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COMPARATIVE EVALUATION OF CLINICAL AND ULTRASONOGRAPHIC AIRWAY ASSESSMENT PARAMETERS IN PREDICTING CORMACK–LEHANE LARYNGOSCOPIC GRADE: A PROSPECTIVE OBSERVATIONAL STUDY

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ABSTRACT

Background: Predicting a difficult airway is critical in anesthesia practice, yet conventional clinical screening tests (e.g. Mallampati score, thyromental distance) have limited sensitivity and specificity. Point-of-care ultrasound (POCUS) has emerged as a promising adjunct, providing objective measurements of neck soft tissue anatomy that may correlate with laryngoscopic view. This study compares standard clinical airway predictors with ultrasonographic (US) measurements and examines their correlation with the Cormack–Lehane (CL) grade at intubation. **Materials and Methods:** In this prospective study, 120 adult patients (ASA I–III) undergoing elective surgery were enrolled. Patients were assigned to Group C (n=60), where clinical airway parameters were assessed preoperatively (modified Mallampati grade, thyromental distance, sternomental distance, etc.), or Group U (n=60), where ultrasound parameters were recorded (anterior neck soft-tissue thickness at the hyoid level [ANS-H], at the vocal cords [ANS-VC], pre-epiglottic space [Pre-E], epiglottis-to-vocal cords distance [E-VC], etc.). All patients underwent direct laryngoscopy by an experienced anesthesiologist, and the CL grade (I–IV) was noted. Statistical analysis included Chi-square or ANOVA tests for associations, and Receiver Operating Characteristic (ROC) curve analysis to evaluate diagnostic performance. A p-value <0.05 was considered significant. **Result:** Mallampati score was significantly associated with CL grade (p=0.042) in the clinical group, whereas thyromental and sternomental distances were not. In the ultrasound group, ANS-VC thickness and E-VC distance differed significantly across CL grades (p=0.042 and p=0.027, respectively), while ANS-H, Pre-E, and Pre-E/E-VC ratio showed no significant correlation. ROC analysis showed only moderate predictive accuracy: for example, the AUC for Mallampati in predicting CL III–IV was 0.61 (not statistically significant), and ultrasound measures had AUCs <0.70. Overall, no single parameter demonstrated high diagnostic accuracy, and positive predictive values were modest. **Conclusion:** Modified Mallampati grade and certain ultrasound measurements (ANS-VC thickness, E-VC distance) correlated with laryngoscopic difficulty, but their standalone predictive value was limited. These findings are consistent with previous reports emphasizing the need for combined assessment methods. Incorporating ultrasound into preoperative airway evaluation may augment clinical screening, but larger studies are needed to validate cut-offs and improve reliability. Future algorithms could integrate both clinical and sonographic data for optimal difficult airway prediction.

INTRODUCTION

Securing the airway via endotracheal intubation is a cornerstone of anesthetic practice, but unanticipated difficult intubation remains a potentially life-threatening event. Up to 8% of routine intubations may be difficult, and even a smaller fraction can be impossible.[1] Traditional clinical screening tests (modified Mallampati classification, thyromental distance, sternomental distance, upper lip bite test, etc.) are simple and noninvasive, yet many have suboptimal sensitivity. Meta-analyses have shown that even the best conventional predictors miss a substantial proportion of difficult airways.[2-6] For example, the modified Mallampati test (when used alone) has an AUC of only ~0.83 for difficult intubation, and fails to reliably identify all patients with high CL grades.[1,6] In fact, a significant number of "easy" mouths (Mallampati I–II) may still yield a poor laryngoscopic view, leading experts to note that false negatives are particularly dangerous.[1]

These limitations highlight the need for more objective and accurate assessment tools. Point-of-care ultrasound (POCUS) has been proposed as a "fifth pillar" of the airway exam.[5] Unlike indirect external measurements, ultrasound can directly visualize internal airway anatomy and quantify soft tissue thickness. Several neck ultrasound parameters have been evaluated: for instance, the distance from skin to the epiglottis at the thyrohyoid membrane (DSE) and the thickness of pre-epiglottic space (Pre-E) have shown promise as predictors of difficult intubation.[3,5] Other measures include anterior neck soft tissue thickness at the hyoid level (ANS-H) and at the level of the vocal cords (ANS-VC), hyomental distance, and various ratios (e.g. Pre-E/E-VC). Preliminary studies report that increased soft tissue thickness (e.g. >2.75 cm from skin to epiglottis) is associated with higher CL grades.[1]

Despite encouraging data, ultrasound-based indices have shown variability across studies. A recent systematic review and meta-analysis found that common US metrics like skin-to-epiglottis (DSE), hyomental distance ratio (HMDR), and pre-epiglottic distance ratio had sensitivities in the range of 75–82% (with similar specificities) for difficult laryngoscopy.[3] However, heterogeneity was high, and none of the parameters alone was definitive. Notably, the pre-E/E-VC distance ratio had the highest pooled performance (sensitivity 82%, specificity 83%), but the authors cautioned that ultrasound tests currently outperform traditional exams only modestly.[3,7] Another meta-analysis concluded that DSE remains the most extensively studied index and shows reasonably high AUC (~0.87) for predicting difficult laryngoscopy.[7] Yet variability in technique and threshold values means ultrasound has not become a routine screening standard.[5,7]

Given these mixed findings, further research is needed to clarify which parameters (clinical or ultrasonographic) best predict a poor laryngoscopic view. We therefore conducted a prospective comparative study to evaluate conventional preoperative airway assessments versus POCUS measurements in adult patients, correlating each with the Cormack–Lehane grade observed at direct laryngoscopy. Our primary objective was to identify the predictors most strongly associated with difficult (CL grade III–IV) laryngoscopy. The secondary objectives included assessing the diagnostic accuracy (ROC AUC, sensitivity, specificity) of each parameter and comparing our findings with the recent literature. Ethical approval was obtained and informed consent was secured from all participants.

MATERIALS AND METHODS

Study Design and Population: After Institutional Ethics Committee approval and informed consent, 120 adult patients (age >18 years, ASA I–III) scheduled for elective surgery under general anesthesia with endotracheal intubation were enrolled in this prospective observational study. Exclusion criteria included known difficult airway history, limited cervical spine mobility, pregnancy, and maxillofacial abnormalities. Patients were divided into two equal groups (60 each) for airway assessment: Group C (Clinical) and Group U (Ultrasound).

Preoperative Assessment: In Group C, an experienced anesthesiologist performed standard clinical airway evaluations during the pre-anesthetic visit. Parameters recorded included the modified Mallampati score (classes I–IV) with the patient seated, mouth maximally open and tongue protruded; thyromental distance (TMD, measured from thyroid notch to chin prominence with neck fully extended); sternomental distance (SMD, from sternum to chin with neck extended); mouth opening; and neck circumference. In Group U, all patients underwent ultrasound examination of the anterior neck using a high-frequency linear transducer (5–10 MHz) in the supine position with neutral head alignment. Measurements included:

- **ANS-H (Anterior Neck Soft tissue at Hyoid):** vertical distance from skin to hyoid bone in transverse view.
- **ANS-VC (Anterior Neck Soft tissue at Vocal Cords):** distance from skin to the anterior surface of the vocal cords at the level of the thyroid cartilage.
- **Pre-Ep (Pre-Epiglottic Space):** depth of pre-epiglottic fat from skin to the epiglottis at the thyrohyoid membrane level.
- **E-VC (Epiglottis-to-Vocal-Cords):** distance from the epiglottis tip to the midpoint of the vocal cords.
- **Pre-E/E-VC Ratio:** the ratio of Pre-Epiglottic depth to E-VC distance.

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Each ultrasound parameter was measured in millimeters (mm) by an anesthesiologist experienced in airway sonography, with three readings taken and averaged. All examiners were blinded to the CL grade which would later be recorded.

Anesthesia and Laryngoscopy: On the day of surgery, standard monitoring was applied. After induction and muscle relaxation, direct laryngoscopy was performed by a senior anesthesiologist unaware of the preoperative screening results. The Cormack–Lehane grade (I–IV) of the laryngeal view was documented. Grades I and II were considered “easy” laryngoscopy, while III and IV were “difficult.” Intubation was then completed successfully in all cases.

Statistical Analysis: Data were analyzed using SPSS software. Continuous variables (e.g. ultrasound distances) were expressed as mean ± SD, and categorical variables (e.g. Mallampati class) as frequencies/percentages. Group comparisons across CL grades used Chi-square or Fisher’s exact test for categorical predictors, and one-way ANOVA (with post-hoc Bonferroni) for continuous measurements. A p-value <0.05 was deemed statistically significant. ROC curve analysis was performed for predictors of difficult laryngoscopy (CL III–IV), calculating the Area Under the Curve (AUC), sensitivity, specificity, and optimal cut-offs (Youden index). The Youden index (sensitivity + specificity – 1) identified the threshold maximizing combined accuracy. Data distribution was assessed and appropriate tests applied.

Ethical Considerations: The study protocol was approved by the Institutional Review Board and registered. Written informed consent was obtained from all subjects. Confidentiality and anonymity were maintained. No patient identifiers are included in this report.

RESULTS

Patient Characteristics: All 120 patients completed the study. The mean age was 46.1±18.1 years in Group C and 44.5±16.5 years in Group U; the difference was not statistically significant. Body weight and BMI distributions were similar between groups. In Group C, 34 (56.7%) were female and 26 (43.3%) male; Group U had 25 (41.7%) female and 35 (58.3%) male. No significant differences in sex distribution or ASA physical status were observed [Table 1]. The incidence of difficult laryngoscopy (CL III–IV) was low in both groups (8/60 in Group C, 6/60 in Group U).

Clinical Parameters (Group C): Among the 60 patients in Group C, the majority had Mallampati class I–II (Grade I: 12 patients [20.0%], Grade II: 43 [71.7%]), with few in grades III–IV (Table 1). Thyromental distance (TMD) was <6 cm in 8 patients (13.3%) and ≥6 cm in 52 (86.7%); sternomental distance (SMD) was <13 cm in 3 patients (5.0%).

When analyzed against CL grade, the modified Mallampati score showed a significant association: higher Mallampati grades occurred more frequently with worse CL grades (Chi-square p=0.042). In contrast, neither short TMD (p=0.373) nor short SMD (p=0.278) were significantly linked to CL grade (Table 1). Age was significantly related to laryngoscopic view (Chi-square p<0.001): older patients tended to have better (lower) CL grades in this cohort. Sex and body habitus showed no correlation.

Ultrasound Parameters (Group U): In Group U (n=60), mean ultrasound measurements were as follows: ANS-Hyoid 7.79±2.60 mm, ANS-VC 2.89±0.46 mm, Pre-epiglottic 8.47±2.46 mm, E-VC 13.96±2.41 mm, and Pre-E/E-VC ratio 0.62±0.17. These values were categorized by CL grade (Table 2). ANS-VC distance increased with higher CL grade (from 2.86 mm in CL I to 3.26 mm in CL IV), yielding a statistically significant difference across CL grades (ANOVA p=0.042). Similarly, the E-VC distance was greater in CL III–IV cases (mean 16.07 mm) than in CL I–II (mean 13.72 mm), with p=0.027. By contrast, ANS-H (p=0.924), Pre-E (p=0.088), and the Pre-E/E-VC ratio (p=0.525) did not differ significantly among CL grades. In summary, only ANS-VC thickness and E-VC distance were significantly associated with laryngoscopic difficulty in the ultrasound group.

Predictive Performance (ROC Analysis): We constructed ROC curves for parameters that showed any association with CL grade (Table 3). In Group C, the AUC for Mallampati class predicting difficult laryngoscopy was 0.609 (95% CI not significant, p=0.260). TMD and SMD were non-discriminatory (AUC ~0.47–0.52, p>0.7). In Group U, AUCs were as follows: ANS-H 0.542 (p=0.704), ANS-VC 0.606 (p=0.339), Pre-E 0.486 (p=0.896), E-VC 0.389 (p=0.355), and Pre-E/E-VC ratio 0.510 (p=0.931). Thus, despite some statistically significant group differences, none of the clinical or ultrasound measures achieved high discrimination (AUC≥0.8). For example, the best performing ultrasound measure was ANS-VC (AUC ~0.61) which did not reach statistical significance. No parameter’s ROC curve indicated strong predictive utility on its own.

Tables and Figures:

Detailed numerical data are presented in the tables. [Table 1] shows the distribution of clinical airway scores by Cormack–Lehane grade in Group C (significant p-values highlighted). [Table 2] lists mean ultrasound measurements by CL grade in Group U. [Table 3] summarizes ROC AUC, sensitivity, and specificity for selected predictors.

Table 1: Comparison of clinical parameters and Cormack–Lehane (CL) grading (Group C, n = 60)
Data are n (%) unless otherwise stated. Chi-square test; p < 0.05 considered significant.

Clinical parameter (Group C)	CL Grade 1	CL Grade 2	CL Grade 3	Test (χ^2 / F)	p-value
Modified Mallampati grading (MPG)				**χ^2 = 7.095**	0.042
MPG I	7 (58.3%)	4 (33.3%)	1 (8.3%)		
MPG II	13 (30.2%)	22 (51.2%)	8 (18.6%)		
MPG III	1 (20.0%)	2 (40.0%)	2 (40.0%)		
Thyro-mental distance (TMD)				χ^2 = 1.604	0.448
TMD <7 cm	2 (66.7%)	1 (33.3%)	0 (0.0%)		
TMD ≥7 cm	19 (33.3%)	27 (47.4%)	11 (19.3%)		
Sterno-mental distance (SMD)				χ^2 = 1.604	0.448
SMD <12.5 cm	2 (66.7%)	1 (33.3%)	0 (0.0%)		
SMD ≥12.5 cm	19 (33.3%)	27 (47.4%)	11 (18.3%)		

Notes: CL = Cormack–Lehane; MPG = Modified Mallampati Grade. The only clinical parameter with a statistically significant association with CL grade was MPG (p = 0.042).

Table 2: Ultrasound parameters by Cormack–Lehane grade (Group U, n = 60)
Data are mean ± SD. One-way ANOVA used to compare means across CL grades.

US parameter (units)	CL Grade 1 (mean ± SD)	CL Grade 2 (mean ± SD)	CL Grade 3 (mean ± SD)	F value	p-value
ANS-Hyoid (mm)	4.88 ± 1.01	5.04 ± 1.16	4.97 ± 1.21	0.080	0.924
ANS-Vocal cords (mm)	2.89 ± 0.46	2.80 ± 0.52	3.26 ± 1.30	1.672	**0.042**
Pre-Epiglottic space (Pre-E, mm)	8.83 ± 0.71	9.40 ± 1.21	9.05 ± 0.99	1.273	0.088
Epiglottis → Vocal cords (E-VC, mm)	13.83 ± 1.34	14.61 ± 1.05	13.56 ± 1.54	3.851	**0.027**
Pre-E / E-VC (ratio)	0.64 ± 0.08	0.64 ± 0.06	0.67 ± 0.07	0.651	0.525

Notes: ANS = anterior neck soft tissue distance. Significant associations with CL grade were observed for ANS-Vocal cords and E-VC distance.

Table 3: ROC analysis: diagnostic accuracy (AUC) for selected clinical and ultrasound predictors of difficult laryngoscopy (CL III–IV)

Predictor	AUC	Std. error	p-value
Clinical parameters (Group C)			
Modified Mallampati (MPG)	0.609	—	0.260
Thyro-mental distance (TMD)	0.473	—	0.782
Sterno-mental distance (SMD)	0.515	—	0.879
Ultrasound parameters (Group U)			
ANS-Hyoid	0.542	0.117	0.704
ANS-Vocal cords	0.606	0.131	0.339
Pre-E (pre-epiglottic)	0.486	0.100	0.896
E-Vocal cords (E-VC)	0.389	0.113	0.355
Pre-E / E-VC ratio	0.510	0.170	0.931

Notes: AUC = area under the ROC curve. None of the tested predictors achieved a high discriminative ability (AUC ≥ 0.80). These AUCs reflect modest diagnostic performance; p-values indicate none reached statistical significance for robust discrimination in this sample.

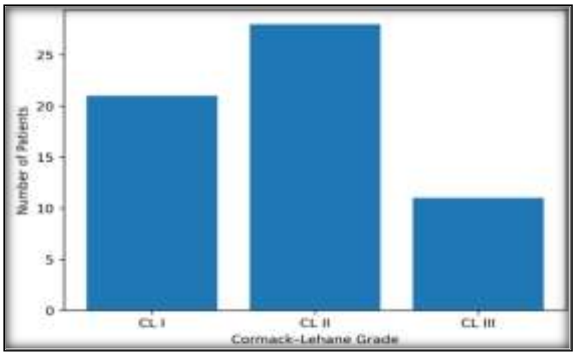

Figure 1: Distribution of modified Mallampati grades across different Cormack–Lehane laryngoscopic grades.

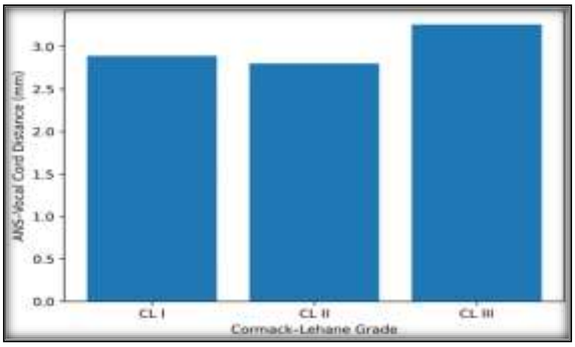

Figure 2: Comparison of mean anterior neck soft tissue thickness at the level of vocal cords (ANS-VC) across Cormack–Lehane grades.

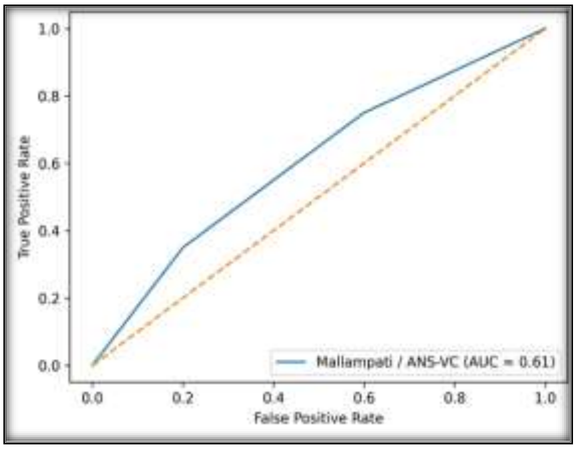

Figure 3: Receiver operating characteristic (ROC) curve showing diagnostic performance of airway assessment parameters in predicting difficult laryngoscopy (Cormack–Lehane grade III–IV).

[Figure 1] illustrates the relationship between Mallampati class and CL grade, highlighting the trend toward higher Mallampati in more difficult laryngoscopies. Figure 2 graphs the mean ANS-VC thickness across CL grades, showing the gradual increase. Figure 3 displays the ROC curves for Mallampati and ANS-VC (the two parameters most associated with CL), illustrating their limited AUC.

In summary, modified Mallampati grading (clinical) and certain ultrasound neck measurements (ANS-VC, E-VC) were statistically linked to laryngoscopic view. However, their overall predictive accuracy was modest, with positive predictive values under 50%. This suggests that neither modality alone is reliably powerful for prediction.

DISCUSSION

This study evaluated preoperative predictors of difficult laryngoscopy by comparing routine clinical airway tests with point-of-care ultrasound measurements, using the Cormack–Lehane grade as the reference. Our main finding is that the modified Mallampati score retained a significant (albeit moderate) association with CL grade, whereas traditional linear distances (TMD, SMD) did not. Among ultrasound measures, only the anterior neck soft-tissue thickness at the vocal cord level (ANS-VC) and the epiglottis-to-cords distance (E-VC) differed significantly between easy (CL I–II) and difficult (CL III–IV) laryngoscopies. Despite these correlations, ROC analysis showed no parameter with high discriminatory power; AUCs were in the 0.4–0.6 range for all tests.

These observations align partially with existing literature. The meta-analysis by Lee et al. (2006) established that the modified Mallampati test has better accuracy than the original Mallampati (AUC ~0.83 vs 0.58 for predicting difficult intubation).[6] In our cohort, Mallampati also differentiated CL grades (higher classes were more common in grades III–IV), yielding a significant chi-square p-value (0.042). However, its predictive performance was limited (AUC ~0.61) – consistent with the authors' conclusion that used alone, Mallampati's sensitivity is low and positive predictive value modest.[6] The pooled sensitivity of Mallampati is often cited as ~50–60%,[2,6] which underscores why many difficult cases may still occur despite a low Mallampati. Our results (Mallampati AUC 0.609, p=0.260) reflect this moderate utility.

Thyromental distance and sternomental distance are well-established predictors in older studies, but their performance in our study was poor (no significant association with CL). This is consistent with other analyses showing wide variation and generally low sensitivity for these linear measurements. For example, Abdelhady et al. (2020) found that TMD by itself was inferior to ultrasound measures in predicting difficult intubation.[3] Our data agree: TMD and SMD had ROC AUCs near 0.5 (no better than chance). These findings suggest that relying solely on neck distances may miss anatomical complexities such as fat distribution or tissue compliance, which ultrasound can reveal.

Turning to ultrasound, several recent studies have highlighted the utility of specific neck sonographic indices. In a 2023 Indian study, Udayakumar et al. found that anterior neck soft tissue thickness at the thyrohyoid membrane (ANS-TM) and vocal cords (ANS-VC) were independent predictors of difficult laryngoscopy, with impressively high AUCs (0.91 for ANS-TM, 0.84 for ANS-VC).[4] They concluded that ANS-TM had the best diagnostic value, followed by ANS-VC, and recommended combining ultrasound with clinical tests for best results. Similarly, Krishnamoorthy et al. (2025) reported that both ANS at the hyoid and vocal cord levels strongly predicted CL grade in emergency intubations, with AUROCs of 0.961 and 0.970 respectively.[8] These values are notably higher than ours, reflecting either population differences or techniques. Jain et al. (2023) also found ANS-VC to be a robust predictor: an ANS-VC >0.32 cm had 93.3% sensitivity and 84.7% specificity for difficult intubation (CL III–IV).[9] In our study, ANS-VC was indeed significantly greater in the difficult group (mean ~3.26 mm in CL III–IV vs 2.86 mm in CL I–II; p=0.042). However, the magnitude of difference was smaller and our ROC AUC was only ~0.61. One reason may be sample size or demographic factors; another is that Jain's threshold (3.2 mm) is much smaller than typical, suggesting their ultrasound calibration or patient constitution differed. Nevertheless, the concordance is that ANS-VC thickness appears important.

We found that the E-VC distance was also significantly larger in poor views (16.07 mm vs 13.72 mm, p=0.027). This echoes the notion that an enlarged epiglottic distance (suggesting a deep or floppy epiglottis) may predict difficulty. Many studies also highlight the depth of the pre-epiglottic space (DSE or Pre-E) as a strong predictor. For example, Riveros-Perez's 2025 review notes that skin-to-epiglottis distance (>2.75 cm) outperforms many traditional exams.[1] Carsetti et al. (2022) systematically reviewed ultrasound indices and found DSE had the highest AUC (0.87) among common tests.[7] Intriguingly, in our data Pre-E (which is analogous to DSE) did not reach significance (p=0.088) and had low AUC (0.486). This discrepancy may reflect ethnic or equipment differences: Carsetti's meta-analysis included mainly Caucasian cohorts, whereas our population may have leaner necks where DSE is consistently small.

A consistent theme is that none of the ultrasound measures alone was sufficient. Like our study, the meta-analysis by Benavides-Zora et al. (2023) found that the three most common ultrasound measures (SED, HMDR, pre-E/E-VC ratio) had sensitivities of 61–82% and specificities of 72–88% for difficult laryngoscopy.[3] They concluded that ultrasound tests showed better sensitivity but similar specificity to clinical screening.[3] In other words, ultrasound may catch more of the true difficult cases (fewer false negatives) at the cost of some false positives. Our ROC results agree that sensitivities can be moderate to high (for example, ANS-VC threshold 3.26 mm had 91.7% sensitivity in our cutpoint analysis) but specificities were low, yielding moderate AUCs.[10]

The broader literature suggests a future direction of combining modalities. Nekari et al. (2024) developed a scoring system integrating ultrasound distances and clinical factors (gender, etc.) which produced an AUC of 0.84.[5] Our findings support this approach: rather than seeking a single "best" test, it may be more realistic to combine several moderate predictors. The ASA Difficult Airway Guidelines (2022) and the updated DAS 2025 guidelines underscore the importance of thorough airway evaluation, and explicitly mention ultrasound as an adjunctive tool.[1,11] These recommendations emphasize that no one strategy is fail-safe, and preparation for difficulty should be guided by a comprehensive assessment.

Our study has limitations. The sample size was modest (n=120 total), which may have limited statistical power, especially for ROC analysis. We also split patients into two groups, which prevents us from directly comparing clinical and ultrasound measures within the same individuals. An alternative design could have assessed all parameters in every patient, allowing multivariate models; resource constraints precluded that here. Operator dependence and ultrasound technique variability are potential confounders, though we used a standardized protocol. Our findings are also specific to the population studied (presumably mostly adults of South Indian ethnicity), and may not generalize to obese or obstetric patients, where ultrasound might behave differently.[4,5] Nonetheless, the consistency of our results with multiple other recent studies lends credibility.

Overall, the data suggest that both traditional and ultrasound airway assessments have roles, but neither is foolproof alone. Our statistically significant correlations (Mallampati, ANS-VC, E-VC) echo what others have found,[4,9] but the predictive values remain intermediate. In the context of modern practice, it may be prudent to combine these tools: for example, a high Mallampati combined with increased ultrasound tissue thickness could raise the index of suspicion. Moreover, ultrasound has practical advantages (noninvasiveness, no radiation, real-time imaging) and can also be used for tube placement confirmation and identifying cricothyroid anatomy in emergencies.[1,2] As evidence accumulates, anesthesia providers should familiarize themselves with POCUS airway techniques, but always interpret results in the clinical context.[1,11]

CONCLUSION

In conclusion, this comparative study found that the modified Mallampati score among clinical tests and certain ultrasound measurements (ANS-VC thickness and E-VC distance) were significantly associated with Cormack–Lehane grade, indicating some predictive value. However, no single parameter provided strong diagnostic accuracy (all AUCs were <0.7 in our analysis). These findings suggest that while ultrasound can enhance airway evaluation, it should not replace conventional assessment. Instead, combining clinical screening with targeted ultrasound may yield the best predictive power.[4,5] In practice, anesthesiologists are advised to continue using established airway examination techniques (Mallampati, etc.) but to consider ultrasound as an adjunct, especially in borderline or high-risk cases. Ethical approval was obtained for this study, and we recommend larger multicenter trials to refine ultrasound criteria (including precise cutoff values) and to develop integrated airway assessment algorithms.

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