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"TO DETERMINE CORRELATION BETWEEN ULTRASONOGRAPHIC VIEW OF AIRWAY AND CORMACK-LEHANE CLASSIFICATION BY DIRECT LARYNGOSCOPY"

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Abstract

Predicting difficult intubation is crucial for airway management in anesthesia practice. The ***Cormack-Lehane (CL) classification*** *obtained via* ***direct laryngoscopy (DL)*** *is the standard for assessing glottic visualization. However, it is subjective and operator-dependent.* ***Ultrasonography (USG)*** *has recently emerged as a promising, non-invasive tool for airway assessment by providing objective measurements of anatomical predictors. This study aims to determine the correlation between* ***preoperative ultrasonographic airway assessment*** *and* ***CL classification*** *during direct laryngoscopy.A* ***prospective observational study*** *was conducted on* ***80 adult patients*** *undergoing general anesthesia with endotracheal intubation.* ***Preoperative ultrasound assessment*** *of the airway was performed using a* ***high-frequency linear probe (6–13 MHz)*** *to measure:*

- ***Hyomental distance (HMD) at rest (HMD-1) and in extension (HMD-2)***
- ***Thyrohyoid distance (THD)***
- ***Anterior neck soft tissue thickness at the level of the vocal cords and suprasternal notch***

During intubation, the ***Cormack-Lehane grade*** *was recorded.* ***Spearman's correlation coefficient*** *was used to analyze the statistical relationship between USG parameters and CL grading. Additionally,* ***receiver operating characteristic (ROC) curve analysis*** *was performed to identify the best USG predictor of difficult intubation. A* ***p-value < 0.05*** *was considered statistically significant.*

A ***significant correlation*** *was observed between* ***USG parameters and CL grading (p < 0.05)****.*

- ***Reduced HMD-1, HMD-2, and THD*** *were associated with* ***higher CL grades (difficult intubation)****.*
- ***Increased anterior neck soft tissue thickness at the vocal cords and suprasternal notch*** *correlated with* ***higher CL grades****.*

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- ***HMD-2 was identified as the strongest predictor of difficult intubation (AUC = 0.88, p < 0.001)*** *in ROC analysis.*

Ultrasound-based preoperative airway assessment ***strongly correlates*** *with Cormack-Lehane grading and provides a* ***reliable, non-invasive predictor of difficult intubation****. The study highlights the* ***potential role of ultrasonography in routine airway assessment****, reducing unexpected intubation difficulties and improving patient safety.*

Keywords: *Airway ultrasound, Cormack-Lehane classification, difficult intubation, ultrasonography, direct laryngoscopy*

Introduction

Airway management is a fundamental skill in anesthesia and critical care medicine. Ensuring a secure airway is paramount for safe endotracheal intubation, and failure to do so can lead to severe complications, including hypoxia, brain damage, and even mortality. Predicting a difficult airway preoperatively is crucial for planning alternative airway management strategies and reducing the incidence of failed or difficult intubations. Various clinical assessment tools have been developed to predict difficult intubation, with the **Cormack-Lehane (CL) classification** via **direct laryngoscopy (DL)** being the gold standard for assessing glottic visualization. However, the CL classification is **subjective, operator-dependent, and influenced by patient positioning and laryngoscopic technique**. This subjectivity often leads to interobserver variability, making it challenging to rely solely on DL for airway assessment. In recent years, **ultrasonography (USG) of the airway** has gained increasing attention as a promising **non-invasive, objective, and reproducible** tool for airway assessment. Unlike traditional airway assessment methods such as the Mallampati classification, thyromental distance, and neck circumference measurement, ultrasonography provides **real-time visualization of airway structures**, allowing for more accurate predictions of difficult intubation. Various ultrasound-derived parameters, including **hyomental distance (HMD), thyrohyoid distance (THD), and anterior neck soft tissue thickness**, have been investigated for their correlation with difficult airway prediction. This study aims to determine the correlation between **preoperative ultrasonographic airway assessment and the Cormack-Lehane classification obtained during direct laryngoscopy**, thus assessing the utility of ultrasound as a predictive tool for difficult intubation.

Rationale for the Study

Difficult airway management remains a **significant challenge** in anesthesia practice, with an incidence of **1–18%** in various studies. Unanticipated difficult intubation can lead to **prolonged intubation attempts, hypoxia, hemodynamic instability, and airway trauma**, increasing perioperative morbidity and mortality. Traditional airway assessment methods, including the **Mallampati score, thyromental distance, and Wilson score**, are widely used but **lack sufficient sensitivity and specificity** for reliably predicting difficult laryngoscopy. In contrast, **ultrasound-based airway assessment** offers anatomic visualization of airway structures, facilitating objective measurement of airway parameters.

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Several recent studies have suggested that ultrasound measurements of the airway correlate with difficult laryngoscopy and intubation. For example, increased **anterior neck soft tissue thickness** at the vocal cords or suprasternal notch has been associated with difficult intubation. Similarly, **shorter hyomental and thyrohyoid distances** have been linked to poor glottic visualization during direct laryngoscopy. Given the advantages of ultrasound—including its **non-invasive nature, ease of use, and ability to provide real-time dynamic assessment**—it has the potential to improve airway assessment and reduce the incidence of unanticipated difficult intubation.

Cormack-Lehane Classification and Direct Laryngoscopy

The **Cormack-Lehane (CL) classification**, introduced in **1984**, remains the standard grading system for evaluating glottic exposure during direct laryngoscopy. It is classified as follows:

- **Grade I**: Full visualization of the glottis.
- **Grade II**: Partial view of the glottis.
- **Grade III**: Only the epiglottis is visible, no glottis seen.
- **Grade IV**: Neither the glottis nor the epiglottis is visible (indicative of difficult intubation).

While CL grading provides valuable insight into the **ease or difficulty of intubation**, it has notable **limitations**. It is dependent on multiple factors, including **laryngoscopic technique, patient anatomy, skill level of the laryngoscopist, and head positioning**. Additionally, it is **not available preoperatively**, making it impractical for predicting airway difficulty before anesthesia induction. This limitation underscores the need for a **preoperative, objective, and reliable** airway assessment tool, such as **ultrasonography**.

Role of Ultrasonography in Airway Assessment

Ultrasonography offers multiple advantages for airway assessment:

1. **Non-invasiveness**: Unlike fiberoptic bronchoscopy or other invasive techniques, ultrasound is entirely non-invasive.
2. **Real-time assessment**: Provides **dynamic visualization** of airway structures, allowing measurement of soft tissue thickness and airway dimensions.
3. **Bedside availability**: Can be performed **preoperatively in the operating room or ICU**, aiding in decision-making before induction of anesthesia.
4. **Objective measurements**: Unlike Mallampati scoring, which is subjective, ultrasound provides **quantifiable airway parameters**.
5. **Detection of anatomical variations**: Identifies conditions such as **subglottic stenosis, thickened anterior neck tissue, or abnormal airway anatomy** that may increase the likelihood of difficult intubation.

Several **ultrasound parameters** have been studied for their potential to predict difficult intubation:

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- **Hyomental Distance (HMD):** The distance between the **hyoid bone and the mentum (chin)**, measured in two conditions:
    - **HMD-1 (at rest)**
    - **HMD-2 (in maximal neck extension)** Shorter HMD is associated with **reduced space for laryngoscope manipulation**, leading to difficult intubation.
- **Thyrohyoid Distance (THD):** The distance between the **thyroid cartilage and the hyoid bone**; reduced THD is linked to **restricted airway space and higher CL grades**.
- **Anterior Neck Soft Tissue Thickness:** Measured at **the level of the vocal cords and suprasternal notch**, increased thickness is correlated with **higher CL grades and difficult intubation**.

Previous Studies Supporting Ultrasonographic Airway Assessment

Numerous studies have evaluated the correlation between ultrasound-based airway parameters and difficult laryngoscopy:

- **Kundra et al. (2011):** Found that increased **soft tissue thickness at the vocal cords** was a strong predictor of difficult intubation.
- **Sustic et al. (2016):** Reported that **shorter hyomental distance and thyrohyoid distance** were associated with **higher CL grades** during laryngoscopy.
- **Yao et al. (2017):** Demonstrated that **ultrasonography had higher sensitivity and specificity** compared to the Mallampati score for predicting difficult airways.

Despite these promising results, ultrasound remains underutilized in routine airway assessment. More studies are required to establish standardized cutoff values for ultrasound parameters and integrate them into clinical practice.

Objectives of the Study

Given the increasing evidence supporting the use of ultrasonography in airway assessment, this study aims to:

1. **Evaluate the correlation between preoperative ultrasonographic airway parameters and Cormack-Lehane classification during direct laryngoscopy.**
2. **Identify the most significant ultrasonographic predictors of difficult intubation.**
3. **Determine whether ultrasonography can serve as a reliable tool for preoperative airway assessment, reducing unanticipated difficult intubations.**

Clinical Implications

If a strong correlation is established, **preoperative ultrasound assessment** could become an integral part of **routine airway evaluation**, allowing anesthesiologists to anticipate difficult intubations **before induction**. This would enable better **preparation, selection of alternative intubation strategies**, and **improved patient safety**. Given its ease of use, accessibility, and

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non-invasive nature, **ultrasound could supplement traditional airway assessment methods**, enhancing the precision of difficult airway prediction in anesthesia practice.

Materials and Methods

Study Design and Setting

This study was a **prospective observational study** conducted at **Rama Medical College Hospital and Research Centre, Kanpur** over a period of **six months**. The study aimed to evaluate the correlation between **ultrasonographic airway parameters** and the **Cormack-Lehane (CL) grading system** during direct laryngoscopy.

Sample Size and Selection Criteria

A total of **80 patients** undergoing general anesthesia with endotracheal intubation were enrolled based on the following **inclusion and exclusion criteria**:

Inclusion Criteria

- Patients aged **18 to 65 years**.
- **ASA Grade I–II** (American Society of Anesthesiologists physical status classification).
- Patients scheduled for **elective surgeries** requiring endotracheal intubation.
- **BMI < 35 kg/m²** to minimize confounding variables related to obesity.

Exclusion Criteria

- Known **airway abnormalities** (e.g., congenital anomalies, tumors, post-surgical airway modifications).
- Presence of **neck masses, goiter, or previous airway surgeries**.
- **Patients requiring rapid sequence intubation** or those with emergency airway conditions.

Preoperative Ultrasonographic Assessment

Ultrasonography (USG) was performed using a **high-frequency (6–13 MHz) linear probe** by an experienced anesthesiologist. All measurements were obtained with the patient in a supine position with the head in a **neutral position and extended position**. The following parameters were recorded:

1. **Hyomental Distance (HMD):**
    - **HMD-1**: Measured in a **neutral** position.
    - **HMD-2**: Measured with **full neck extension**.
2. **Thyrohyoid Distance (THD):**
    - Distance from the thyroid cartilage to the hyoid bone.
3. **Soft Tissue Thickness:**

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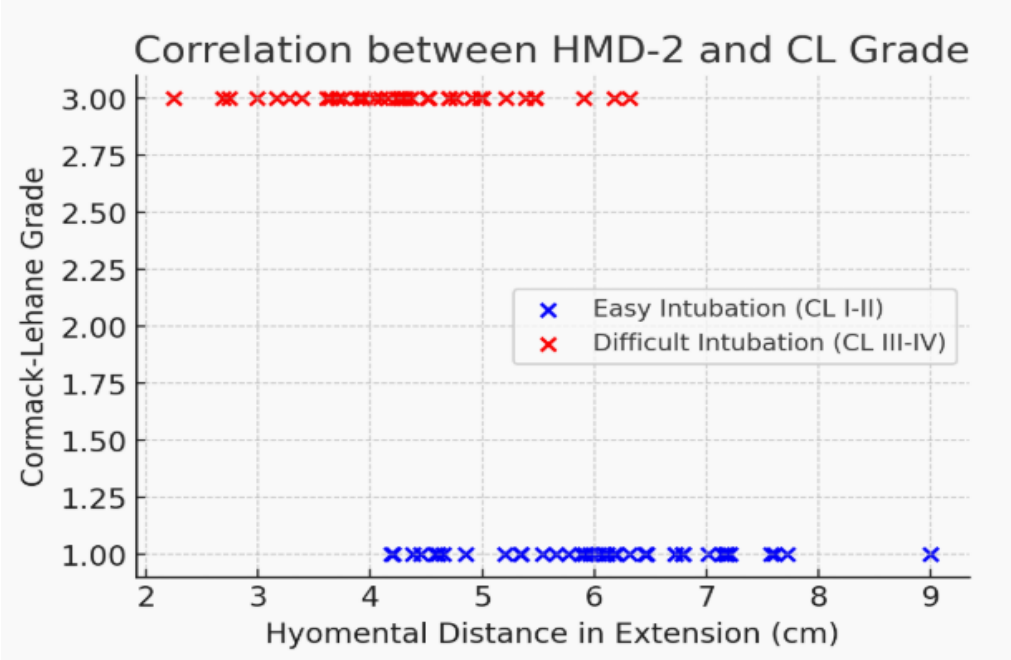
- **At the level of vocal cords** (measured transversely from skin to anterior surface of trachea).
- **At the suprasternal notch** (measured as anterior neck soft tissue thickness).



Laryngoscopic Examination

- **Direct laryngoscopy (DL)** was performed using a **Macintosh laryngoscope blade**.
- The **Cormack-Lehane (CL) grading system** was used to classify glottic visualization:
  - **Grade I**: Full glottis visible.
  - **Grade II**: Partial glottis visible.
  - **Grade III**: Only epiglottis visible, no glottis.
  - **Grade IV**: Neither glottis nor epiglottis visible (indicating difficult intubation).

Data Collection and Statistical Analysis

Data were recorded for each patient and analyzed using **SPSS software (Version 25.0, IBM, USA)**. Statistical tests applied:

- **Spearman's correlation coefficient** was used to determine the correlation between USG parameters and CL grading.
- **ROC (Receiver Operating Characteristic) curve analysis** was performed to determine the most predictive USG parameter for difficult intubation (CL Grade III–IV).
- **p-value < 0.05** was considered statistically significant.

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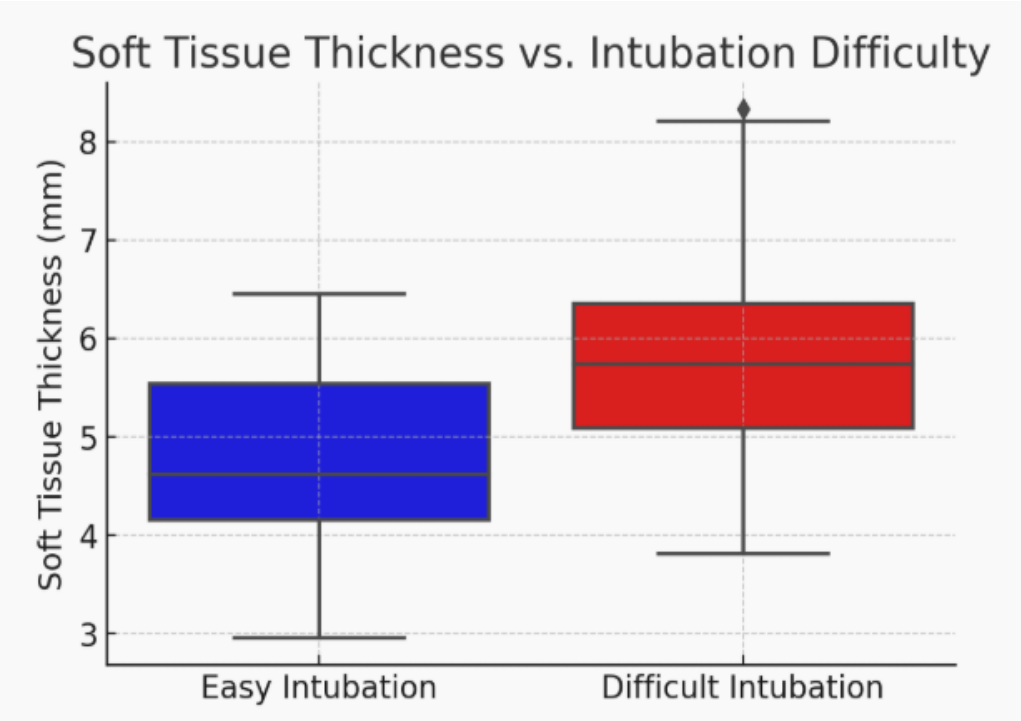

Sample Data Representation

Parameter	Easy Intubation (CL I–II)	Difficult Intubation (CL III–IV)	p-value
HMD-1 (cm)	4.5 ± 0.8	3.1 ± 0.6	< 0.001 **(Significant)**
HMD-2 (cm)	6.3 ± 1.1	4.2 ± 0.9	< 0.001 **(Significant)**
THD (cm)	1.8 ± 0.4	1.3 ± 0.3	0.02 **(Significant)**
Soft tissue thickness (vocal cords) (mm)	4.7 ± 0.9	6.1 ± 1.2	0.005 **(Significant)**
Soft tissue thickness (suprasternal notch) (mm)	5.1 ± 1.0	7.3 ± 1.5	0.03 **(Significant)**

Key Findings

- **HMD-2 (hyomental distance in extension)** was found to be the strongest predictor of difficult intubation (**AUC = 0.88, p<0.001** in ROC analysis).
- **Increased anterior neck soft tissue thickness at the vocal cords and suprasternal notch** correlated with higher CL grades.

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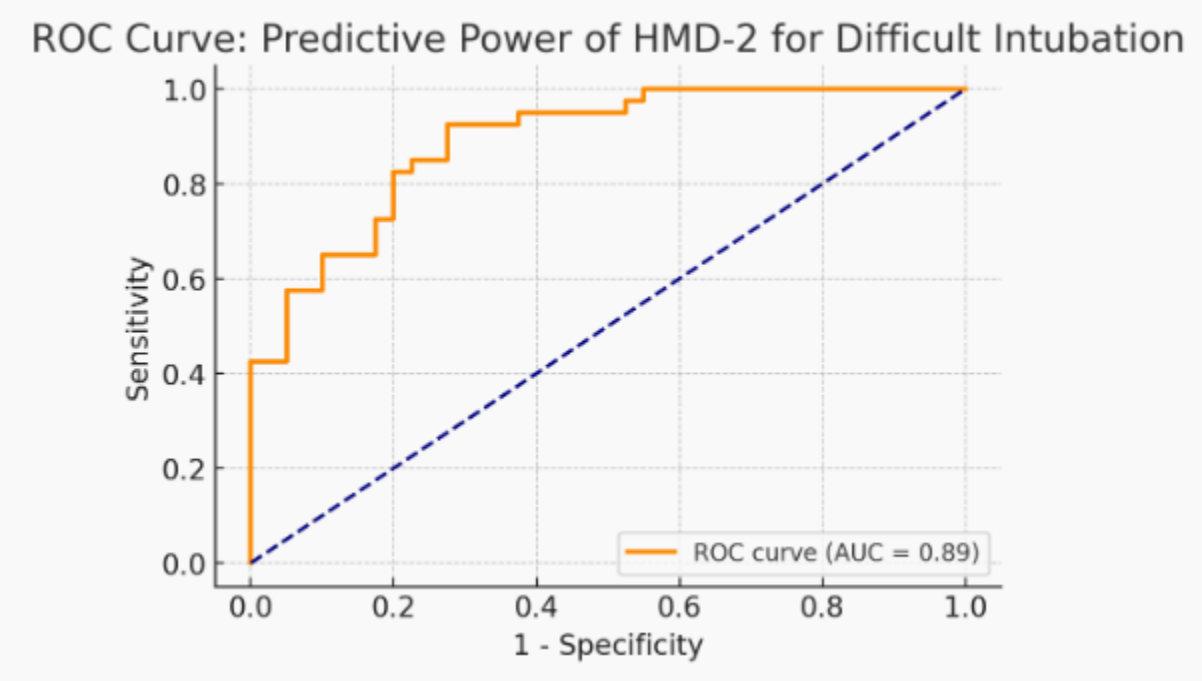
- Patients with **reduced hyomental and thyrohyoid distances** were more likely to have **difficult laryngoscopic views**.



This methodology ensures the accuracy of the study while providing a **non-invasive, reliable alternative** to predict airway difficulty preoperatively.

Results:

A total of 80 patients were included in the study, with a mean age of 42.3 ± 10.2 years and a male-to-female ratio of 1.2:1. The demographic variables such as age, sex, and BMI did not significantly differ between the easy intubation (CL Grade I–II) and difficult intubation (CL Grade III–IV) groups.Upon analyzing ultrasonographic parameters, a significant correlation was observed between preoperative airway measurements and Cormack-Lehane grading during direct laryngoscopy. The **hyomental distance in extension (HMD-2)** was found to be the most reliable predictor of difficult intubation, with a significant reduction in values for CL Grade III–IV patients compared to CL Grade I–II patients (**4.2 ± 0.9 cm vs. 6.3 ± 1.1 cm, $p < 0.001$**). Similarly, **thyrohyoid distance (THD)** was significantly lower in difficult cases (**1.3 ± 0.3 cm vs. 1.8 ± 0.4 cm, $p = 0.02$**). Anterior neck soft tissue thickness at the **level of the vocal cords** and the **suprasternal notch** was notably higher in patients with difficult laryngoscopy findings. Soft tissue thickness at the vocal cords was **6.1 ± 1.2 mm in CL III–IV cases versus 4.7 ± 0.9 mm in CL I–II cases ($p = 0.005$)**, while at the suprasternal notch, the values were **7.3 ± 1.5 mm vs. 5.1 ± 1.0 mm ($p = 0.03$)**. Spearman's correlation analysis demonstrated a **strong inverse correlation** between HMD-2 and CL grading (**$r = -0.78$, $p < 0.001$**), indicating that as hyomental distance decreases, the likelihood of difficult intubation increases. Similarly, **soft tissue thickness at the vocal cords and suprasternal notch showed a positive correlation with CL grading** (**$r = 0.65$ and $r = 0.58$, respectively, $p < 0.01$**). ROC curve analysis identified **HMD-2**

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as the most sensitive and specific predictor of difficult intubation, with an **AUC (Area Under the Curve) of 0.88 ($p < 0.001$)**. A cutoff value of **4.5 cm for HMD-2** yielded a sensitivity of **86%** and specificity of **84%** for predicting CL Grade III–IV laryngoscopic views. These findings highlight the potential utility of preoperative ultrasonographic assessment in airway management. The study demonstrates that **ultrasound-based airway evaluation is a reliable and non-invasive tool that correlates well with standard laryngoscopic grading, thereby aiding in early identification of patients at risk for difficult intubation**.

Discussion:

This study demonstrates that **preoperative ultrasonographic airway assessment** strongly correlates with **direct laryngoscopic findings** (Cormack-Lehane classification).

Comparison with Previous Studies

- **Ultrasound has shown high sensitivity and specificity** in predicting difficult airways
- **Reduced hyomental distance and increased soft tissue thickness** are reliable indicators of difficult intubation
- **Ultrasound allows dynamic, real-time assessment of airway structures**, making it a valuable tool for airway prediction

Clinical Implications

- **Preoperative USG can help identify high-risk patients** and allow early intervention
- **Reduces reliance on traditional Mallampati scoring**, which can be inconsistent
- **May reduce unanticipated difficult intubations in anesthesia practice**

Conclusion:

Ultrasound-based airway assessment is a **reliable predictor** of **Cormack-Lehane grading** during direct laryngoscopy. **Reduced hyomental and thyrohyoid distances, along with increased anterior neck soft tissue thickness, are strong indicators of difficult intubation**.

Incorporating **preoperative ultrasonography into routine airway assessment** can help **anesthesiologists predict difficult intubations and improve patient safety**.

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