1/ Grade 2/ Grade 3/ Grade 4 | 80 / 100 / 45 / 0 |

The Mallampati class, bag mask ventilation grading, ease of laryngoscopy and Cormack-Lehane grading among the participants are displayed.

MMP – Modified Mallampati, BMV – Bag mask ventilation

**C. Clinical and USG measured airway parameters**

| Table 3: Clinical & USG parameters among the participants (n = 225) | | |
|---|---|---|
| Parameters | Mean | ± SD |
| Mouth Opening (cm) | 5.24 | 0.57 |
| Thyromental Distance (cm) | 6.67 | 0.62 |
| RHTMD | 24.15 | 2.35 |
| US-SED (cm) | 2.25 | 0.43 |

Mouth opening, RHTMD, Thyromental distance and US-SED are shown in Table 3. Data expressed as Mean ± SD.

RHTMD – Ratio of height to thyromental distance, US-SED – Ultrasound skin to epiglottis distance

**D. Comparison of Mean US-SED and RHMD on the ease of laryngoscopy**

| Table 4: Comparison of mean US-SED values based on the ease of laryngoscopy | | | | | | |
|---|---|---|---|---|---|---|
| Parameter | Laryngoscopy | n | Mean | SD | Mean Diff | p-value |
| US-SED (cm) | Easy | 180 | 2.16 | 0.42 | - 0.45 | < 0.001* |
| | Difficult | 45 | 2.61 | 0.21 | | |

* Independent student's t-test, statistically significant

Mean value of US-SED is 2.61 cm in 45 subjects with difficult laryngoscopy. Mean difference between easy and difficult laryngoscopy is -0.45 cm. Higher the mean difference higher is the significance of our study. P- value is statistically significant

Table 5 depicts mean value of RHMD - 25.19. Mean difference between easy and difficult laryngoscopy was – 1.30. Higher the mean difference higher is the significance, but the mean difference is less when compared to US-SED. P value is statistically significant.

| Table 5: Comparison of mean RHTMD values based on the ease of laryngoscopy | | | | | | |
|---|---|---|---|---|---|---|
| Parameter | Laryngoscopy | n | Mean | SD | Mean Diff | p-value |
| RHTMD | Easy | 180 | 23.89 | 2.23 | - 1.30 | 0.001* |
| | Difficult | 45 | 25.19 | 2.53 | | |

*Independent student's t-test, statistically significant

### E. ROC curve analysis for US-SED for determining predictive value for difficult laryngoscopy

Table 6 depicts the ROC curve analysis for US-SED for determining the predictive value for difficult laryngoscopy. Cut off value was > 2.45 cm with sensitivity of 82.2% and specificity of 76.7%.

| Table 6: ROC Curve analysis for US - SED values for determining the predictive value for difficulty laryngoscopy among study participants | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Variable | AUC | Std. Error | 95% Confidence Interval | | p-Value | Cut off | Sensitivity (%) | Specificity (%) |
| | | | Lower | Upper | | | | |
| US-SED | 0.82 | 0.03 | 0.77 | 0.87 | <0.001* | > 2.45 | 82.2 | 76.7 |

*Statistically Significant

### F. ROC curve analysis for RHTMD for determining predictive value for difficult laryngoscopy

Table 7 depicts the ROC curve analysis for RHTMD values for determining the predictive score for difficult laryngoscopy. Cut off value is > 24.7 with a sensitivity of 57.8% and specificity of 69.4%.

So, in our study, US-SED had higher sensitivity and specificity in predicting difficult laryngoscopy

| Table 7: ROC Curve analysis for RHTMD values for determining the predictive value for difficulty laryngoscopy among study participants | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Variable | AUC | Std. Error | 95% Confidence Interval | | P-Value | Cut off | Sensitivity (%) | Specificity (%) |
| | | | Lower | Upper | | | | |
| RHTMD | 0.65 | 0.05 | 0.59 | 0.71 | 0.002* | > 24.7 | 57.8 | 69.4 |

*Statistically Significant

### G. Correlation between RHTMD and US-SED analysis and scatter plot

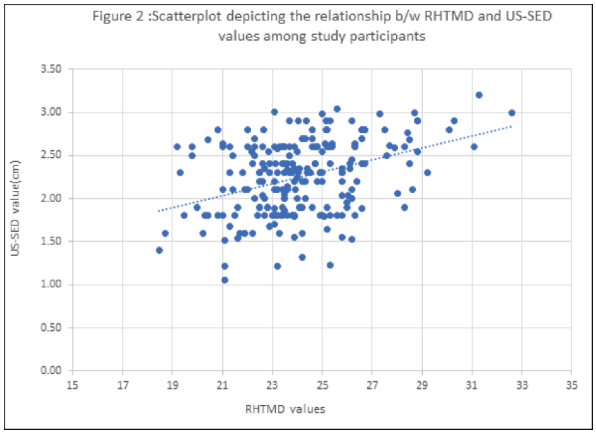
Table 8 depicts the correlation between US-SED and RHTMD. Indicated a weak correlation i.e., for every rise in RHTMD value by 1, it increases US-SED by 0.38 cm indicating a difficult laryngoscopy.

| Table 8: Correlation b/w RHTMD & US-SED among the participants | | |
|---|---|---|
| Parameter | US-SED (cm) | |
| | r | p-value |
| RHTMD | 0.38 | < 0.001* |

r – Pearson correlation coefficient, 0.21 – 0.40 denotes weak correlation

*Statistically Significant

On plotting both RHTMD on x-axis and US-SED on y-axis the values are scattered throughout the line of trend, indicating a weak correlation.




## DISCUSSION

Airway management in terms of endotracheal intubation and providing general anaesthesia is a daily routine in the life of an anaesthesiologist. Early identification of any difficult airway in the above-mentioned task enhances both patient safety and to plan airway management meticulously.1.5% - 13% of laryngoscopies and tracheal intubations are unexpectedly difficult. [1] Numerous airway parameters were assessed clinically and concluded that combination of various parameters helps in predicting difficult laryngoscopy and intubation but still a single best airway parameter for prediction of difficult laryngoscopy is doubtful because of lack of greater sensitivity and specificity. [7] Ultrasound, a simple, non-invasive tool started gaining importance in recent years and near future as a first line tool in difficult airway management. [8,9] Various individual USG airway parameters have studied in different clinical setting like skin to epiglottis distance, tongue thickness and anterior neck soft tissue and concluded with different values in predicting laryngoscopy but also added that clinical assessment is important. So, in our study we decided to analyse one clinically measured parameter ratio of height to thyromental distance (RHTMD) and ultrasound guided skin to epiglottis distance (US-SED). [10,11,12]

One of the reasons we developed our research idea and carried out our study was because Bajracharya GR et al., systematic search found that ultrasound has an additional benefit of real-time upper airway examination over CT or MRI. [13] In a different investigation, Hall et al., compared ultrasonography evaluation to BMI and Mallampati class and found that the measurements correlated with Mallampati rather than the patient's BMI. [14] So, in our study we decided to compare the relation between RHTMD and US-SED and their influence in routine practice in predicting difficult laryngoscopy.

We enrolled 225 participants without anticipated difficult airway in our study. Mean US-SED was 2.25 ± 0.43 cm (Table 3). All 225 study participants were intubated in first attempt of which 45 patients had difficult laryngoscopy (CL grade ≥ 3). In them mean US-SED was as high as 2.61 cm (Table 4). 6 A cut-off value of 2.54 cm was found by Falcetta et al.,[11] in 301 individuals with higher laryngoscopic grade. In a pilot study conducted by Adhikari et al [15] in 2011 measured different ultrasound neck parameters and concluded that a cut-off value 2.8 cm for US-SED in predicting higher grades of laryngoscopy but the major limitation was their smaller sample size (n = 51). In contrary to above findings Abdelhady BS et al., [16] found a cut-off value of 1.85 cm US-SED in Egyptian population for predicting difficult laryngoscopy and recommended that clinical judgement is also important along with ultrasound measurement. These varied values in predicting difficult laryngoscopy needs further studies with proper training in US measurement and uniformly designed protocol across the globe with recruitment involving all the population groups. Hopefully this can fetch a single best value in predicting higher laryngoscopy grade with greater sensitivity and specificity.

Mean RHTMD (n = 225) in our study was 24.15 ± 2.35 (Table 3). Forty-five subjects with higher laryngoscopic grade mean RTHMD was 25.19 (Table 5). Cut-off value for RHTMD in predicting difficult laryngoscopy observed in our trial was > 24.7 (Table 7) but lacks greater sensitivity (57.8%) and specificity (69.4%). In contrast, Kaniyil et al., concluded that a cut off value of 22.1 predicted difficult laryngoscopy among 300 individuals with higher sensitivity. [17] A study conducted by Kumar PS et al., [18] in comparison with RHTMD

and RHSMD (ratio of height to sterno-mental distance) among 131 participants concluded that RHTMD was a better predictor of difficult laryngoscopy than RHSMD, and a cut-off value greater than 21.50 for predicting difficult airway.

In our study, we decided to compare the influence of one clinically measured parameter ratio of height to thyromental distance (RHTMD) with ultrasound guided skin to epiglottis distance (US-SED). Pearson coefficient ("r" value, Table 8), was 0.38 indicating a weak correlation. Scatter plot also illustrates this (Figure 2). Individual clinical assessment though rapid and can be performed bedside lacks greater sensitivity and specificity, so it would be better to add ultrasound measurement whenever available in our routine practice of airway assessment for better planning and execution of endotracheal intubation.

The limitation of our study was that correlation of only one clinical parameter with US-SED was compared. The other parameters need to be evaluated, and among the other ultrasound guided parameters, which one has superior sensitivity and specificity in predicting challenging laryngoscopy has to be evaluated in future studies. This helps the search for the one optimal airway parameter move forward.

To conclude, ultrasound guided skin to epiglottis distance has greater sensitivity and specificity in predicting difficult laryngoscopy compared to ratio of height to thyromental distance and also ultrasound guided skin to epiglottis distance of 2.45 cm is the cut off for anticipating a difficult laryngoscopy in our study population.

## CONCLUSION

- Ultrasound guided skin to epiglottis distance has greater sensitivity (82.2%) and specificity (76.7%) compare to clinically measured ratio of height to thyromental distance in predicting difficult laryngoscopy
- Cut off value of skin to epiglottis distance above which one can anticipate a difficult laryngoscopy is 2.45 cm
- Even though ratio of height to thyromental distance above 24.7 can predict difficult laryngoscopy, it lacks greater sensitivity and specificity

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