**Original Research Article**

# Prediction of difficult intubation using bedside sonographic airway measurements in elective surgical patients

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## Abstract

**Background:** Airway Management refers to establishing an airway pathway and ensuring adequate ventilation and oxygenation. It is the cornerstone of Anesthesia, thereby mitigating the adverse effects of Anesthesia on the respiratory system. For successful Airway Management, a spectrum of knowledge and skills are required one end of the spectrum is the ability to predict difficulty with airway management and the other end is executing the management plan by using the wide array of airway devices. In between lies formulation of the airway management plan.
**Aim and objectives:** To study the predictability of difficult intubation (defined as CL3 and CL4 grade indirect laryngoscopic view) using ultrasound airway measurements, Hyomental distance, Pre epiglottic space, the anterior soft tissue at the level of vocal cords.
**Materials and methods:** This Prospective, observational study was conducted in a Government Kilpauk Medical College. 100 Patients were included in the study. Duration of study: 6 months in 2019. Ultrasound machine with B mode 2 dimensional with high-frequency linear probe 10-14 MHz. • Monitors - ECG, NIBP, SPO2, EtCO2. Study outcome measures: To study the predictability of difficult intubation (defined as CL3 & CL4 grade indirect laryngoscopic view) using ultrasound airway measurements. Hyomental distance, Pre epiglottic space, Anterior soft tissue at the level of vocal cords. Feasibility of routine use of ultrasound in airway assessment. Enhancing safety during intubation in a tertiary care institution. Probability of usage of ultrasound for quick airway assessment.
**Results:** The majority of the study population (24) which falls in category 1(more than 6 cm) add IDS ero followed by 9 people who had IDS 1-5 and 1 with IDS more than 5. In category 3 (less than 4

cm), 11 out of 21 had IDS more than 5 and 1 had IDS zero. The results were analyzed with the chi-square test and it showed the association between hyomental distance and intubation difficulty score is statistically significant. In this study, in group one, 11 of them had IDS >5, 8 had IDS 1-5 and only 2 had IDS zero. In group three, 21 of the study population had IDS zero. 9 had IDS 1-5 and no one had IDS >5. The data were analyzed with a chi-square test and the action between anterior soft tissue distance and intubation difficulty score is found to be statistically significant. The majority had IDS zero. In category 2, more population more people had IDS more than 5. The results were analyzed with a chi-square test and the association between Arne Score and IDS is found to be statistically significant. The 54% of the population with IDS zero had a lesser duration of an examination. Whereas 92% of people with IDS>5 took a longer duration for examination. The data are analyzed with a chi-square test and the association between USG neck examination duration and IDS was found to be statistically significant.

**Conclusion:** Bedside sonographic airway measurements of Pre epiglottic space, Hyomental distance, and Anterior soft-tissue distance help in the prediction of difficult intubation in elective surgical patients. Ultrasound can be routinely used for airway assessment and prediction of difficulty in intubation, thereby enhancing the preparedness and safety during intubation.

## Key words

Intubation Difficulty Scoring, Preepiglottic space, Hyomental distance, Anterior soft-tissue distance.

## Introduction

Airway Management refers to establishing an airway pathway and ensuring adequate ventilation and oxygenation. It is the cornerstone of Anesthesia, thereby mitigating the adverse effects of Anesthesia on the respiratory system [1]. For successful Airway Management, a spectrum of knowledge and skills are required one end of the spectrum is the ability to predict difficulty with airway management and the other end is executing the management plan by using the wide array of airway devices [2]. In between lies formulation of the airway management plan [3]. A difficult airway is defined as "the clinical situation in which a conventionally trained Anesthesiologist experiences difficulty with ventilation of upper airway in a mask, difficulty with tracheal intubation or both" Prediction of difficult airway includes History taking, General Examination of the patient, specific indices / or group of indices (Risk Scores) and Imaging Techniques [4]. The most commonly used Imaging technique for Airway assessment is USG since it has several advantages of providing safe, quick, repeatable, portable, and widely available. It gives real-time dynamic images and noninvasive techniques [5]. Other Imaging techniques are CT, MRI which have their own disadvantages radiation and need patient mobilization to radiology suites. (Claustrophobia, time-consuming, easily available) specialty consultation by radiologist, expensive modality [6].

## Materials and methods

This prospective, observational study was conducted in a Government Kilpauk Medical College. 100 patients were included in the study. Duration of study: 6 months in 2019. Ultrasound machine with B mode 2 dimensional with high-frequency linear probe 10-14 MHz. • Monitors-ECG, NIBP, SPO2, EtCO2. Study outcome measures: To study the predictability of difficult intubation (defined as CL3 & CL4 grade indirect laryngoscopic view) using ultrasound airway measurements. Hyomental distance, Pre epiglottic space, Anterior soft tissue at the level of vocal cords. Feasibility of routine use of ultrasound in airway assessment. Enhancing safety during intubation in a tertiary care institution. Probability of usage of ultrasound for quick airway assessment.

**Exclusion criteria:** History of Seizures and any neurological deficit, Abnormal dentition, absent teeth, Head and neck pathology, Restricted mouth opening, Facial deformities (congenital or post-traumatic) Emergency surgery. Previous – Anesthesia records, H/o voice changes, previous surgery, snoring, burns, trauma, tumor in the oral cavity, cervical spine were elicited. History of systemic illness like Diabetes mellitus Rheumatoid Arthritis, Ankylosing spondylitis were asked and noted. If head and neck pathology and any other positive history mentioned in exclusion criteria are present, they were excluded from the study.

Examination of anomalies of mouth and tongue, temperomandibular joint pathology, facial anomalies, pathology of nose and palate are done. Patient height and weight is taken and BMI calculated. Measurement of airway indices A-O Joint Movement – Neck extension. The patient was to look at the ceiling without raising the eyebrows and the range of movement was noted. Abnormalities like a cracked tooth, bucktooth, loose tooth, artificial dentures, and missing tooth were examined and recorded. The palate, bleeding gums were examined. Samsoon and Young modification and Malompatti grading (MMS) Patient in a sitting position, is asked to open the mouth to the maximum without any phonation, and observer's eye is in level with patients mouth. The degree to which the rule, faucial pillars, soft palate, and hand palate were visible were recorded and classified as follows; Ultrasound measurement of HMD: This is the distance measured from hyperechoic linear hybrid bone to hyperechoic mental prominence. Hyoid bone on transverse view appears as hyperechoic inverted U-shaped structure. In the sagittal view, it has a narrow hyperechoic curved structure. Measurement is done using curved problem and in sagittal view. Preepiglottic space is the potential hyperechoic space that lies anterior to the epiglottis. Its measurement is done from Hypoechoic cumi linear structure. Epiglottis to the thyrohyoid membrane using linear probe by the transverse view.

**USG measurement of ASTD**

The vocal cords are seen in a transverse plane and placed at 3 separate locations: (1) the thyrohyoid membrane; (2) the thyroid cartilage; and (3) the cricothyroid membrane. The true cords are hypoechoic, outlined by the hyperechoic vocal ligament. They are triangular. The false vocal cords lay parallel and cephalad to the true cords and are more hyperechoic in appearance. The true and false cords can be further distinguished during phonation ("aa-aa" and "ee-ee" words): the true cords will be observed to oscillate and move toward the midline compared with the false cords, which will remain relatively immobile. Anterior soft tissue thickness is measured at the level of vocal cards after identifying true cords. After routine airway assessment and USG guided, time taken for USG measurement of all three parameters are noted in seconds. Airway assessment, standard general anesthesia procedures were performed. The following standardization measures were taken before obtaining the Cormack Lehane grading and intubation difficulty scale.

**Statistical analysis**

The data was entered in excel and double-checked for missing data statistical Analysis was done by SPSS version 23 (demo version). Data cleaning was done. Outliers were identified. Continuous variables were expressed as Mean with Standard deviation. Categorical variables were expressed in numbers and percentages. Chi-square test with or without Yates correction and Fischers test was used for univariate analysis. The factors significantly associated with the Intubation Difficulty score by univariate analysis were Pre epiglottic distance, Hyomental distance, Anterior soft-tissue distance, USG time taken for intubation, Time is taken for normal intubation, Arnes score. A p-value of less than 0.05 is considered statistically significant for rejecting the null hypothesis.

## Results

Characteristics of the study subjects were as per **Table – 1**. Arnes score vs intubation difficulty

score was as per **Table - 2**. Intubation difficulty score was as per **Table – 3**. Intubation difficulty score vs USG examination was as per **Table – 4**. Intubation difficulty score vs neck circumference was as per **Table – 5**. Intubation difficulty score vs duration of intubation in seconds was as per **Table – 6**. Intubation difficulty score vs hyomental distance in cm was as per **Table – 7**. Intubation difficulty score vs pre epiglottic space in cm was as per **Table – 8**.

**Table - 1:** Characteristics of the study subjects.

| **Variables** | **Mean with a standard deviation** | **95% confidence interval of the mean** |
|---|---|---|
| Age in years | 38.16 ± 15.112 | 34.8 to 41.5 |
| Height in cm | 155.94 ± 6.894 | 154.40 to 157.47 |
| Weight in Kg | 67.18 ± 17.419 | 63.3 to 71.05 |
| BMI as Weight in Kg / Height in Metre$^2$ | 27.70 ± 8.047 | 25.9 to 29.49 |
| Hyomental distance in cm | 5.358 ± 1.0887 | 5.115 to 5.600 |
| Pre epiglottic distance in cm | 1.375 ± 0.266 | 1.316 to 1.434 |
| Anterior soft-tissue distance in cm | 5.336 ± 0.82 | 5.15 to 5.52 |
| Time taken for USG examination of Neck in seconds | 214.34 ± 27.195 | 208.29 to 220.39 |
| Time taken for Intubation | 22.56 ± 10.292 | 20.27 to 24.85 |

**Table – 2:** Arnes score vs intubation difficulty score.

| **ARNES SCORE** | **Intubation difficulty score** | | |
|---|---|---|---|
| | **Easy (0)** | **Slightly difficult (1 to 5)** | **Moderate to major difficulty (> 5)** |
| <11 | 34 ( 97% ) | 25 (78% ) | 1 (8%) |
| 11 and above | 1 (3% ) | 7 (22% ) | 12 (92% ) |
| Total | 35 | 32 | 13 |

**Table – 3:** Intubation difficulty score.

| **Body mass Index** | **Intubation difficulty score** | | |
|---|---|---|---|
| | **Easy (0)** | **Slightly difficult (1 to 5)** | **Moderate to major difficulty (> 5)** |
| < 25 | 21 (60%) | 18 (56%) | 5 (39%) |
| 25 TO 30 | 7 (20%) | 3 (9%) | 3 (23%) |
| 31 TO 40 | 4 (11%) | 9 (28%) | 3 (23%) |
| >40 | 3 (9%) | 2 (7%) | 2 (15%) |
| TOTAL | 35 | 32 | 13 |

**Table – 4:** Intubation difficulty score vs USG examination.

| **USG examination in seconds** | **Intubation difficulty score** | | |
|---|---|---|---|
| | **Easy (0)** | **Slightly difficult (1 to 5)** | **Moderate to major difficulty (> 5)** |
| 101 TO 200 | 19 (54%) | 14 (44%) | 1 |
| 201 TO 300 | 16 (46%) | 18 (56%) | 12 |
| Total | 35 | 32 | 13 |

## Discussion

There are several traditional indices of predicting difficult laryngoscopy, but none of them is 100% sensitive and specific. Ultrasound is a new addition to the anesthesiologist's armamentarium, which has revolutionized care in several areas. The role of ultrasound in airway assessment is still primitive, with no established standard parameters to predict difficult laryngoscopy [7].

The present study was designed to establish a correlation between preoperative sonographically assessed parameters and the grade of difficulty at direct laryngoscopy. The parameters assessed by ultrasound, in our study, were the volume of the tongue, the volume of the floor of the mouth, the skin to hyoid distance, the anteroposterior thickness of the geniohyoid muscle, and the skin to epiglottis distance at the level of the thyrohyoid membrane [8].

**Table – 5:** Intubation difficulty score vs neck circumference.

| Neck circumference in cm | Intubation difficulty score | | |
|---|---|---|---|
| | Easy (0) | Slightly difficult (1 to 5) | Moderate to major difficulty (> 5) |
| < 30 CM | 28 (80%) | 22 (70%) | 2 (15%) |
| 30 TO 35 CM | 6 (17%) | 5 (15%) | 1 (8%) |
| >35 CM | 1 (3%) | 5 (15%) | 10 (77%) |
| TOTAL | 35 | 32 | 13 |

**Table – 6:** Intubation difficulty score vs duration of intubation in seconds.

| DURATION OF INTUBATION IN SECONDS | INTUBATION DIFFICULTY SCORE | | |
|---|---|---|---|
| | EASY (0) | SLIGHTLY DIFFICULT (1 TO 5) | MODERATE TO MAJOR DIFFICULTY (> 5) |
| <20 | 30 (86%) | 17 (53%) | 1 (8%) |
| 20 - 30 | 4 (11%) | 8 (25%) | 0 |
| >30 | 1 (3%) | 7 (22%) | 12 (92%) |
| TOTAL | 35 | 32 | 13 |

**Table – 7:** Intubation difficulty score vs hyomental distance in cm.

| HYOMENTAL DISTANCE IN CM | INTUBATION DIFFICULTY SCORE | | |
|---|---|---|---|
| | EASY (0) | SLIGHTLY DIFFICULT (1 TO 5) | MODERATE TO MAJOR DIFFICULTY (> 5) |
| >6 CM | 24 (66%) | 9 (28%) | 1 (8%) |
| 4 TO 6 CM | 11 (31%) | 14 (44%) | 0 |
| <4 CM | 1 (3%) | 9 (28%) | 11 (92%) |
| TOTAL | 36 | 32 | 12 |

**Table – 8:** Intubation difficulty score vs pre epiglottic space in cm.

| PRE EPIGLOTTIC SPACE IN CM | INTUBATION DIFFICULTY SCORE | | |
|---|---|---|---|
| | EASY (0) | SLIGHTLYDIFFICULT (1 TO 5) | MODERATE TO MAJOR DIFFICULTY (> 5) |
| <1.5 | 33 (94%) | 24 (77%) | 1 (14%) |
| 1.5 AND ABOVE | 2 (6%) | 8 (23%) | 12 (86%) |
| TOTAL | 35 | 31 | 14 |

The prevalence of difficult intubation in our study was 9.2%, which is comparable to previous studies. Cormack RS et.al used ultrasound to determine the utility of sonographic measurements of the thickness of the tongue, anterior neck soft tissue at the level of the hyoid bone, and the thyrohyoid membrane in distinguishing between easy and difficult laryngoscopy. They demonstrated that sonographic measurements of anterior neck soft tissue thickness at the level of hyoid bone and thyrohyoid membrane could be used to distinguish easily from difficult laryngoscopy. The ease of laryngoscopy also depends on the

space available to displace the tongue. The size of the tongue, about the oropharyngeal space, is an important determinant of ease of introduction of the laryngoscope blade. Among the traditional parameters, modified Mallampati classification is used to assess this variable but is of moderate sensitivity [9]. Using ultrasound, we calculated the width and cross-sectional area of the tongue, to calculate the tongue volume, to assess the effect of tongue size on laryngoscopy. The volume of the tongue had reasonable sensitivity and specificity in predicting difficult laryngoscopy, in our study, but was not as predictive as anterior neck soft tissue thickness. The difference could be because the tongue volume should be taken about the mandibular volume [10]. One of the limitations of our technique was the time taken for complete airway assessment using ultrasound. In our study, the total time for preoperative airway assessment, to measure all the sonographic variables was approximately 10 min in each patient [11]. This is more time-consuming compared to the sublingual ultrasound technique described by Arne J, et al. however, we aimed to identify all possible variables which can be measured and find which had the maximum correlation with the laryngoscopic view. Another limitation of our study was the use of cutoff points for the different sonographically assessed variables using our pilot study, except for tongue volume, where we chose the value of >100 $cm^3$ to predict a difficult laryngoscopy [12]. Like most other traditional airway assessment indicators, we found that the sonographically assessed indicators also had a better negative predictive value, than a positive predictive value. They may be more useful to predict an easy laryngoscopy than being able to predict a difficult laryngoscopy [13, 14, 15].

## Conclusion

In summary, our study shows that ultrasound can be used to assess the airway preoperatively, and several sonographic parameters can be measured. The highest sensitivity and negative predictive value were shown by the skin to epiglottis distance, followed by the volume of the tongue. The exact value of these variables measured sonographically that would correlate with a difficult laryngoscopy needs to be established through future research.

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