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Original Research Article

To evaluate the reliability of upper lip bite test and ultrasound guided airway assessment in predicting difficult intubation in elective surgeries under general anaesthesia: A prospective randomised trial

Bhavini Shah[1], Reshma Salim[1]*, Brinda Badam[1]

[1]Dept. of Anaesthesiology, Dr. D Y Patil Medical College Hospital and Research Center, Dr. D Y Patil Vidyapeeth, Pimpri, Pune, Maharashtra, India

Abstract

Background and Aims: Airway management is a crucial aspect of anaesthetic practice, and predicting difficult intubation is essential to avoid severe complications. While the Upper Lip Bite Test (ULBT) is a widely used bedside screening tool, it has limitations in accurately predicting difficult intubation. Ultrasound evaluation of the airway has emerged as a promising alternative. This study aimed to evaluate the reliability of the ULBT and anterior neck soft tissue measurement at the vocal cord level (ANS-VC) in predicting difficult intubation and its correlation with Cormack-Lehane (CL) grading, intubation attempts, technique modifications, and failed intubations.

Materials and Methods: This prospective observational study included 100 adult patients (ASA I–II) undergoing elective surgery under general anaesthesia. Preoperative ULBT and ultrasound evaluation of the anterior neck soft tissue at the vocal cord level (ANS-VC) were performed. Laryngoscopy was conducted by a blinded anaesthesiologist, and Cormack-Lehane (CL) grades were recorded. The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy of both ULBT and ANS-VC were calculated. Receiver Operating Characteristic (ROC) analysis was performed to determine the optimal ANS-VC cutoff value for predicting difficult intubation.

Results: ULBT demonstrated a sensitivity of 73.4%, specificity of 33.3%, and an overall accuracy of 65%. ANS-VC, with an optimal cutoff value of 0.33 cm, had a sensitivity of 73.4%, specificity of 71.4%, and an accuracy of 73%. The ANS-VC cutoff showed superior balanced predictive performance compared to ULBT. ULBT was more effective in terms of sensitivity, whereas ANS-VC demonstrated better specificity and a more balanced overall predictive performance.

Keywords: Airway management, Difficult intubation, Upper lip bite test, Ultrasound airway assessment, Cormack-Lehane grading, Predictive validity, Airway ultrasound.

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1. Introduction

Airway management is a cornerstone of safe anaesthetic practice, representing one of the most critical skills for an anaesthesiologist. It is essential for oxygenation, ventilation, and the effective delivery of anaesthetic drugs during general anaesthesia (GA).[1] Inadvertent difficult intubation can lead to catastrophic consequences such as hypoxia, aspiration, airway trauma, brain injury, and death.[2] As Dr. Benumof famously stated, "Airway management is the essence of anaesthesia, it is the one thing we cannot afford to fail," highlighting the need for meticulous preoperative airway evaluation.[3] Difficult intubation, defined as the inability to visualize the glottis or successfully pass the endotracheal tube during direct laryngoscopy, occurs in approximately 1–8% of GA procedures. Though rare, failed intubation remains a significant cause of anaesthesia-related morbidity and mortality, underscoring the importance of accurate airway assessment to enable proactive planning and patient safety.[4]

*Corresponding author: Reshma Salim
Email: reshmasalim63@gmail.com

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Several bedside tests, including the Mallampati classification (MPC), thyromental distance (TMD), sternomental distance (SMD), and inter-incisor gap (IIG), have been developed to predict difficult airways. Among these, the Upper Lip Bite Test (ULBT) has gained popularity due to its simplicity, ease of use, and ability to be performed without special equipment. However, other tests like Mallampati can be influenced by patient cooperation and positioning, and TMD and SMD are operator-dependent, lacking sensitivity when used in isolation. Although the ULBT has been shown to be relatively simple and reproducible, its predictive validity remains inconsistent, particularly across different ethnic groups and varying levels of clinical experience.[5] Recent advancements in point-of-care ultrasound (POCUS) have added a promising new dimension to airway assessment. Ultrasound enables real-time, dynamic, and high-resolution visualisation of airway anatomy, providing objective measurements to complement traditional evaluations. Key parameters such as tongue thickness, anterior neck soft tissue at various levels, pre-epiglottic space, and skin-to-hyoid bone distance have all shown correlations with difficult laryngoscopy, offering insights not available through conventional bedside tests. The portability and non-invasive nature of ultrasound make it a viable tool for both elective and emergency settings. However, its widespread adoption has been hindered by the need for standardized protocols, adequate training, and suitable equipment.[6]

Given the advantages and limitations of both bedside testing and ultrasound, an integrated, multimodal approach to airway evaluation may improve predictive accuracy. This research aimed to assess the reliability of the ULBT and ultrasound-guided airway assessment in the prediction of difficult intubation. The objectives were to ascertain the correlation of ULBT and ultrasound findings with Cormack-Lehane (CL) grading on laryngoscopy, to assess the correlation with the number of attempts at intubation, to identify any modifications required during intubation, and to assess the correlation with failed intubation incidences.

2. Materials and Methods

This prospective observational study was conducted at the Department of Anaesthesiology, with approval from the Institute Ethics Committee (IESC/PGS/2023/158) and registration with the Clinical Trials Registry of India (CTRI/2024/09/073927). The study was carried out from September 2024 to January 2025. Sample size estimation was performed using WINPEPI software (version 11.3), with the prevalence of difficult intubation, as reported by Faramarzi et al., being 21.51%.[7] Based on a 95% confidence level and an 8% margin of error, the required sample size was calculated to be 100 patients.

Participants included in the study were between 18 and 70 years old, of either gender, and classified as American Society of Anaesthesiology (ASA) physical status grade I or II. Exclusion criteria involved patients with facial or anatomical abnormalities, ASA grade III or IV, mouth opening less than 3 cm, emergency surgeries, pregnancy, neck swelling, restricted neck mobility (inability to extend the neck beyond 30 degrees), or obesity. A trained anaesthesiologist with 3 years of experience, who was blinded to the ULBT and ultrasound parameters, performed the laryngoscopy.

Each patient underwent a thorough pre-anaesthesia evaluation, including a physical examination and history taking to assess conditions affecting airway management. The ULBT was classified into Class I (lower incisors bite the upper lip above the vermilion line), Class II (lower incisors bite the upper lip below the vermilion line), and Class III (lower incisors cannot bite the upper lip), with Class III indicating a potentially difficult intubation. ULBT was performed while the patient was seated.

Following the ULBT, an ultrasound-guided airway evaluation was carried out with the patient in the supine position, with the head and neck in neutral alignment, without the support of a pillow. A high-frequency linear probe (Hitachi/Aloka Arietta S 70, 6-12 MHz) was placed transversely over the anterior neck to visualize the vocal cords. Soft tissue thickness at the vocal cord level (ANS-VC) was measured at the midline and 10 mm to the left and right of the midline, with the average of these three measurements used for analysis.

After completing the airway assessments, patients were transferred to the operating room, where standard ASA monitors were applied. Preoxygenation was performed with 100% oxygen, and intravenous premedication included midazolam (0.02 mg/kg) and glycopyrrolate (0.004 mg/kg), followed by succinylcholine (2 mg/kg), propofol (2 mg/kg), and fentanyl (2 µg/kg). To maximize glottic visibility, patients were positioned in the ramp position, aligning the external auditory meatus with the sternal notch. A Macintosh blade (size 3 for females and size 4 for males) was used for direct laryngoscopy, and Cormack-Lehane (CL) grades were noted. CL grading was as follows: Grade I – full view of the glottis, Grade II – incomplete view of the glottis or arytenoids, Grade III – only epiglottis visible, and Grade IV – neither the glottis nor epiglottis visible. Intubation was considered easy for CL Grades I and II and challenging for Grades III and IV. The correct placement of the endotracheal tube was confirmed using auscultation and capnography.

The number of intubation attempts, any modifications in technique (such as the use of bougies, fiberoptic scopes, or other laryngoscopes), and the incidence of failed intubations were recorded. Anaesthesia was maintained with sevoflurane, vecuronium (0.1 mg/kg), and a 50:50 mixture of oxygen and nitrous oxide. At the end of the procedure, patients were reversed with intravenous neostigmine (0.05

mg/kg) and glycopyrrolate (0.008 mg/kg), extubated, and observed in the post-anaesthesia care unit for at least 30 minutes for any postoperative airway issues. Once stable, patients were transferred to the ward.

Data were analysed using SPSS v27.0. Categorical data were compared using the Chi-square test, and continuous variables were compared using the Student's t-test. Continuous variables were expressed as means and standard deviations (SD). Statistical significance was set at a p-value of less than 0.05. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy were calculated to assess the prognostic accuracy of the airway tests. Receiver operating characteristic (ROC) curves were constructed to determine the optimal cutoff values, and the area under the curve (AUC) was used to evaluate the overall prognostic accuracy of the tests.

3. Results

The study included patients aged between 18 and 70 years, with a mean age of 45.34 ± 13.64 years. The average height of the participants was 168.28 ± 11.49 cm, and their average weight was 71.17 ± 14.40 kg. The mean Body Mass Index (BMI) was 25.49 ± 6.45 kg/m² (**Table 1**).

Table 1: Comparison of age, height, weight, and BMI

Demographic Parameter	Mean ± SD
Age in years	45.34 ± 13.64
Height in cms	168.28 ± 11.49
Weight in kilograms	71.17 ± 14.40
BMI in Kg/m^2	25.49 ± 6.45

Table 2 shows that ULBT correctly predicted easy intubation (Class I and II) in seventy-two patients (72%) and correctly predicted difficult intubation (Class III) in twenty-eight patients (28%). According to CL classification on direct laryngoscopy, easy intubation was found in seventy-nine patients (79%) and difficult intubation in twenty-one patients (21%). The diagnostic performance of ULBT was assessed by comparing its results with CL grading, and the sensitivity, specificity, and Area Under the Curve (AUC) values were calculated.

Table 2: Descriptive statistics of difficult intubation using ULBT, CL classification

Test	**Easy Intubation**	**Difficult Intubation**
ULBT	72(72%)	28(28%)
CL Classification	79(79%)	21(21%)

ULBT correctly predicted easy intubation (Class I and II) in 72 patients (72%) and difficult intubation (Class III) in 28 patients (28%). According to the Cormack-Lehane (CL) classification on direct laryngoscopy, easy intubation was found in 79 patients (79%) and difficult intubation in 21 patients (21%). **Table 3** summarizes the comparison of ULBT validation with CL classification, where ULBT Class I and II were considered predictors of easy intubation, and Class III as predictors of difficult intubation.

The results showed 58 true positive (TP) cases where ULBT accurately predicted easy intubation and 14 false positive (FP) cases where ULBT predicted easy intubation, but CL rated the intubation as difficult. There were 21 false negative (FN) cases, where ULBT predicted difficult intubation but CL rated it as easy, and 7 true negative (TN) cases where ULBT accurately predicted difficult intubation. The sensitivity of ULBT was 73.4%, indicating a moderate ability to correctly predict easy intubation. The specificity was low at 33.3%, suggesting that ULBT often misinterpreted complex cases as easy. The positive predictive value (PPV) was high at 80.6%, showing that when ULBT predicted easy intubation, it was correct most of the time. However, the negative predictive value (NPV) was low at 25%, indicating that ULBT was less consistent in predicting difficult intubation. The overall accuracy of ULBT for predicting difficult intubation was 65%. These findings suggest that while ULBT is moderately useful for predicting easy intubation, its accuracy in detecting challenging airway situations is not as reliable.

Table 3: Comparing ULBT against CL classification

		CL		**Total**
		Easy	**Difficult**	
ULBT	Easy	58 (TP)	14 (FP)	72
	Difficult	21 (FN)	7 (TN)	28
Total		79	21	100

The cutoff value for ANS-VC was determined by analysing sensitivity, specificity, and the area under the curve (AUC) across different cutoff points, as shown in **Table 4**. Various cutoffs were evaluated to find the optimal combination of sensitivity and specificity, with the highest AUC. The best acceptable range for sensitivity and specificity was considered to be 70%–100%, while AUC values were interpreted as follows: excellent (90–100%), good (80–90%), fair (70–80%), poor (60–70%), and very poor (50–60%). From this analysis, a cutoff value of 0.33 cm for ANS-VC was identified as optimal, providing the best balance of sensitivity, specificity, and an acceptable AUC to predict difficult intubation.

As shown in **Table 5**, using the ANS-VC cutoff of 0.33, out of the 100 patients, 64 (64%) were classified as having easy intubation, while 36 (36%) were classified as having difficult intubation.

Table 4: Cutoffs vs performance metrics for ANS-VC

Cutoff	Sensitivity	Specificity	AUC
0.11	0.01265822785	1	0.5063291139
0.12	0.03797468354	1	0.5189873418
0.13	0.07594936709	1	0.5379746835
0.14	0.07594936709	0.9523809524	0.5141651597
0.15	0.08860759494	0.9523809524	0.5204942737
0.18	0.1139240506	0.9523809524	0.5331525015
0.2	0.1265822785	0.9523809524	0.5394816154
0.22	0.1392405063	0.9047619048	0.5220012055
0.23	0.164556962	0.8571428571	0.5108499096
0.24	0.1772151899	0.8571428571	0.5171790235
0.25	0.1898734177	0.8571428571	0.5235081374
0.26	0.2151898734	0.8571428571	0.5361663653
0.27	0.2911392405	0.8571428571	0.5741410488
0.28	0.3291139241	0.8571428571	0.5931283906
0.29	0.4050632911	0.8571428571	0.6311030741
0.3	0.5443037975	0.8095238095	0.6769138035
0.31	0.6329113924	0.7619047619	0.6974080772
0.32	0.7088607595	0.7142857143	0.7115732369
0.33	0.7341772152	0.7142857143	0.7242314647
0.38	0.746835443	0.6666666667	0.7067510549
0.39	0.7594936709	0.6666666667	0.7130801688
0.4	0.7594936709	0.619047619	0.689270645
0.47	0.7721518987	0.5714285714	0.6717902351
0.5	0.7848101266	0.5238095238	0.6543098252
0.52	0.7974683544	0.5238095238	0.6606389391
0.53	0.7974683544	0.4761904762	0.6368294153
0.56	0.8101265823	0.4761904762	0.6431585292
0.57	0.835443038	0.4761904762	0.6558167571
0.58	0.835443038	0.4285714286	0.6320072333
0.59	0.8481012658	0.3333333333	0.5907172996
0.6	0.8607594937	0.3333333333	0.5970464135
0.61	0.8734177215	0.3333333333	0.6033755274
0.63	0.8987341772	0.3333333333	0.6160337553
0.64	0.8987341772	0.2857142857	0.5922242315
0.65	0.9113924051	0.2380952381	0.5747438216
0.66	0.9367088608	0.2380952381	0.5874020494
0.67	0.9746835443	0.2380952381	0.6063893912
0.68	0.9873417722	0.2380952381	0.6127185051
0.69	1	0.2380952381	0.619047619
0.7	1	0.1428571429	0.5714285714
0.72	1	0.09523809524	0.5476190476
0.76	1	0.04761904762	0.5238095238
0.8	1	0	0.5

Table 5: Descriptive statistics of ANS-VC

Test	Easy Intubation	Difficult Intubation
ANS-VC cut-off = 0.33	64(64%)	36(36%)

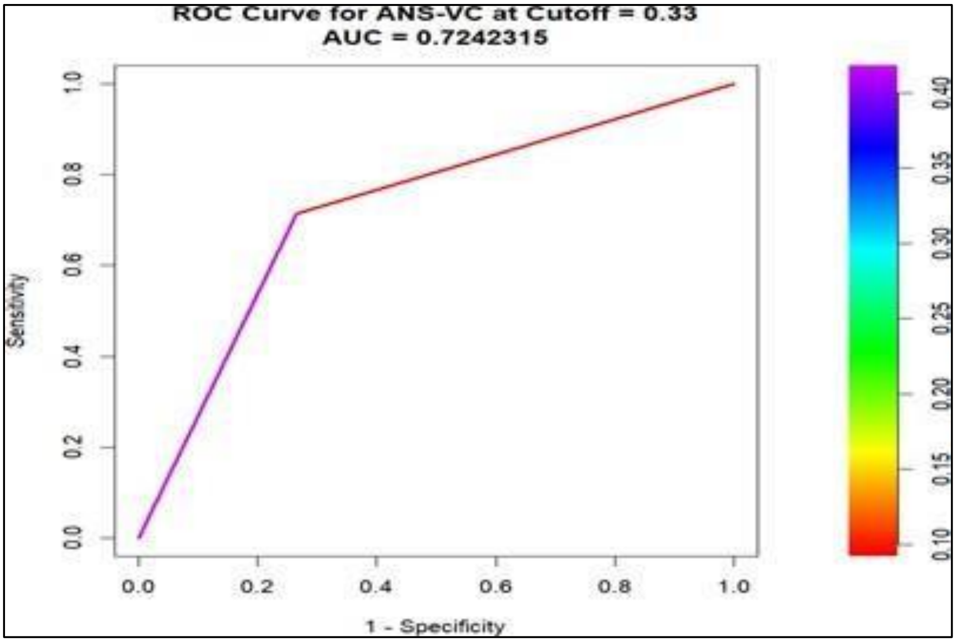

Figure 1: ROC curve for ANS-VC at cutoff = 0.33

The performance of the ANS-VC versus the CL classification in predicting difficult intubation was assessed using sensitivity, specificity, and AUC as key parameters (**Figure 1**). The optimal cutoff point for ANS-VC was found to be 0.33 cm. ANS-VC ≤ 0.33 cm predicted easy intubation, while ANS-VC > 0.33 cm predicted difficult intubation. At this cutoff point, sensitivity was 0.7342, specificity was 0.7143, and the AUC was 0.7242, indicating that ANS-VC performed moderately as a predictor of difficult intubation, with balanced discrimination between easy and difficult cases.

Additionally, **Figure 2** presents the Receiver Operating Characteristic (ROC) curve for ANS-VC at various cutoffs, further highlighting its diagnostic accuracy in predicting difficult intubation.

Table 6 presents a detailed analysis of the ANS-VC versus CL classification. The results indicate that there were 58 true positive (TP) cases where ANS-VC correctly predicted easy intubation and 6 false positive (FP) cases where ANS-VC predicted easy intubation, but CL classified it as difficult. Additionally, there were 21 false negative (FN) cases where ANS-VC predicted difficult intubation, but CL classified it as easy, and 15 true negative (TN) cases where ANS-VC accurately predicted difficult intubation.

The sensitivity was found to be 73.4%, indicating a high capacity of ANS-VC to detect easy intubations. The specificity was 71.4%, which is significantly better than ULBT's 33.3%, highlighting ANS-VC's superior ability to correctly identify difficult intubation. The positive predictive value (PPV) was 90.6%, meaning that when ANS-VC predicted easy intubation, it was correct most of the time. However, the negative predictive value (NPV) was relatively low at 41.7%, indicating that when ANS-VC predicted difficult intubation, it was incorrect in a significant number of cases. The overall accuracy of ANS-VC was 73%, which is higher than ULBT's 65%, suggesting that ANS-VC with a 0.33 cm cutoff could be a more reliable predictor of difficult intubation.

Table 6 also highlights that ULBT is most effective when the sensitivity of the test is prioritized, particularly for the correct detection of easy intubation. In contrast, ANS-VC with a cutoff of 0.33 cm is best suited when both specificity and sensitivity are equally important, making it ideal for detecting both easy and difficult intubations accurately.

Among the 100 patients studied, 60 patients (60%) required two attempts for successful intubation, while 40 patients (40%) were successfully intubated on the first attempt. No cases of failed intubation (0%) were observed throughout the study. Additionally, 7 patients (7%) required adjustments during the intubation procedure, such as the use of a bougie. Statistical analysis revealed that these factors were not statistically significant, indicating that the number of attempts and the need for adjustments were not associated with any specific predictive factors of intubation difficulty (**Table 7**).

A total of 40 patients (40%) were successfully intubated on the first attempt, while 60 patients (60%) required two attempts for successful intubation. There were no cases of failed intubation (0%). Modifications, such as the use of a bougie or other adjustments, were required in 7 patients (7%).

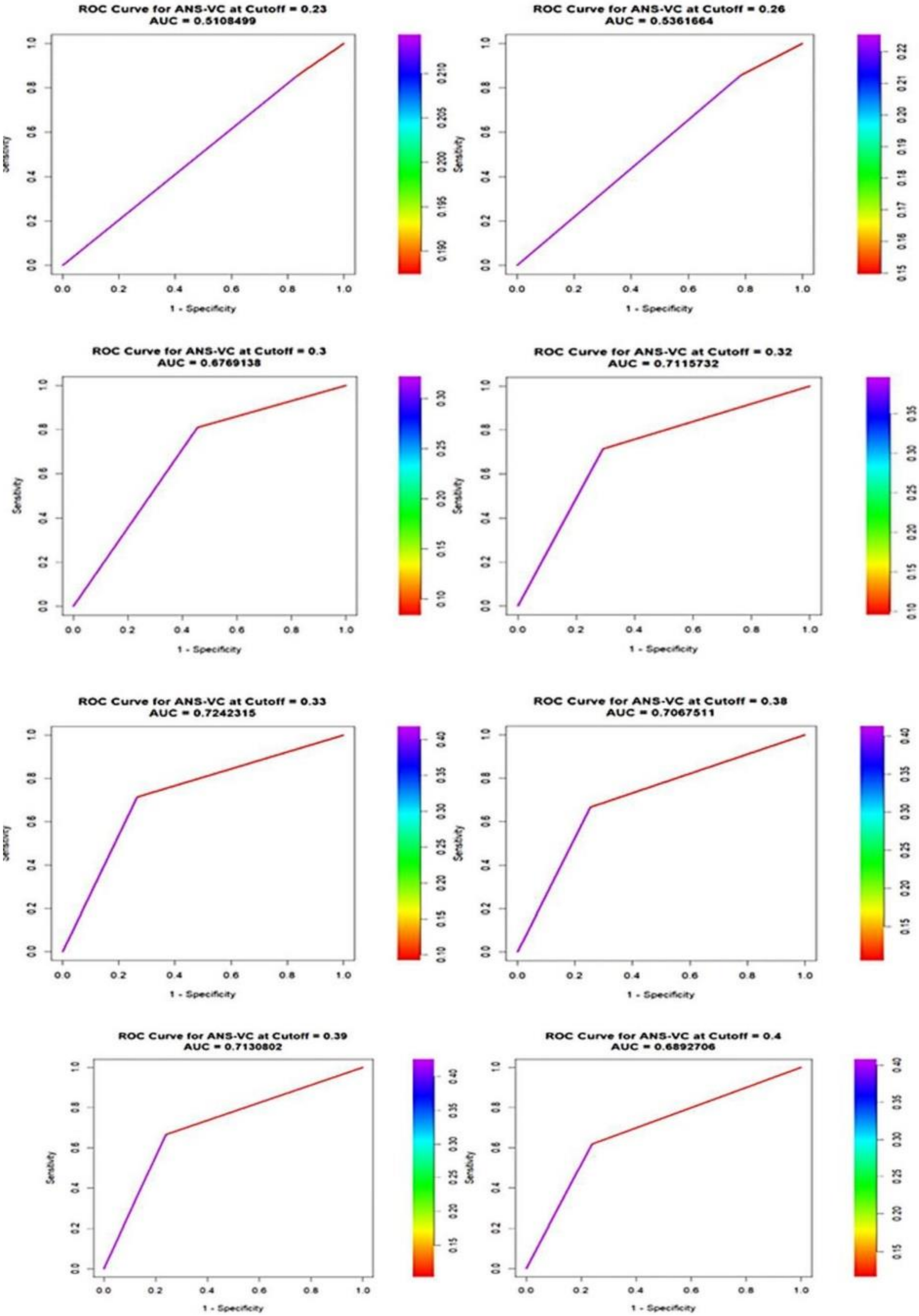

Figure 2: ROC curve for ANS-VC at various cutoff

Table 6: Comparing ANS-VC (cutoff = 0.33cm) against CL classification

		CL		Total
		Easy	Difficult	
ANS-VC (Cut-off = 0.33 cm)	Easy	58 (TP)	6 (FP)	64
	Difficult	21 (FN)	15 (TN)	36
Total		79	21	100

Table 7: Performance metrics of ULBT, ANS-VC against CL

Metrics	**ULBT**	**ANS-VC (Cutoff =0.33 cm)**
Accuracy	0.65	0.73
Sensitivity	0.7342	0.7342
Specificity	0.33	0.7143
PPV	0.8056	0.9063
NPV	0.25	0.4167
Prevalence	0.79	0.79
Detection rate	0.58	0.58
AUC	0.534	0.5108

4. Discussion

Predicting difficult intubation is a critical responsibility for anaesthesiologists, as it directly impacts patient safety and the success of anaesthesia management during surgery. Failure to secure the airway during induction can lead to severe complications such as hypoxia, trauma, regurgitation, aspiration, and cardiovascular instability, particularly in high-risk patients with underlying cardiovascular or respiratory conditions. Early identification of patients at risk for difficult intubation allows for better preparation, including the use of alternative airway management techniques and appropriate equipment. This proactive approach enhances patient safety and improves surgical outcomes.[8]

The Cormack-Lehane (CL) classification was used as the gold standard in this study to assess the predictive value of two clinical tests, ULBT and ANS-VC, for predicting difficult intubation under anaesthesia. The reliability and effectiveness of both tests were compared by evaluating their sensitivity, specificity, accuracy, positive predictive value, negative predictive value, and area under the curve (AUC).

Demographic parameters, including age, gender, weight, and height distribution, showed no confounding variables. A large proportion of patients were classified as ASA I (80%), indicating predominantly healthy individuals, while the remaining 20% were classified as ASA II. ASA grading is crucial, as it directly impacts the likelihood of complications during anaesthesia and surgery. These findings align with studies conducted by Wang et al., Tang et al., and Bhanushali et al.[9-11]

ULBT demonstrated moderate sensitivity (73.4%) for predicting easy intubation, but its specificity was relatively low (33.3%). This suggests that while the ULBT is useful for identifying easy intubations, it may not be as effective in predicting difficult intubations, especially in ruling out such cases. The overall accuracy of 65% indicates that while ULBT is somewhat reliable, it may not be the best predictive tool for difficult intubation when used alone. These findings are consistent with the study by Sinharay et al., which concluded that ULBT was a superior option compared to the Mallampati classification (MPC) for predicting difficult airways and should be part of preoperative evaluation.[12] Tang et al. also noted that ULBT had a lower AUC than other airway tests, which aligns with our results showing moderate performance.[10] Furthermore, Singh et al. found that the Modified Mallampati Test (MMT) had higher sensitivity, specificity, positive predictive value, and negative predictive value compared to ULBT.[13]

The ANS-VC test with a 0.33 cm cutoff demonstrated superior overall performance, with a sensitivity of 73.4%, specificity of 71.4%, and an AUC of 0.7242. These findings suggest that the ANS-VC test provides a more balanced prediction of both easy and difficult intubations. The 0.33 cm cutoff proved to be an optimal choice, offering satisfactory accuracy and reliability. These results are consistent with the findings of Falsafi et al., who reported that ultrasound-based measures, such as the thickness of anterior neck tissue, can predict challenging laryngoscopy. Li et al. also highlighted the value of ultrasound measurements, like the skin-to-vocal-cord distance, for predicting difficult intubation in both awake and comatose patients.[14,15]

The intubation attempts were largely successful, with 60% of patients requiring two attempts and 40% being successfully intubated on the first attempt. Notably, no intubation failures were observed, and a small proportion (7%) of patients needed adjustments, such as the use of a bougie. These results further validate the clinical usefulness of the tests in predicting and managing difficult intubation, as adequate preparation and readiness for modifications during intubation were crucial in preventing failure. These findings align with those of Tasdemir et al., who reported a similar percentage of patients requiring multiple attempts or additional equipment, underlining the importance of preparedness during the procedure.[16]

Both the ULBT and ANS-VC tests have their respective strengths and limitations, and their combined use may offer a more comprehensive strategy for predicting difficult intubation. In clinical practice, anesthesiologists can initially apply ULBT due to its simplicity, rapid execution, and lack of equipment requirements. This makes it particularly useful in high-volume settings, such as outpatient or day-care surgeries, where time and resources may be limited. Ultrasound may be more advantageous in settings where difficult intubation carries higher risk, or where advanced airway equipment and personnel are available, such as in tertiary care hospitals, intensive care units, or preoperative evaluations for high-risk surgeries. For routine cases with low suspicion of airway difficulty, bedside tests may be sufficient, reserving ultrasound for ambiguous or high-risk cases. Future implementation strategies could involve multistage airway screening protocols, where a positive or equivocal bedside test triggers further evaluation with ultrasound. This approach could optimize both time efficiency and diagnostic accuracy, supporting safer and more personalized airway management.

While ultrasound has shown great potential as a predictive tool for difficult intubation, its widespread clinical adoption is limited by factors such as the need for specialized training, operator dependency, and the absence of standardized measurement protocols. However, these challenges can be addressed through structured implementation strategies, such as the development of focused training programs and simulation-based workshops. These can equip anaesthesiologists with the necessary skills to perform airway scans accurately and efficiently. The increasing availability of portable and handheld ultrasound devices provides a practical solution, especially in resource-limited or point-of-care settings. Additionally, integrating airway ultrasound into residency and continuing education curricula, along with the development of consensus guidelines for image acquisition and interpretation, could enhance standardization and consistency across institutions. Addressing these limitations through education and technology can make ultrasound a more accessible and reliable adjunct in airway evaluation.

5. Conclusion

Preoperative assessment is crucial in predicting difficult intubation for safe anaesthesia. ULBT and ANS-VC both offer moderate predictive value, with ULBT being more sensitive for easy intubations but less specific. ANS-VC, at a cutoff of 0.33 cm, provides a better balance of sensitivity and specificity. Combining both tests enables more accurate risk stratification, improving airway management, reducing complications, and enhancing surgical outcomes. Further studies are needed to validate and refine these predictive methods in diverse clinical settings.

6. Source of Funding

None.

7. Conflict of Interest

None.

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