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**ORIGINAL ARTICLE**

# Prediction of Difficult Airway Using Sonographic Assessment of Pre-Epiglottic Space versus Mallampati Grading in Correlation to Cormack Lehane Grading

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## ABSTRACT

**Background:** In the intensive care units, emergency, and operating rooms, ultrasound (US) has become a safe, simple, small, noninvasive, and portable technique for quick airway evaluation and management. This work aimed to assess the validity of ultrasound as regards the correlation to the Cormack-Lehane (CL) grading using direct laryngoscopy and for predicting the difficult airway.

**Methods:** A group of 140 patients, ASA I/II were selected in this prospective observational study who took part in elective surgical procedures that required intubation using direct laryngoscopy under general anesthesia. Before starting anesthesia, an ultrasound image of the airway was recorded, and measurements were taken for the pre-epiglottis space (PES) depth and the distance between the epiglottis and vocal cords (E-VC). The CL grade was then matched to the ultrasound measures taken during direct laryngoscopy.

**Results:** There were positive significant correlations between difficult Laryngoscopy and ASA, number of attempts, PES, PES/E-Vc, time of US, and complications ($p<0.001$). A negative significant correlation was revealed between difficult Laryngoscopy and E-Vc ($p<0.001$). Mallampati grading (MG) predicted difficult Laryngoscopy with a cut-off value >2, 40.91% sensitivity and 88.64% specificity. PES/E-Vc predicted difficult laryngoscopy with a cut-off value >1.75, 100% of sensitivity, and 100% specificity. E-VC predicted difficult Laryngoscopy with a cut-off value ≤0.64, 81.8% of sensitivity and 80% specificity. PES predicted difficult Laryngoscopy with a cut-off value >1.27, 100% of sensitivity, and 96.9% of specificity. The prediction with difficult Laryngoscopy was more accurate using US parameters than MG.

**Conclusion:** Patients with difficult airway could be better identified with sonographic assessment of the upper airway. The ratio of the pre-epiglottic space to the distance between the epiglottis and midway through the vocal cords proved a reliable predictor for the Cormack-Lehane grading compared to Mallampati grading in which increasing Pre E and the ratio of Pre E/E-VC were associated with increased risk of difficult intubation.

**Keywords:** Difficult Airway, Sonographic Assessment, Pre-Epiglottic Space, Mallampati Grading, Cormack Lehane.

## INTRODUCTION

Managing the airway is a primary concern for anesthesiologists. The most significant obstacle in everyday practice is the unpredictable and difficult intubation that continues to cause higher rates of morbidity as well as mortality [1]. Mallampati grading, jaw protrusion, neck extension, mouth-opening distance, thyromental distance, as well as the upper-lip bite test are some of the clinical

criteria that have been developed to assess the patient's airway before the start of anesthesia [2].
Many physical airway assessment tests can be used, however, they all have poor sensitivity and specificity and a large level of inter-observer variability [3]. The Cormack-Lehane grading is a reliable way to predict difficult intubation. Nevertheless, it necessitates direct laryngoscopy, a very intrusive operation that poses significant challenges when performed on an awake patient. Additionally, it cannot be utilized for prediction of the tracheal intubations among first-time patients undergoing general anesthesia [4,5].
Nevertheless, laryngeal views can occasionally be unexpectedly poor despite meticulous airway assessment and direct laryngoscopy. Ultrasound (US) is a noninvasive, inexpensive, portable, and user-friendly technology that has revolutionized airway assessment and treatment in various healthcare settings, including operating rooms, emergency departments, and critical care units [6]. When compared to computed tomography (CT) scans, ultrasound is just as good at quantifying nearly all aspects of the structures of the airway [7].
The hypothesis that fat pads affect the view during direct laryngoscopy suggests that a larger pre-tracheal soft tissue or pre-epiglottic gap, which reduces the mobility of the pharyngeal structures, would be a strong indicator of difficult laryngoscopy [8]. Upon that, ultrasound can be used to evaluate the distance of pre-epiglottic space for the prediction of difficult laryngoscopy [9].
So, this study aimed to evaluate and compare the difficult airway using ultrasound assessment of pre-epiglottic space versus Mallampati grading, before anesthesia induction.

## METHODS

A group of 140 patients, ASA I/II were selected in this prospective and observational study who were intubated with direct laryngoscopy during elective surgeries performed under general anesthesia at operating theatres of Zagazig University Hospitals from January 2023 to January 2024.
***Sample size:*** Assuming the mean pre-epiglottic space was 14+_4.72 vs 11.96+_3.839 in difficult vs easy airway (70). At 80 % power and 95 % CI, the estimated sample was 140 cases using open epi.
After institutional review board approval of IRB, all participants were asked to sign an informed consent. Human subjects research adhered to the guidelines set in the Declaration of Helsinki, which is part of the World Medical Association's Code of Ethics.

***Inclusion criteria:*** We included 140 patients from both sexes aged 21-70 years, Body mass index (BMI) ≤ 35 kg/m$^2$, Patients classified as ASA I or II who were planned to undergo endotracheal intubation under general anesthesia for elective surgery.
***Exclusion criteria:*** Patients who were excluded from the study those who had emergency surgery and rapid sequence induction, patients who had existing pathology or airway deformities such as cervical or face fractures, maxillofacial anomalies, malignancies in the cervical region, or trauma, women who were pregnant were excluded from the study.
Full history-taking, and physical examinations, were performed on all study participants. Patients were fasting before the operation (8 h for solid meals and 2 h for clear fluids).

***Assessment of airway:***

As part of the pre-operative airway assessment, we had the patient sit up straight, open their mouth as wide as possible, and protrude their tongue without phonation to get an oropharyngeal image, which we then documented using the Mallampati grading system [9], Grade 1: the uvula, tonsils and soft palate to be fully visible, Grade 2: upper portions of uvula and tonsils to be visible ( both soft and hard palate), Grade 3: hard as well as soft palate and base of the uvula to be visible, Grade 4: the hard palate only is the only visible. Then, sonographic assessment of the airway was assessed in a transverse plane with a linear probe (HFL 38X / L6-12-MHz) of GE Logiq P7 (GE HealthCare, LLC., Chicago, USA) and noted.
While the patients are in the preoperative holding room, they should lie supine and actively lift their head and neck to their fullest extent. The midline submandibular area was chosen for the placement of the high-frequency device. To view the epiglottis and the back of the vocal folds with the arytenoids on the screen at the same time, we rotated the linear array of the US probe in the transverse planes from cephalad to caudal without moving the probe. When the oblique-transverse US image of the airway was obtained, the following measurements were taken [10]: How deep is the pre-epiglottic space (PES), the space between the vestibular ligaments (EVL) at mid-distance from the epiglottis, is the ratio of the space before the epiglottis to the distance after the epiglottis to a point halfway along the vocal cords.
The next step was to bring the patients to the surgery room. Upon arrival in the operating room, all necessary equipment, including airway devices, anesthetic machines, ventilators, flowmeters, and more, was promptly checked.

***Induction:***

Pulse oximetry, non-invasive blood pressure, and electrocardiography were among the standard intra-operative monitoring used to keep the patient safe during surgery. Every patient in the study underwent the same conventional anesthetic procedure. An anesthesiologist with a minimum of two years of experience performed the procedure after administering Propofol 2-2.5 mg/kg, fentanyl 1 microgram/kg, and the muscle relaxant rocuronium 0.6 mg/kg intravenously to induce anesthesia. The procedure also included direct laryngoscopy and endotracheal intubation.

Without leaning forward or backward, each patient maintained a neutral posture. To expose the target larynx, we utilized a 4 Macintosh blade and did not apply any external laryngeal pressure to help us see better. Following the laryngoscopy, the following grading system was used: Cormack and Lehane [11]: Grade 1: laryngeal aperture to be entirely visible, Grade 2: only parts of the laryngeal aperture both arytenoids to be visible, Grade 3: only the epiglottis to be visible, Grade4: the soft palate is the only part visible. Laryngoscopy performed according to Cromack Lehane grades I and II was considered straightforward, however, grades III and IV were classified as difficult laryngoscopy.

Maintenance of anesthesia was done by Isoflurane MAC 1.15, and Atracurium (loading dose 0.5 mg/kg followed by 0.1 mg/kg increments every 20 minutes).

Following the patient's recovery to spontaneous breathing, the reversal of muscular relaxation was performed using (neostigmine 0.05 mg/kg and atropine 0.01 mg/kg) after the discontinuation of isoflurane at the end of the surgery. After that, patients were sent to the post-anesthesia care unit (PACU).

## STATISTICAL ANALYSIS

IBM's statistical analysis software, SPSS, version 27.0, was used to process the data. Normality was tested using the Shapiro–Wilk test and Kolmogorov-Smirnov Normality Test. When comparing the two sets of continuous data, an independent sample t-test was employed. One-way ANOVA was used for comparing continuous data between Mallampati grades. Correlation between continuous and dichotomous variables was conducted using point biserial correlation. Correlation between 2 categorical variables was performed using phi correlation. The accuracy of predictors was assessed using the Kappa test and ROC curve.

## RESULTS

This study included 140 patients who were intubated by an endotracheal tube during elective surgery while under general anesthesia. The mean age of included patients was 41.9 years. BMI was 28.5±4.42. 58% of included patients were males, 69.3% had ASA grade I, according to Mallampati grading (MPG), 49.3 % was grade II, 35.7% Grade I, and 14.3% grade III, a statistically significant difference was found between before and during intubation in satO2 and diastolic BP ($p<0.05$) (**Table 1**).

Regarding ultrasonographic parameters, the mean Pre-epiglottis space (PES) was 0.94 with a standard deviation of 0.29, and the mean distance between the epiglottis and the vocal cords (E-VC) was 0.72±0.14. The PES/E-Vc ratio was 1.34± 0.53. The time to perform US (second) was 28.88±3.70 seconds. The mean number of attempts of intubation was 1.16±0.40. The number of attempts was one in 85.7% and two in 12.9 % of included patients, according to Cormack and Lehane grading, 62% were Grade I, 23.6 % was Grade II, 14.3% Grade III, and no patient with Grade IV (**Table 2**).

Regarding Cormack and Lehane grades, PES, time of US, and systolic BP during intubation were higher while satO2 was lower among patients diagnosed with grade III than in grade II and grade I patients. E-Vc was higher in patients diagnosed with grade I than in grade II and grade III patients (**Table 3**).

There was a significant difference in the number of attempts of intubation between various CL grades ($p<0.001$), also incidence of complications that were more in grade III and Mallampati grading differed significantly between various CL grades ($p<0001$) (**Table 4**).

The percentage of those in group C who used pethidine was significantly higher than those in group D ($P1<0.05$). Pethidine consumption also varied significantly across groups C and K ($P3<0.05$) (Table 4).

There were positive significant correlations between difficult Laryngoscopy and ASA, number of attempts, PES, PES/E-Vc, time of US, and complications ($p<0.001$). There was a negative significant correlation between difficult Laryngoscopy and E-Vc ($p<0.001$) (**Table 5**).

Positive significant correlations were revealed between the number of attempts and PES, PES/E-Vc; while a negative correlation was found between number of attempts and E-Vc ($p<0.05$), also positive correlations were found between the incidence of complications and number of attempts, difficult Laryngoscopy, PES, PES/E-Vc, time of US. There was a negative correlation between incidence of complications and E-Vc (p<0.05) (**Table 6**).

Mallampati grading (MG) predicted difficult Laryngoscopy with >2 cut-off values of 40.91% Sensitivity and 88.64% Specificity. PES/E-Vc predicted difficult Laryngoscopy with >1.75 cut-off value of 100% Sensitivity and 100% Specificity. E-VC predicted difficult Laryngoscopy with ≤0.64 cut-off value 81.8% Sensitivity and 80% Specificity. PES predicted difficult Laryngoscopy with >1.27 cut-off value of 100% Sensitivity and 96.9% Specificity. The prediction with difficult Laryngoscopy was more accurate using US parameters than MG. Mallampati grading (MG) predicted CL grade 2 with ≤1 cut-off value of 60.5% Sensitivity and 68% Specificity. PES/E-Vc predicted CL grade 2 with >1.27 cut-off value of 100% Sensitivity and 79.3% Specificity. PES predicted CL grade 2 with >0.92 cut-off value of 89.4% Sensitivity and 67.24% Specificity (**Figure 1, Supplementary Tables 1 and 2**).

**Table 1:** Distribution of the studied cases according to Socio-demographic, Mallampati grading (MPG), Blood pressure, Oxygen saturation, and pulse before and during endotracheal intubation parameters:

| **Parameters** | **Mean ± SD** | |
|---|---|---|
| **Age (years)** | 41.92±15.12 | |
| **Weight (kg)** | 81.13±15.37 | |
| **Height (cm)** | 168.04±6.92 | |
| **BMI (kg/m2)** | 28.50±4.42 | |
| **ASA** | | |
| I | 97(69.3%) | |
| II | 42(30%) | |
| III | 1(0.7%) | |
| **MPG** | **Number** | **%** |
| Grade I | 50 | 35.7 |
| Grade II | 69 | 49.3 |
| Grade III | 20 | 14.3 |
| Grade IV | 1 | .7 |

| | **before endotracheal intubation** | | **During endotracheal intubation** | | **P-value** |
|---|---|---|---|---|---|
| **Vital signs** | **Mean** | **SD** | **Mean** | **SD** | |
| **Diastolic BP** | 73.17 | 8.26 | 70.27 | 12.72 | **0.018** |
| **Systolic BP** | 123.36 | 9.34 | 120.95 | 14.38 | 1.08 |
| **pulse** | 77.95 | 7.83 | 78.04 | 11.98 | .936 |
| **satO2** | 97.06 | 1.29 | 98.64 | 2.39 | **.000** |

MPG: Mallampati grading, ASA: American Society of Anesthesiology, BP: Blood pressure, BMI: Body mass index, SD: Standard deviation.

**Table 2:** Descriptive analysis of the studied cases according to Ultrasonographic parameters, number of attempts of intubation, and Distribution of the studied cases according to Cormack and Lehane grading

| **Ultrasonographic parameters** | **Mean±SD** | |
|---|---|---|
| **PES (cm)** | 0.94±0.29 | |
| **E-Vc (cm)** | 0.72±0.14 | |
| **PES/E-Vc** | 1.34±0.53 | |
| **Time to perform US (second)** | 28.88±3.70 | |
| **Number of attempts (mean±SD)** | 0.16±0.40 | |
| **Frequencies** | **Number** | **%** |
| **One** | 120 | 85.7 |
| **Two** | 18 | 12.9 |
| **Three** | 2 | 1.4 |

| CL | Number | % |
|---|---|---|
| I | 87 | 62.1 |
| II | 33 | 23.6 |
| III | 2 | 14.3 |

SD: Standard deviation, PES: Pre-epiglottic space, CL: Cormack and Lehane, E-Vc: Distance between the epiglottis and the vocal cords.

**Table 3:** Distribution of various parameters regarding Cormack and Lehane grades

| | grade I | grade II | grade III |
|---|---|---|---|
| | Mean±SD | Mean±SD | Mean±SD |
| **Age** | 38.6±14.1 | 48.4±14.1 | 44.9±17.9 |
| **BMI** | 28.2±4.8 | 29.5±4.2 | 27.9±3.2 |
| **PES** | 0.8±0.2 | 1±0.2* | 1.5±0.1*# |
| **E-Vc** | 0.8±0.1 | 0.7±0.1* | 0.6±0.1* |
| **PES/E-Vc** | 1±0.1 | 1.5±0.1* | 2.5±0.2*# |
| **Time of US** | 27.9±3.4 | 29.5±3.6 | 32.1±3.3*# |
| **Vital signs** | **Grade I** | **Grade II** | **Grade III** |
| **Before intubation diastolic BP** | 71.3±8.1 | 76.4±7.0 | 75.7±9.0 |
| **Before intubation systolic BP** | 121.6±8.9 | 128.1±8.7 | 123±10.4* |
| **During intubation systolic BP** | 114.36±9.64 | 122±9.21* | 147.27±4.67*# |
| **Before intubation pulse** | 78.3±7.6 | 76.8±8.7 | 78.5±8.0 |
| **During intubation pulse** | 75.09±8.93 | 73.68±9.17 | 98.18±7.07*# |
| **Before intubation satO2** | 97.3±1.2 | 96.7±1.2 | 96.5±1.6* |
| **During intubation satO2** | 99.72±0.45 | 99.21±0.54* | 93±1.00*# |

PES: Pre-epiglottic space, CL: Cormack and Lehane, E-Vc: Distance between the epiglottis and the vocal cords, BP: Blood pressure, BMI: Body mass index ***indicate a statistically significant difference with grade I, # indicates a statistically significant difference with grade II.

**Table 4:** Number of attempts of intubation, incidence of complications, Mallampati grading (MG) regarding Cormack and Lehane's grades:

| CL grades | Number of attempts of intubation | | | p-v |
|---|---|---|---|---|
| | **1** | **2** | **3** | |
| **I** | 87 | 0 | 0 | 0.00 |
| | 72.50% | 0.00% | 0.00% | |
| **II** | 33 | 0 | 0 | |
| | 27.50% | 0.00% | 0.00% | |
| **III** | 0 | 18 | 2 | |
| | 0.00% | 100% | 100% | |
| **CL grades** | **Complication** | | | **p-value** |
| | **Yes** | | **NO** | |
| **I** | 87 | | 0 | |
| | 69.60% | | 0.00% | |

| | | | | | |
|---|---|---|---|---|---|
| **II** | 33 | | 0 | | 0.00 |
| | 26.40% | | 0.00% | | |
| **III** | 5 | | 15 | | |
| | 4.00% | | 100% | | |
| **CL grades** | **MG** | | | | **p-value** |
| | **Grade 1** | **Grade 2** | **Grade 3** | **Grade 4** | |
| **I** | 27 | 53 | 7 | 0 | 0.00 |
| | 56.30% | 74.60% | 35.00% | 35.00% | |
| **II** | 18 | 9 | 6 | 0 | |
| | 37.50% | 12.70% | 30.00% | 35.00% | |
| **III** | 3 | 9 | 7 | 1 | |
| | 6.30% | 12.70% | 35.00% | 100% | |

CL: Cormack and Lehane grading. p: p-value for comparing the two studied categories

**Table 5:** Correlation between difficult Laryngoscopy and various parameters

| various parameters | R | P value |
|---|---|---|
| **Gender** | -.254* | .026 |
| **Age** | .223 | .052 |
| **weight** | .173 | .133 |
| **BMI** | .025 | .830 |
| **ASA** | .290* | **.011** |
| **Number of attempts of intubation** | .788** | **.000** |
| **PES** | .811** | **.000** |
| **E-Vc** | -.415** | **.000** |
| **PES/E-Vc** | .943** | **.000** |
| **Time of US** | .396** | **.000** |
| **complication** | .683** | **.000** |

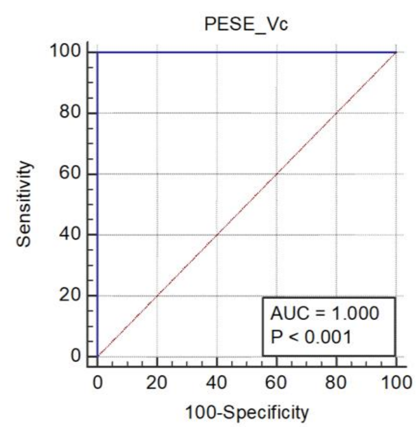
PES: Pre-epiglottic space, CL: Cormack and Lehane, E-Vc: Distance between the epiglottis and the vocal cords, BP: Blood pressure, BMI: Body mass index, ASA: American Society of Anesthesiology p: p-value for comparing the two studied categories. r: correlation coefficient **: Statistically highly significant at $p \leq 0.01$.

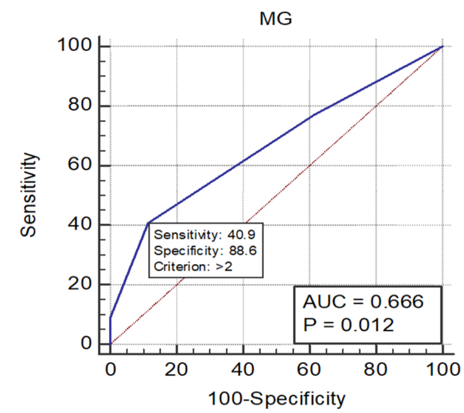
**Table 6:** Correlation between the number of attempts of intubation, complications, and various parameters:

| Number of attempts of intubation | r | P value |
|---|---|---|
| **Gender** | -.066 | .571 |
| **Age** | .056 | .626 |
| **weight** | .027 | .818 |
| **BMI** | -.067 | .564 |
| **ASA** | .193 | .092 |
| **PES** | .691** | **.000** |
| **E-Vc** | -.400** | **.000** |
| **PES/E-Vc** | .864** | **.000** |
| **Correlation between complications and various parameters** | | |
| **Complications** | **r** | **P value** |
| **Gender** | -.144 | .322 |
| **Age** | .007 | .949 |
| **weight** | -.022 | .847 |
| **BMI** | -.102 | .378 |
| **ASA** | .111 | .338 |
| **Number of attempts of intubation** | .831** | **.000** |
| **Difficult Laryngoscopy** | .683** | **.000** |

| Correlation between complications and various parameters | | |
|---|---|---|
| **Complications** | **r** | **P value** |
| **PES** | .664** | **.000** |
| **E-Vc** | -.323** | **.004** |
| **PES/E-Vc** | .787** | **.000** |
| **Time of US** | .243* | **.033** |

PES: Pre-epiglottic space, CL: Cormack and Lehane, E-Vc: Distance between the epiglottis and the vocal cords, BP: Blood pressure, BMI: Body mass index, ASA: American Society of Anesthesiology
p: p-value for comparing the two studied categories. r: correlation coefficient; **: Statistically highly significant at $p \leq 0.01$.

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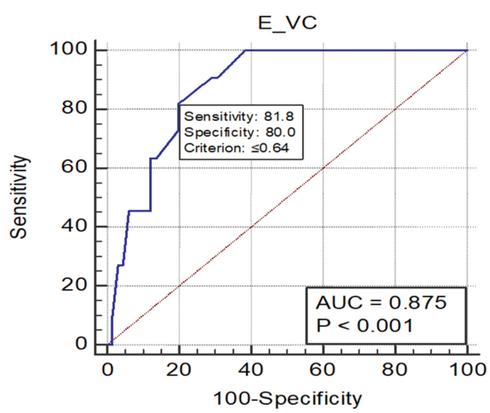


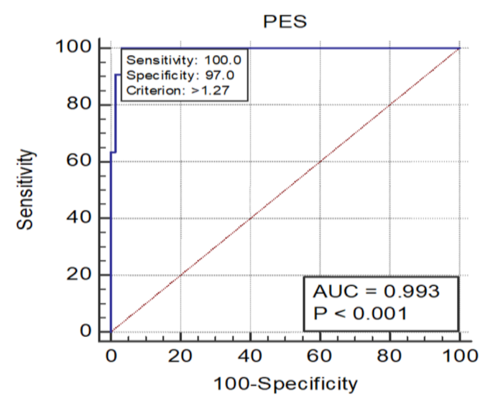


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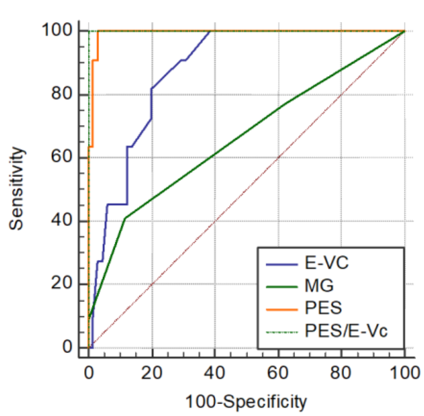


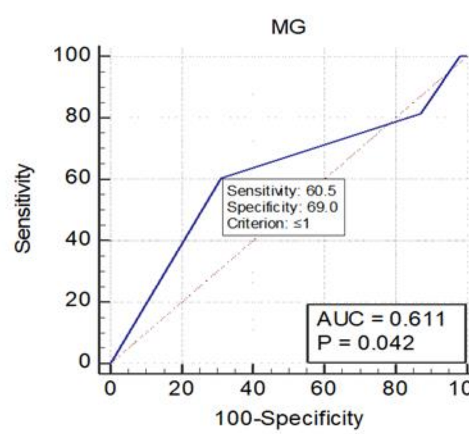

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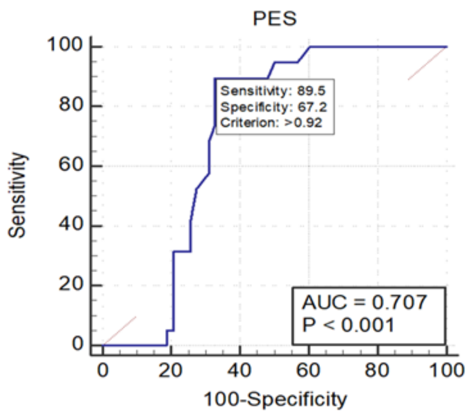


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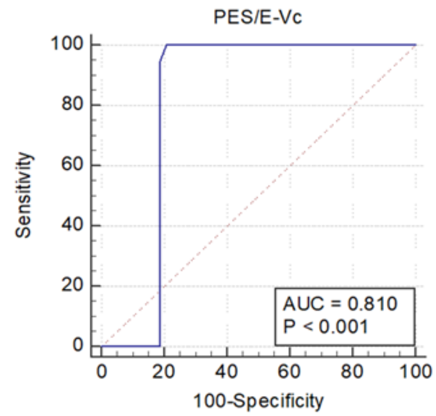


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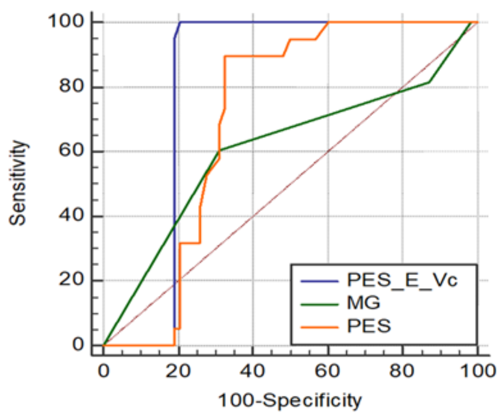


**(H)**

**(I)**

**Figure 1:** ROC curves for (**A**): prediction with CL grade 3 using PES/E-Vc, (**B**): prediction with CL grade 3 using MG, (**C**): prediction with CL grade 3 using E-Vc, (**D**): prediction with CL grade 3 using PES, (**E**): Comparison between ROC curves for prediction with difficult Laryngoscopy, (**F**): prediction with CL grade 2 using Mallampati grading, (**G**): prediction with CL grade 2 using PES, (**H**): prediction with CL grade 2 using PES/E-Vc, (**I**): Comparison between ROC curves for prediction with CL grade 2.
PES: Pre-epiglottic space, CL: Cormack and Lehane, E-Vc: Distance between the epiglottis and the vocal cords, BP: Blood pressure, BMI: Body mass index, ASA: American Society of Anesthesiology, MG: Mallampati grading, AUC: area under curve.

## DISCUSSION

Anesthesiologists now commonly use ultrasound for a range of procedures in the operating room and critical care areas. These include predicting the size of a pediatric endotracheal tube (ETT), confirming that the ETT is properly positioned, diagnosing pathology in the upper airway, guiding percutaneous tracheostomy and cricothyroidotomy, assisting with awake intubation, predicting post-extubation stridor, and ensuring proper positioning of the laryngeal mask airway. Additionally, it has been utilized to measure the thickness of the anterior neck soft tissues, the size of the vocal cords, the pre-epiglottic space (PES), the floor of the mouth musculature, and the distance from the epiglottis to the midpoint of that distance. Cormack-Lehane grading during direct laryngoscopy and results from physical assessments have been utilized to establish a correlation with these data [7].

Our research shows that a 30-second ultrasound of the neck is sufficient for determining a patient's Cormack Lehane grade. The anesthetic care teams can benefit from this additional tool, which is a fast and easy airway examination.

In this work, we used ultrasound to measure three parameters: the pre-epiglottic space depth (PES), the distance between the vocal cords and the epiglottis (E-VC), and the ratio of these two distances.

We observed a positive association between Pre-E and CL grade, a negative correlation between E-VC and CL grade, and the largest positive correlation between Pre-E/E-VC and CL grade as a ratio. Direct laryngoscopy involves inserting a McIntosh blade into the mouth. The hyoepiglottic ligament acts as a hinge, and the blade's tip moves the tongue and epiglottis aside to expose the voice chords. As a result, seeing the vocal cords becomes more challenging with increasing PRE-E depth since the tongue and epiglottis cannot be properly displaced. In a similar vein, a smaller space between the epiglottis and the vocal cords indicates a lower larynx visibility when the vocal cords are elevated.

The results showed that CL Grading correlates better with PRE-E distance/epiglottic vocal cord distance than Mallampati grading. This is because higher grades of CL Grading are associated with a greater PRE-E space and a smaller epiglottic vocal cord distance. Concurrently, a small ratio indicated reduced CL Grading and simple intubation if the PRE-E space was very large and the epiglottic vocal cord distance was significant.

As regards Cormack Lehane's grading, the present study showed that during intubation systolic BP was higher in patients diagnosed with grade III than in grade II and grade I patients. During intubation, satO2 was lower in patients diagnosed with grade III than in grade II and grade I patients.

Regarding to number of attempts of intubation, there was a positive correlation between the number of attempts and PES, PES/E-Vc; and a negative correlation between the number of attempts and E-Vc.

Gupta et al. [12] discovered a positive correlation between Pre-E and CL grade, a negative correlation between E-VC and the same grade, and the strongest positive correlation between the ratio of Pre-E/E-VC and CL grade in a study of 72 patients undergoing general anesthesia with endotracheal intubation. The present study results were in line with their study as The ratio of PE/E-VC was found to be significantly different from zero, with a sensitivity of one hundred percent and a specificity of one hundred percent ($P < 0.0001$). A higher ratio was linked to a higher Cormack-Lehane grade on direct laryngoscopy and could be utilized to anticipate intubation difficulties [10].

Rana et al. [13] discovered that a Pre E/E-VC ratio greater than 1.77 cm had an 82 percent sensitivity and 80 percent specificity in predicting difficult laryngoscopy in 120 patients having general anesthesia with endotracheal intubation. Their study was related to ours, which found that a Pre E/E-VC ratio greater than 1.75 cm had a sensitivity and specificity of 100% in predicting difficult laryngoscopy.

Researchers Himadarshini et al. [14] observed that the anterior neck soft tissue-vocal cord (ANS-VC) could be used as a guide to evaluating the airway in 155 patients undergoing general anesthesia with endotracheal intubation. The researchers also found that increased thickness had a sensitivity of 95.1% and specificity of 85.7% in predicting difficult intubation. Statistical significance was determined using a p-value of less than 0.001 for the pre-and post-EVC distance ratios. Our study found similar results, suggesting that the PE/E-VC ratio could be used as a guide for airway assessment. An increase in the ratio effectively predicted difficult intubation with a sensitivity of one hundred percent and a specificity of one hundred percent, and the p-value was less than 0.001.

Yadav et al. [15] found that among 200 patients receiving general anesthesia, those who had difficulty intubating had a proportion of Pre-E / E-VC that was considerably greater ($P = 0.00073$), which is consistent with our findings.

Consistent with our findings, a study conducted by Debomita et al. [16] on 94 patients receiving general anesthesia discovered a substantial association between CL and the ratio of PRE-E distance/epiglottic vocal cord distance (with a sensitivity of 83.4% and a specificity of 81.4%; $P=0.000$).

Reddy et al. [17] found no statistically significant link between the Pre-E and E-VC and the CL grade in a sample of 100 patients having general anesthesia with endotracheal intubation ($P = 0.154$ and 0.084 respectively). A significant connection ($P = 0.026$) was found between the CL grade and the ratio of Pre-E/E-VC. Our study also revealed similar results, but we found a statistically significant link between the Pre-E and E-VC and the CL grade ($P < 0.0001$ and $=0.0024$ respectively), as well as a significant correlation between the Pre-E/E-VC ratio ($p < 0.0001$).

In a study conducted by Mohammadi et al. [18] on 155 patients undergoing general anesthesia with endotracheal intubation, they discovered that a significant ratio of the distance from skin to epiglottis (DSE) / from the epiglottis to mid-vocal cord distance (EMVD) was associated with higher Cormack-Lehane grades on direct laryngoscopy and useful for predicting difficult intubation. The cutoff value for this ratio was 1.64, and it had a 95%

accuracy rate, 100% sensitivity, and 91% specificity (P=0.004). Our findings align with their work, which found that a ratio of PE/E-VC (with a sensitivity of 100 percent and a specificity of 100 percent; P <0.0001) was very useful in predicting challenging laryngoscopy, even though we utilized PE measurement rather than DSE.

On the other hand, Mohammadi et al. [18] found weak relationships between the pre-epiglottic space (Pre-E) and Cormack-Lehane grades I, II, and III in their study of 53 patients undergoing general anesthesia. Cormack-Lehane grades I, II, and III were not strongly correlated with the E-VC or distance from the epiglottis to the vocal cords. The correlations between the sonographic image and laryngoscopy were 87.5 percent sensitive and 30 percent specific, as measured by the (Pre-E)/(E-VC) ratio.

In contrast, Nazir et al. [19] on 90 patients undergoing general anesthesia observed that There was a very weak negative correlation between PES and CL grading, as well as a very weak positive correlation between EVL and CL grading when the researchers compared the pre-epiglottic space depth (PES) and the distance from the epiglottis to the midpoint of the vestibular ligaments (EVL) in order to predict difficult laryngoscopy. Statistical significance was not reached for either ultrasound measurement (p>0.05).

Possible explanations for this discrepancy include racial differences in airway anatomy, study limitations related to sample size and expertise, and variations in airway sonography techniques.

Our findings are consistent with those of Rana et al. [13] in that CL Grading is significantly correlated with the PRE-E distance/epiglottic vocal cord distance ratio. The results of our study were as follows: CL Grade 1 corresponds to 0-1.27, CL Grade 2 is approximately 1.27-1.75, and CL Grade 3 is greater than or equal to 1.75.

Limitations:

Some limitations of our study include a small sample size (no patient had a body mass index (BMI) >35 kg/m2) and the inclusion of only one race. One investigator obtained the ultrasonographic measurements, which could introduce bias. No cases of Cormack-Lehane grade IV were included, and the study did not include participants in the pediatric age range or those known to have difficult intubation. Neither did we check whether there was a connection between the two ultrasound-measured tongue volumes using the modified Mallampati class. The Mallampati class is determined by the space that the tongue occupies; future study that correlates this value with the Mallampati class could shed light on challenging laryngoscopies. Ultrasound can be used to determine the exact volume of the tongue.

Additional research is required to determine the best preoperative screening test combination for difficult intubations, taking into account US-guided predictors such as anterior soft tissue neck thickness at the level of the hyoid and vocal cord in addition to HMDR and Pre E/E-VC.

## CONCLUSION

Patients with difficult airway could be better identified with sonographic assessment of the upper airway. The ratio of the pre-epiglottic space to the distance between the epiglottis and a position midway through the vocal cords proved a reliable predictor for the Cormack-Lehane grading compared to Mallampati grading in which increasing Pre E and the ratio of Pre E/E-VC were associated with increased risk of difficult intubation.

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## REFERENCES

1. Pinto J, Cordeiro L, Pereira C, Gama R, Fernandes HL, Assunção J. Predicting difficult laryngoscopy using ultrasound measurement of the distance from skin to the epiglottis. J Crit Care. 2016;33:26-31.
2. Shiga T, Wajima Z, Inoue T, Sakamoto A. Predicting difficult intubation in apparently normal patients: a meta-analysis of bedside screening test performance. Anesthesiology. 2005;103(2):429-37.
3. Reed MJ, Dunn MJ, McKeown DW. Can an airway assessment score predict difficulty at intubation in the emergency department?. Emerg Med J. 2005;22(2):99-102.
4. Adnet F, Racine SX, Borron SW, Clemessy JL, Fournier JL, Lapostolle F, et al. A survey of tracheal intubation difficulty in the operating room: a prospective observational study. Acta Anaesthesiol Scand. 2001;45(3):327-32.
5. Lundstrøm LH, Vester-Andersen M, Møller AM, Charuluxananan S, L'hermite J, Wetterslev J;et al. Poor prognostic value of the modified Mallampati score: a meta-analysis involving 177 088 patients. Br J Anaesth. 2011;107(5):659-67.
6. Osman A, Sum KM. Role of upper airway ultrasound in airway management. J Intensive Care. 2016;4:52.
7. Fulkerson JS, Moore HM, Anderson TS, Lowe RF Jr. Ultrasonography in the preoperative

difficult airway assessment. J Clin Monit Comput. 2017;31(3):513-30.
8. Ezri T, Gewürtz G, Sessler DI, Medalion B, Szmuk P, Hagberg C, et al. Prediction of difficult laryngoscopy in obese patients by ultrasound quantification of anterior neck soft tissue. Anaesthesia. 2003;58(11):1111-4.
9. Hall EA, Showaihi I, Shofer FS, Panebianco NL, Dean AJ. Ultrasound evaluation of the airway in the ED: a feasibility study. Crit Ultrasound J. 2018;10(1):3.
10. Apfelbaum JL, Hagberg CA, Caplan RA, Blitt CD, Connis RT, Nickinovich DG,et al. Practice guidelines for management of the difficult airway: an updated report by the American Society of Anesthesiologists Task Force on Management of the Difficult Airway. Anesthesiology. 2013;118(2):251-70.
11. Cormack RS, Lehane J. Difficult tracheal intubation in obstetrics. Anaesthesia. 1984;39(11):1105-11.
12. Gupta D, Srirajakalidindi A, Ittiara B, Apple L, Toshniwal G, Haber H. Ultrasonographic modification of Cormack Lehane classification for pre-anesthetic airway assessment. Middle East J Anaesthesiol. 2012;21(6):835-42.
13. Rana S, Verma V, Bhandari S, Sharma S, Koundal V, Chaudhary SK. Point-of-care ultrasound in the airway assessment: A correlation of ultrasonography-guided parameters to the Cormack-Lehane Classification. Saudi J Anaesth. 2018;12(2):292-6.
14. Himadarshini L, Ganapathi P and Dr. Anish Sharma NG. Correlation between preoperative ultrasonographic airway assessment and laryngoscopic view in adult elective surgical patients: A prospective observational study. Int. j. multidiscip. res. dev.,2021 ;8(3):38-44.
15. Yadav U, Singh RB, Chaudhari S, Srivastava S. Comparative Study of Preoperative Airway Assessment by Conventional Clinical Predictors and Ultrasound-Assisted Predictors. Anesth Essays Res. 2020;14(2):213-8.
16. Debomita D, Dipasri B, Bani PMH, Arpita C. Comparative study of sonographic measurement of PRE-E/E-VC ratio versus Hyomental distance ratio to correlate Cormack–Lehane grading for airway assessment. Asian J. Med. Sci.;2022, 13(9): 34–8.
17. Reddy PB, Punetha P, Chalam KS. Ultrasonography - A viable tool for airway assessment. Indian J Anaesth. 2016;60(11):807-13.
18. Sussan S M, Abdolhossein B T,Mojtaba M. Correlation between Ultrasound Measured Distance from Skin to Epiglottis and Epiglottis to Mid-Vocal Cord with Cormack-Lehane Classification for Predicting Difficult Intubation. TUMS.; 2021,6(91): 23-6.
19. Nazir I, Mehta N. A comparative correlation of pre-anaesthetic airway assessment using ultrasound with cormack lehane classification of direct laryngoscopy. IOSR J Dental Med Sci. 2018,17(4):43–51.

**Supplementary Table 1:** Accuracy of prediction with difficult Laryngoscopy (CL grade 3)

| CL grade 3 | Cut -off | Sensitivity | Specificity | AUC | Youden index J | 95%CI | P |
|---|---|---|---|---|---|---|---|
| **MG** | >2 | 40.91 | 88.64 | 0.666 | 0.2955 | 0.586 to 0.740 | **0.0121** |
| **PES/E-Vc** | >1.75 | 100 | 100 | 1.000 | 1 | 0.976 to 1.000 | **<0.0001** |
| **E-VC** | ≤0.64 | 81.82 | 80.00 | 0.875 | 0.6182 | 0.811 to 0.923 | **<0.0001** |
| **PES** | >1.27 | 100 | 96.97 | 0.993 | 0.9697 | 0.964 to 1.000 | **<0.0001** |
| **PES/E-Vc versus MG** | P < 0.0001 | | | | | | |
| **MG versus PES** | P < 0.0001 | | | | | | |
| **E_VC versus MG** | P = 0.0024 | | | | | | |

95%CI: Lower and upper bound 95% confidence intervals. p: p-value for comparing the two studied categories. AUC: Area Under the ROC Curve

**Supplementary Table 2:** Accuracy of prediction with CL grade 2

| CL grade_2 | cut-off value | Sensitivity | Specificity | AUC | Youden index J | 95%CI | P |
|---|---|---|---|---|---|---|---|
| **MG** | ≤1 | 60.53 | 68.97 | 0.611 | 0.2949 | 0.529 to 0.688 | 0.0419 |
| **PES/E-Vc** | >1.27 | 100.00 | 79.31 | 0.810 | 0.7931 | 0.739 to 0.869 | <0.0001 |
| **PES** | >0.92 | 89.47 | 67.24 | 0.707 | 0.5672 | 0.628 to 0.777 | <0.0001 |
| **PES/E-Vc versus MG** | P value= **0.0035** | | | | | | |
| **MG versus PES** | P value= 0.1847 | | | | | | |

95%CI: Lower and upper bound 95% confidence intervals. p: p-value for comparing the two studied categories. AUC: Area Under the ROC Curve

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