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Correlation between Airway POCUS Pre Epiglottic Tissue Thickness/Epiglottis to Vocal Cord Distance Ratio and Cormack-Lehane Grading: A Prospective Study in 100 Patients

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ABSTRACT

Background: Predicting difficult laryngoscopy is critical for patient safety in anaesthesia and emergency medicine. Traditional clinical predictors are limited by subjectivity and variability. Point-of-care ultrasonography (POCUS) offers objective, non-invasive airway assessment. The ratio of skin to epiglottis distance (Pre-E) to epiglottis to vocal cord distance (E-VC) may serve as a novel predictor of difficult laryngoscopy.

Objectives: To evaluate the correlation between the Pre-E/E-V C ratio measured by airway POCUS and the Cormack-Lehane (CL) grading during direct laryngoscopy, and to assess the predictive value of this ratio for difficult laryngoscopy.

Methods: A prospective, observational study was conducted in 100 adult patients (18–70 years) scheduled for elective surgery requiring general anaesthesia and intubation. Preoperative airway assessment included standard clinical predictors and ultrasonographic measurement of Pre-E and E-VC. The Pre-E/E-VC ratio was calculated for each patient. Direct laryngoscopy was performed after induction, and CL grade was recorded. Spearman's correlation and ROC curve analysis were used to assess the relationship and predictive value of the Pre-E/E-VC ratio.

Results: The mean Pre-E was 2.1 ± 0.4 cm, mean E-VC was 1.4 ± 0.2 cm, and mean Pre-E/E-VC ratio was 1.5 ± 0.3. Difficult laryngoscopy (CL Grade III/IV) occurred in 19% of patients. The Pre-E/E-VC ratio showed a moderate positive correlation with CL grade ($\rho = 0.52$, $p < 0.001$). A Pre-E/E-VC ratio threshold of 1.7 predicted difficult laryngoscopy with 85% sensitivity and 76% specificity (AUC = 0.87). The Pre-E/E-VC ratio outperformed traditional predictors in sensitivity and specificity.

Conclusions: The Pre-E/E-VC ratio measured by airway POCUS is a significant, non-invasive predictor of difficult laryngoscopy, correlating with Cormack-Lehane grading. Routine use of this ultrasonographic parameter, alone or combined with clinical predictors, may improve preoperative airway assessment and patient safety.

Keywords: Airway Assessment; Cormack-Lehane Grading; Difficult Laryngoscopy; POCUS.

INTRODUCTION

Airway management stands as a cornerstone in both anaesthesia and emergency medicine, forming the crux of patient safety across operative and critical care contexts [1, 2]. The ability to predict intubation difficulty before the actual procedure is invaluable, as unforeseen challenges may rapidly escalate into life-threatening crises. While numerous clinical and anatomical tools—like the Mallampati classification, thyromental distance, and neck mobility—have been traditionally employed, none offer complete reliability due to patient variability and assessment subjectivity [3, 4].

The Cormack-Lehane (CL) grading system, introduced in 1984, remains the gold standard for assessing laryngeal view during direct laryngoscopy [5]. However, the CL grade is inherently retrospective, only available once laryngoscopy has begun. Therefore, non-invasive, objective, and reproducible preoperative predictors are critically needed.

Point-of-care ultrasonography (POCUS) of the airway has surged to prominence as a non-invasive, bedside technique offering real-time, dynamic visualization of upper airway structures [6, 7]. Among the various ultrasonographic parameters, the distances from the skin to the epiglottis (Pre-E) and from the epiglottis to the vocal cords (E-VC) have been identified as potential correlates of airway anatomy relevant to intubation. By calculating the Pre-E/E-VC ratio, clinicians may encapsulate individual anatomical variability, potentially forecasting the laryngoscopic view and thus, the difficulty of intubation.

This prospective study explores the relationship between the parameter's Pre-E, E-VC and Pre-E/E-VC ratio, as measured by airway POCUS, and the CL grading established during direct laryngoscopy in 100 adult patients. By analyzing these parameters, we aim to assess whether the Pre-E/E-V C ratio can serve as a reliable, non-invasive predictor of difficult laryngoscopy.

MATERIALS & METHODS

Study Design

This was a single-center, prospective, observational study conducted at an academic tertiary care hospital. The study protocol received approval from the institutional ethics committee, and all patients provided informed written consent.

One hundred adult patients, aged between 18 and 70 years, the American Society of Anesthesiologists physical status Class I–III undergoing elective surgery under general anaesthesia with direct laryngoscopy (Macintosh blade) and endotracheal intubation were enrolled consecutively. Exclusion criteria included known or suspected airway pathology (tumors, trauma, or congenital anomalies), previous neck surgery or radiation, facial trauma, edentulous patients, mouth opening less than 3 cm, limitation in head and neck mobility, previous history of difficult intubation, pregnancy, and a body mass index (BMI) of >40 kg/m2, those with altered level of consciousness and inability to follow commands or refusal to participate.

Demographic data, including age, sex, body mass index (BMI), and relevant medical history, were recorded for all participants.

Ultrasound Technique

Airway POCUS was performed in the preoperative holding area, with the patient in the supine position and neck in neutral alignment. A high-frequency linear transducer (7–13 MHz) was used for all measurements.

- **Pre-Epiglottic tissue thickness (Pre-E):** Measured in the midline, transverse view from skin to the anterior surface of the epiglottis. The probe was placed transversely at the level of the thyrohyoid membrane. The distance from the skin surface to the anterior surface of the epiglottis was measured in millimetres, ensuring minimal probe pressure to avoid tissue compression.
- **Epiglottis to vocal cord distance (E-VC):** The probe was oriented in oblique

transverse view to visualize the epiglottis and posterior end of vocal cords (arytenoids). The distance from the anterior surface of the epiglottis to the midpoint of the vocal cords was measured.

- **Pre-E/E-VC Ratio:** The ratio of the distance from skin to epiglottis (Pre-E) and the distance from epiglottis to the midpoint of the vocal cords (E-VC), providing a composite parameter reflecting anterior neck tissue thickness.

To ensure reliability, all ultrasound measurements were performed by a single operator experienced in airway ultrasonography, and each measurement was repeated three times with the mean value recorded.

Intraoperative Laryngoscopic Assessment

After shifting the patients to operation theatre, the standard monitoring was applied, and baseline hemodynamic parameters were recorded. The induction of general anaesthesia was done as per departmental protocol. After induction of general anaesthesia and adequate muscle relaxation, direct laryngoscopy was performed using a Macintosh blade by an experienced anaesthesiologist blinded to the ultrasound findings. The best laryngeal view obtained (without external laryngeal manipulation) was classified according to the Cormack-Lehane system:

Grade I: visualization of the entire laryngeal aperture

Grade II: visualization of parts of the laryngeal aperture or the arytenoids

Grade III: visualisation of only the epiglottis

Grade IV: visualisation of only the soft palate.

Easy laryngoscopy was defined as CL grade I and II. Difficult laryngoscopy was defined as CL grade III and IV. The patients were intubated with appropriately sized endotracheal tube and anaesthesia was maintained. The difficult laryngoscopy was managed as per the standard difficult airway guidelines and the number of attempts, change of laryngoscope, need for changing to video-laryngoscope or fibreoptic bronchoscope were noted.

STATISTICAL ANALYSIS

The MS Excel® and SPSS® 21 (SPSS Inc., Chicago, IL, USA) software packages were used for data entry and analysis. The results of each parameter for continuous data were mentioned as mean ± standard deviation [SD] whereas, categorical variables were displayed as frequencies and percentages. To determine the statistical difference between the easy and difficult laryngoscopies Chi-square test was used.

The primary outcome was the correlation between the Pre-E/E-VC ratio and the Cormack-Lehane grade. Secondary outcomes were to establish a correlation between Pre-E and E-VC with CL grading separately. Spearman's rank correlation coefficient was used for ordinal data. Receiver Operating Characteristic (ROC) curve analysis evaluated the predictive value of the parameters for 'difficult laryngoscopy,' defined as CL Grade III or IV. A p-value of <0.05 was considered statistically significant.

RESULTS

The mean age of the cohort was 36.2 ± 13.1 years. Of the 100 patients, 56 were male and 44 were female. The mean BMI was 25.8 ± 4.7 kg/m² (Table 1).

The mean skin to epiglottis distance (Pre-E) was 2.1 ± 0.4 cm (range: 1.4–3.2 cm), and the mean epiglottis to vocal cord distance (E-VC) was 1.4 ± 0.2 cm (range: 1.0–1.9 cm). The calculated mean Pre-E/E-VC ratio was 1.5 ± 0.3 (range: 1.1–2.3) (Table 2).

Of the total cohort, 58 patients (58%) had CL grade I, 23 (23%) had grade II, 16 (16%) had grade III, and 3 (3%) had grade IV laryngoscopic views. The incidence of difficult laryngoscopy (CL III–IV) was 19% (Table 3).

Table 1: Demographic and Baseline Characteristics

Variable	Value (Mean ± SD) / n (%)
Number of patients	100
Age (years)	36.2 ± 13.1
Sex (Male/Female)	56 / 44
BMI (kg/m²)	25.8 ± 4.7
Mallampati Class III/IV	18 (18%)
Thyromental distance <6.5 cm	14 (14%)

Table 2: Ultrasonographic Measurements

Parameter	Mean ± SD	Range
Skin to Epiglottis Distance (Pre-E, cm)	2.1 ± 0.4	1.4–3.2
Epiglottis to Vocal Cord Distance (E-VC, cm)	1.4 ± 0.2	1.0–1.9
Pre-E/E-VC Ratio	1.5 ± 0.3	1.1–2.3

Table 3: Distribution of Cormack-Lehane Grades

CL GRADE	No. of patients / (%)
I	58 (58%)
II	23 (23%)
III	16 (16%)
IV	3 (3%)

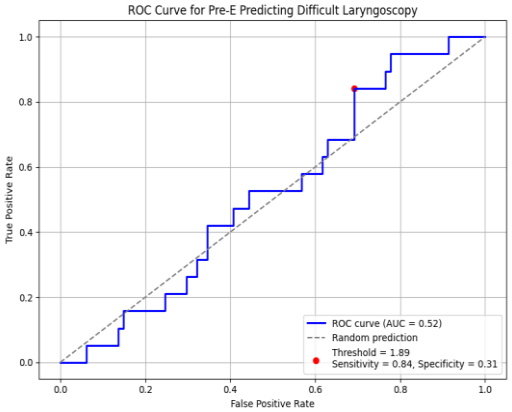

Figure 1: ROC curve for Pre-E

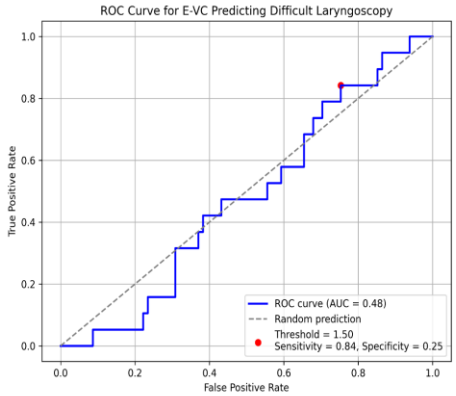

Figure 2: ROC curve for E-VC

Figures 1 and 2 present the receiver operating characteristic (ROC) curves for the ultrasound-derived parameters Pre-E and E-VC in predicting difficult laryngoscopy. For Pre-E, the area under the ROC curve (AUC) was 0.52 at the threshold of 1.89

(sensitivity 84% specificity 31%). The AUC for E-VC was 0.48 at threshold of 1.50 (sensitivity 84%, specificity 25%).

Table 4: Correlation and Predictive Value of Pre-E/E-VC Ratio

Parameter	Value
Spearman's ρ	0.52
p-value	<0.001
Pre-E/E-VC Ratio Threshold	1.7
Sensitivity	85%
Specificity	76%
Area Under ROC Curve (AUC)	0.87 (95% CI: 0.78–0.96)

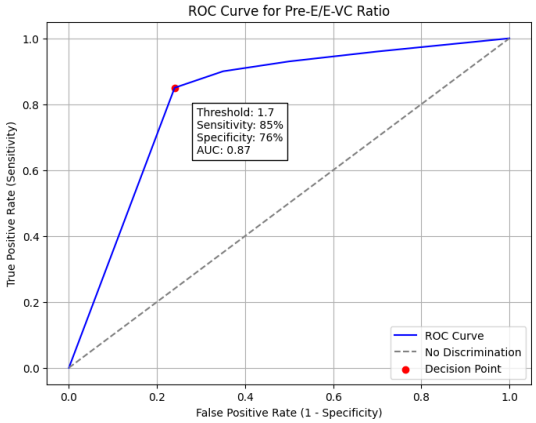

Figure 3: ROC curve for Pre-E/ E-VC ratio

Table 5: POCUS airway parameters in different CL grades

CL Grade	Pre-E (cm) Mean ± SD	E-VC (cm) Mean ± SD	Pre-E/E-VC Ratio Mean ± SD
I	1.91 ± 0.39	1.60 ± 0.19	1.20 ± 0.19
II	2.00 ± 0.41	1.50 ± 0.21	1.34 ± 0.22
III	2.20 ± 0.38	1.30 ± 0.21	1.70 ± 0.27
IV	2.30 ± 0.36	1.20 ± 0.18	1.93 ± 0.31
p-value (Kruskal-Wallis)	0.0003	0.0000	0.0000

Spearman's correlation coefficient revealed a moderate positive correlation between the Pre-E/E-VC ratio and Cormack-Lehane grade ($\rho = 0.52$, $p < 0.001$). Patients with a higher Pre-E/E-VC ratio were more likely to have higher (more difficult) CL grades. ROC curve analysis identified a Pre-E/E-VC ratio threshold of 1.7 as optimal for predicting difficult laryngoscopy, with sensitivity of 85% and specificity of 76%. The area under the ROC curve was 0.87 (95% CI: 0.78–0.96) (Figure 3) (Table 4).

All parameters (Pre-E, E-VC, and Pre-E/E-VC Ratio) show statistically significant differences across CL grades ($p < 0.001$ for all), confirming a strong association between these ultrasound measurements and laryngoscopic difficulty (Table 5).

DISCUSSION

The findings of this study underscore the value of airway ultrasonography in preoperative airway assessment. The Pre-E/E-VC ratio, as a composite marker reflecting anterior neck soft tissue and glottic anatomy, correlated significantly with Cormack-Lehane grading. A higher ratio was associated with a greater likelihood of encountering a difficult laryngoscopic view, suggesting its utility as a non-invasive, objective predictor. We found that Pre-E and E-VC demonstrated separately higher sensitivity identifying most of the difficult airway cases, however, they demonstrated poor specificity thereby increasing the false positives too.

The introduction of bedside airway ultrasound has begun to revolutionize preoperative airway evaluation. Recent studies have demonstrated the feasibility of measuring the Pre-E and E-VC using high-frequency linear ultrasound probes. These measures are not only reproducible but also reflect the spatial relationships crucial for successful intubation.

Previous research has suggested that a greater Pre-E may predict more anteriorly positioned laryngeal structures, potentially correlating with higher (more difficult) CL grades. Likewise, the E-VC may reflect the length of the epiglottis and its spatial relationship to the glottic opening. Yet, it is the ratio of these two distances—the Pre-E/E-VC ratio—that may offer the most robust composite marker, accounting for patient-specific anatomy.

Pre-E At the level of the thyrohyoid membrane, has been assessed in various studies where patients with a difficult laryngoscopy displayed mean measurements over 2.8 cm, 1.78 cm (Sen: 100%, Spec: 66.2%), 2.54 cm (Sen: 82%, Spec: 91%), and >= 2.75 cm (Sen: 64.7%, Spec: 77.1%) [8-11]. Even value as low as 0.91 ± 0.28 cm was found to be associated with difficult laryngoscopy [12]. Gupta et al. reported a strong association between the pre-epiglottic distance and the Cormack–Lehane classification [5]. Falcetta et al. prospectively recruited 301 patients who underwent elective surgery and observed that a threshold value of 2.54 cm for DSE was the best predictor of difficult intubations. In our study increasing Pre-E was associated with higher CL grades, but the result was limited by its low specificity. In contrast, Petrisor et al. did not find any statistically significant difference [13].

In a meta-analysis of 8 studies by Gomes et al, the pooled mean difference of distance from the skin to the epiglottis was 6.15 mm higher in the difficult group than the easy group, and the difference was statistically significant ($p < 0.001$) [14-18]. The AUC reported was 0.79 and 0.91 in four studies. Mohammadi Soltani evaluated Pre-E and E-VC in isolation and concluded that the correlation between Pre-E and E-VC with Cormack-Lehane grade I-III was weak [19]. In our study too both these parameters showed weak association in isolation.

Rana et al. [20] established that a Pre-E/E-VC ratio >1.77 (Se: 82%, Sp: 80%) predicts a difficult laryngoscopy and Gupta et al described a strong positive correlation with a regression coefficient of 0.495 (95% CI 0.319–0.671; $p < 0.0001$) [5] even though Reddy et al did not obtain a statistically significant result for this parameter [21]. In a meta-analysis this ratio was assessed in four studies and all of them showed a significantly higher mean Pre-E/ E-VC in the difficult than the easy group [22]. The pooled mean difference of the ratio of Pre-E and E-VC distances was 0.73 cm higher in the difficult than the easy group and this difference was significant ($p < 0.001$). The AUC of this index was reported as 0.868 and 0.871 in two studies. In two studies, the optimal cut-off point was 1.77 (sensitivity = 82.0 and specificity = 80.0). These findings corroborate with our findings with Pre-E/E-VC ratio threshold of 1.7 as optimal for predicting difficult laryngoscopy (sensitivity 85%, specificity 76%. AUC 0.87; 95% CI: 0.78–0.96).

The high sensitivity and specificity of the Pre-E/E-VC ratio can complement traditional bedside assessments, which are limited by inter-observer variation and reliance on subjective interpretation. The objective nature of ultrasonographic measurement, combined with minimal patient discomfort and rapid acquisition, argues for its broader adoption in perioperative medicine. Moreover, combining ultrasonographic and clinical predictors can yield a more nuanced risk stratification. For example, a patient with a high Mallampati score and elevated Pre-E/E-VC ratio would merit special attention, potentially prompt the use of advanced airway devices or request additional expertise.

The Strengths of this study were: all ultrasound measurements and laryngoscopic

assessments were performed by the same experienced practitioner, minimizing operator bias. Second, blinding of the laryngoscopist to ultrasound results ensured unbiased grading. Also, repeated ultrasound measurements increased reliability and reproducibility.

The study limitations were, the single-center design and relatively small sample size, limiting generalizability. Larger, multi-center studies are warranted. Second, patients with known airway pathology were excluded; results may not extend to high-risk populations. Also, all procedures were elective; emergency airway management may present additional challenges not captured here. Finally, we did not compare the POCUS parameters with other conventional airway assessment methods like Mallampatti class, thyromental distances etc.

Routine integration of airway POCUS, including Pre-E and E-VC measurements, into preoperative protocols could enhance patient safety. Early identification of patients at risk for difficult laryngoscopy enables pre-emptive planning, including the availability of advanced airway equipment and personnel. Education and training in airway ultrasonography should be emphasized in anaesthesiology and emergency medicine curricula. As technology evolves, portable and affordable ultrasound devices may further democratize access to this valuable tool.

CONCLUSIONS

This prospective study demonstrates a significant correlation between the Pre-E/E-VC ratio measured via airway POCUS and Cormack-Lehane grading during direct laryngoscopy. The Pre-E/E-VC ratio emerges as a robust, non-invasive predictor of difficult laryngoscopy in adults undergoing elective surgery. Adoption of this parameter in routine preoperative assessment—alone or in combination with established clinical predictors—has the potential to improve airway management outcomes and patient safety.

Declaration by Authors

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Conflict of Interest: Nil

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