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Correlation between Point-of-Care Ultrasound (POCUS) airway parameters and Cormack-Lehane grading

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Abstract:

Background and aims: Airway assessment is an important part of pre-anaesthetic check-ups, which mostly rely on bedside screening tests. However, these are subjective tests and have significant inter-observer variability. Point of care ultrasound (POCUS) airway has proven to be an important add-on in airway examinations with multiple parameters defined by now. We aim to identify if tongue thickness (TT), distance from skin to hyoid bone (DSH) and hyomental distance ratio (HMDR) have any correlation with Cormack Lehane (CL) grading in identifying difficult airways.

Methods: This prospective, observational study was conducted in a tertiary care institute and included 100 adult patients between 18 to 70 years, ASA grade I-III, Scheduled to under elective surgeries under general anaethesia. The POCUS assessment of airway parameters TT, DSH and HMDR was performed by the study investigator during pre-anaesthetic check-up. During laryngoscopy, CL grading was assessed. The data was entered and analyzed. The statistical analysis was done using SPSS version 21.0.

Results: Difficult laryngoscopy was observed in 19 (19%) patients. The TT>59mm (sensitivity 76%, specificity 81%) and DSH > 9.5 mm (sensitivity 83%, specificity 79) had a high predictive value in identifying difficult airway. The HMDR < 1.28 had a moderate predictive value in identifying difficult airway (sensitivity 69%, specificity 74%).

Conclusion: The POCUS airway parameters tongue thickness, distance from skin to hyoid and hyomental distance ratio are very useful predictors to identify difficult airway in the cutoff values of >59 mm, > 9.5 mm and <1.28 respectively.

Key-words: Airway; Cormack-Lehane grading; Difficult laryngoscopy; Ultrasonography.

Introduction

Airway assessment remains a cornerstone of safe anaesthesia and emergency medicine practice [1]. Predicting a difficult airway is critical for reducing perioperative morbidity and mortality, the incidence of difficult airway varies from 1.5 to 13% [2]. Traditional bedside screening tests, such as the Mallampati score or thyromental distance, often demonstrate limited sensitivity and specificity [3]. In recent years, point-of-care ultrasound (POCUS) has emerged as a promising, non-invasive tool to augment the clinical evaluation of the airway, offering real-time, dynamic visualisation of relevant anatomical structures [4]. Several articles are emerging, trying to establish correlation between various POCUS airway parameters and difficult airway [5, 6]. This report presents comprehensive observational data on key POCUS airway parameters—tongue thickness, hyomental distance ratios and distance from skin to hyoid—and explores their correlation with the Cormack-Lehane (CL) grading system, a widely accepted classification of laryngoscopic view and thus, airway difficulty.

This document aims to provide an in-depth, data-driven analysis of these parameters, elucidate their relevance in airway assessment, and discuss their potential utility in predicting difficult laryngoscopy. The intended audience includes medical professionals and clinical researchers interested in airway management and the integration of ultrasound technologies into routine clinical practice.

Material and Methods

Study Design

This observational study was conducted at a tertiary care centre over a period of 12 months. The study protocol was approved by the institutional ethics committee, and written informed consent was obtained from all participants. The goal was to systematically evaluate POCUS airway parameters and correlate them with CL grade obtained during direct laryngoscopy.

Patient Selection

Inclusion criteria: Patients of 18–70 years with only 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 included. Exclusion criteria included patients with known airway pathology, 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.

Ultrasound Technique and Measurement Protocols

All ultrasound assessments were performed preoperatively by clinicians trained in airway sonography, using a high-frequency linear transducer (7–13 MHz) for most of the parameters except tongue thickness and hyomental distance which required low-frequency curved transducer (3-5 MHz). Patients were positioned supine with the head in neutral and sniffing positions as appropriate for each parameter. Standardised protocols were followed for each measurement (Figure 1):

- **Tongue Thickness (TT):** Measured in the mid-sagittal plane, using curved transducer, from the submental skin to the superior surface of the tongue, with the mouth closed and tongue at rest (Figure 2).
- **Hyomental Distance (HMD) Ratio**: HMD was measured from the hyoid bone to the mentum in both neutral (HMDn) and extended (HMDe) head positions. The ratio HMDe/HMDn was calculated. The HMDe/HMDn ratio reflects the relative increase in distance upon extension, serving as a surrogate for neck mobility and submandibular compliance (Figure 2).
- **Distance from Skin to Hyoid (DSH):** Measured in the transverse plane at the level of the hyoid bone, from skin surface to the anterior aspect of the hyoid, using linear probe.

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. Direct laryngoscopy was performed by a clinician blinded to USG findings, and the laryngoscopic view was graded according to the Cormack-Lehane (CL) classification:

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 number of intubation attempts, need for alternative intubation approaches or inability to secure the airway was also noted.

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 sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated to assess the predictive value of the tests. To assess the optimal cut-off scores, receiver operating characteristic (ROC) graphs were plotted and the area under the curve was calculated to assess the prognostic accuracy.

Figure 1: Performing POCUS Airway

Results

A total of 100 patients were included in the final analysis (Table 1). 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% (Figure 3) (Table 4).

TABLE 1: Demographic data

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%)

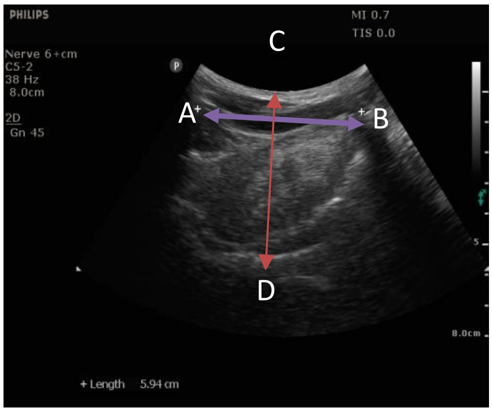

Figure 2: AB=Hyomental distance (HMD), CD=Tongue Thickness (TT)

Table 3: Summary Statistics for Airway Parameters

Parameter	Mean (SD)	Range
Tongue Thickness (mm)	53.2 (6.1)	41–69
HMDn (cm)	4.8 (0.4)	3.6–5.6
HMDe (cm)	6.4 (0.5)	5.1–7.7
HMDR	1.33 (0.06)	1.18–1.49
DSH (mm)	8.7 (1.2)	6.1–11.4

Table 4: Distribution by Cormack-Lehane Grade

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

Parameters	CL Grade	n	Mean	± SD	Unpaired T-test	P-value
DSH (mm)	E D	81 19	10.2 8.8	1.0 1.1	-5.389	<0.0001
TT (mm)	E D	81 19	51.9 58.4	5.6 5.7	4.538	<0.0001
HMDR (E/N) ratio	E D	81 19	1.25 1.34	0.04 0.05	8.403	<0.0001

Table 2: Ultrasonographic airway parameters in comparison to Cormack Lehane grade

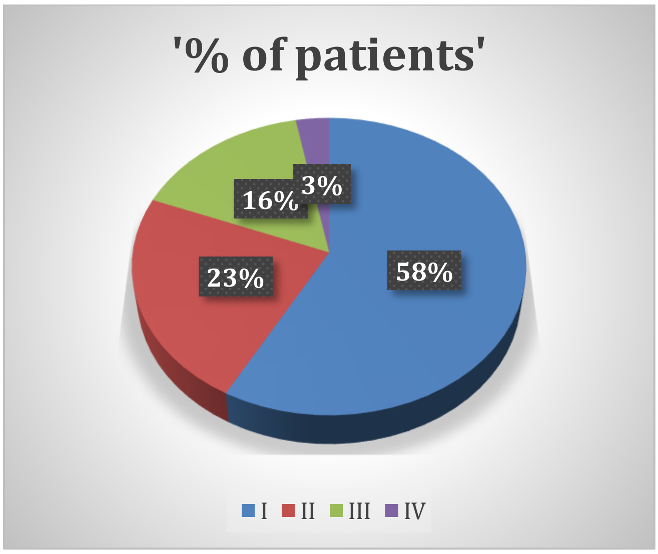

Figure 3: Distribution by Cormack-Lehane Grade

Correlation of POCUS airway parameters with CL Grade (Table 5)

Correlation of Tongue Thickness with CL Grade

The mean tongue thickness across the cohort was 53.2 mm (SD 6.1). Patients with CL grades III–IV demonstrated significantly greater tongue thickness (mean 58.4 mm, SD 5.7) compared to those with CL grades I–II (mean 51.9 mm, SD 5.6; $p < 0.001$).

Statistical analysis (Pearson's correlation, $r = 0.42$, TT > 59 mm as an independent predictor of difficult laryngoscopy (sensitivity 76%, specificity 81%, AUC= 0.814) (Figure 4).

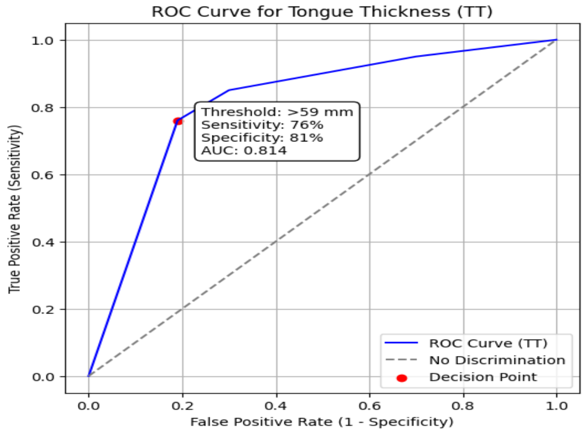

Figure 4: Correlation of Tongue Thickness with CL Grade

Correlation of DSH with CL Grade

The mean skin-to-hyoid distance was 8.7 mm (SD 1.2). Patients with higher CL grades (III–IV) had greater mean distances (10.2 mm, SD 1.0) compared to grades I–II (8.4 mm, SD 1.1; $p < 0.001$).

A strong positive correlation was observed ($r = 0.51$, DSH > 9.5 mm was associated with increased risk of difficult laryngoscopy (sensitivity 83%, specificity 79%, AUC= 0.87) (Figure 5).

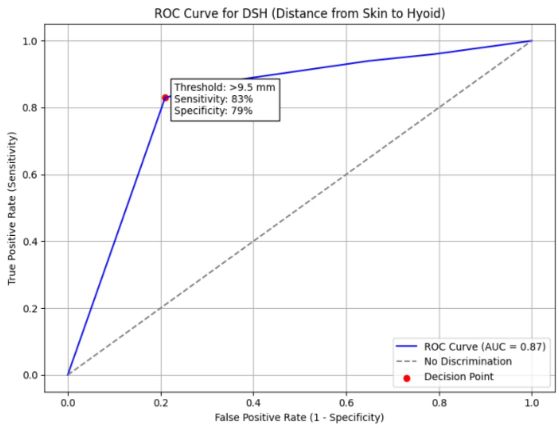

Figure 5: Correlation of DSH with CL Grade

Parameter	Correlation with CL Grade	Threshold	Sensitivity (%)	Specificity (%)	AUC	Predictive Value
TT	r = 0.42 (Pearson)	> 59 mm	76	81	0.814	Strong predictor of difficult laryngoscopy
DSH	r = 0.51 (Pearson)	> 9.5 mm	83	79	0.87	Strong predictor of difficult laryngoscopy
HMDR	rho = –0.37 (Spearman)	< 1.28	69	74	0.73	Moderate predictor of difficult laryngoscopy

Table 5: Correlation of POCUS Airway parameters with CL grade [Correlation coefficients: TT and DSH use Pearson's r; HMDR uses Spearman's rho]

Correlation of HMDR with CL Grade

The mean HMDn was 4.8 cm (SD 0.4), and mean HMDe was 6.4 cm (SD 0.5), yielding a mean HMDR of 1.33 (SD 0.06). Patients with CL grades III–IV had significantly lower HMDR ratio (mean 1.25, SD 0.04) compared to grades I–II (mean 1.34, SD 0.05; $p < 0.01$).

A lower HMDR was associated with higher CL grade (Spearman's rho = –0.37, $p < 0.01$). A ratio <1.28 predicted difficult laryngoscopy (sensitivity 69% and specificity 74%, AUC=0.73) (Figure 6).

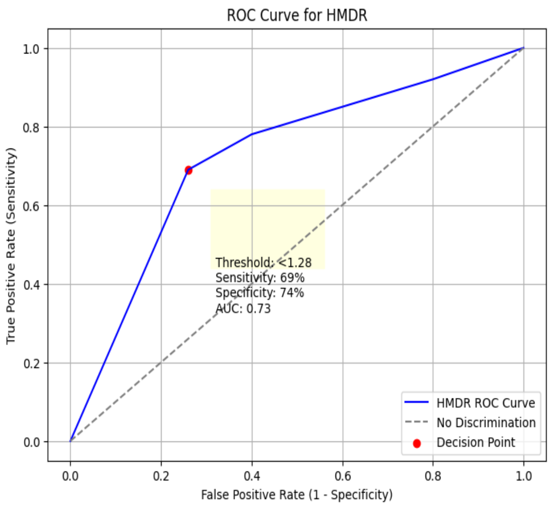

Figure 6: Correlation of HMDR with CL Grade

Comparative Analysis

Multivariate logistic regression including all parameters identified tongue thickness, skin-to-hyoid distance, and HMDR as independent predictors of difficult laryngoscopy (TT > 59 mm and DSH >9.5 mm achieved the highest predictive accuracy.

Parameter Inter-relationships:

Tongue thickness correlated moderately with skin-to-hyoid distance ($r = 0.44$), suggesting that increased submental tissue may reflect overall anterior neck thickness. The HMDR showed weak negative correlation with tongue thickness and skin- to-hyoid distance, indicating partial independence of neck mobility and tissue bulk.

Discussion

Our data demonstrate that several sonographic airway parameters, specifically tongue thickness, skin-to-hyoid distance, and hyomental distance ratio, exhibit significant correlation with Cormack-Lehane grades and thus, the likelihood of a difficult laryngoscopy. Larger tongue thickness and increased anterior neck tissue bulk were associated with higher CL grades, reflecting more challenging visualisation of glottic structures during direct laryngoscopy. The HMDR ratio, representing neck extension capacity and submandibular compliance, was lower in patients with difficult airways.

The use of POCUS in airway assessment offers several advantages: it is non-invasive, repeatable, and provides objective, quantifiable data.

Incorporating POCUS parameters into routine preoperative evaluation may enhance the prediction of difficult laryngoscopy, especially in patients with ambiguous or borderline clinical findings. This could lead to improved planning, resource allocation, and patient safety. When used in combination, ultrasound-derived parameters improved the sensitivity and specificity for predicting difficult laryngoscopy compared to individual measurements or traditional clinical tests alone. The integration of POCUS parameters into preoperative assessment protocols may facilitate early identification and management of potentially difficult airways.

Our findings are consistent with prior studies reporting the utility of tongue thickness and skin-to-hyoid distance as predictors of difficult airway. The observed thresholds in our cohort align with previously published cut-offs, though variation exists due to differences in patient populations and measurement techniques.

Yadav NK et al. showed a median TT of 5.30 cm in easy laryngoscopy and 6.1 cm in difficult laryngoscopy [7]. It predicted difficult laryngoscopy (*AUC* 0.72) with a sensitivity of 71% and specificity of 72%. Pillai et al found the values respectively 6.35 for difficult laryngoscopy and 5.3 for easy laryngoscopy [8]. In their study, a cutoff TT $\geq$ 5.98 could predict difficult laryngoscopy with higher sensitivity (83%) and higher specificity (88%). Yao W et al reported a sensitivity of 75% and specificity of 72% at TT > 6.1 cm in predicting difficult laryngoscopy (*AUC* 0.69, $p < 0.001$) [9]. Similar results were found by Xu et al, where a tongue thickness > 5.86 cm predicts difficult laryngoscopy with a sensitivity = 85% and specificity = 91% [10]. In our study too, TT > 59 mm was an independent predictor of difficult laryngoscopy (sensitivity 76%, specificity 81%).

Wu et al. in their study of 203 patients found that DSH measurements were greater in the difficult DL group and recognized it as a potential predictor of difficult intubation ($p = 0.0001$) [5]. Zheng et al also found a strong positive correlation between DSH and CL grading [11]. They showed an AUC of 0.9 with a sensitivity of 85.7% and specificity of 85.1% at cutoff 1.28 cm ($p < 0.0001$). Similarly, Adhikari et al in 51 African American patients [1] and Koundal et al in 200 Indian patients [12] found that the distance from the skin to hyoid bone is a reliable predictor of difficult laryngoscopy ($p = 0.000$). Contrary to our findings, Reddy et al [13], Chabbra et al [14] and Pillai et al [8] showed that DSH is not indicative of difficult intubation ($p > 0.05$).

The HMDR ratio has also been validated as a marker of neck mobility, reinforcing its value in airway assessment. Takenaka et al first introduced HMDR in patients with rheumatoid arthritis in the sitting position and concluded HMDR < 1.2 cm is associated with difficult intubation [15]. In another study conducted in obese patients, HMDR range of 1.0-1.03 was found to be associated with difficult intubation and 1.12-1.16 with easy intubation [16]. These results have been further confirmed by two different researchers with almost similar results. Huh *et al* evaluated the predictive value of HMDR measurements in 213 nonobese adult patients and concluded that HMDR alone had the highest predictive validity for difficult laryngoscopy with an optimal cutoff point of 1.2 with a sensitivity of 88% and specificity of 60% for predicting difficult laryngoscopy [17]. In our study HMDR showed a moderate association with CL with sensitivity of 69% and specificity of 74% with a cutoff value of 1.28.

The values of different parameters appear to be different in our study in comparison to various other studies as the standard threshold value as observed in other racial and ethnic population in predicting difficult airway may not apply to the Indian population. Despite this, our study gives comparative and useful insights into the application of POCUS in airway assessment.

Our study has some limitations, too. Single-centre design may limit generalisability to broader populations. The procedures were operator dependent and inter-observer variability in ultrasound measurements are very likely. Exclusion of patients with known airway pathology may underestimate performance in high-risk groups. We did not compare POCUS parameters directly with other bedside tests (e.g., Mallampati, thyromental distance) in this cohort. Sample size for difficult laryngoscopy (CL III–IV) was relatively small, potentially affecting statistical power.

Areas for Further Research

Future multicentre studies with larger, more diverse populations are warranted to validate these findings and establish standardised measurement protocols. Comparative studies integrating POCUS with established clinical predictors and machine learning-based risk models may further refine airway assessment algorithms.

Conclusion

In summary, this observational analysis demonstrates that POCUS-derived parameters—particularly tongue thickness, skin-to-hyoid distance, and hyomental distance ratio—are valuable predictors of difficult laryngoscopy as reflected by higher Cormack-Lehane grades. Their integration into preoperative airway assessment protocols may enhance the identification and management of patients at risk for difficult airway, with potential to improve perioperative safety and outcomes.

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