RESEARCH PAPER

A Prospective Correlation Study between Airway Ultrasound and Clinical Parameters for the Prediction of Difficult Laryngoscopy

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ABSTRACT

Introduction: Study aims to compare ultrasonographic and clinical assessment for difficult laryngoscopy by comparing their combined predictive accuracy and enhancing preoperative airway management methods.

Aim and Objective: The study aims to assess the accuracy of sonographic assessment of airway includes, skin to hyoid, skin to thyrohyoid membrane distance and tongue thickness and routine clinical parameters like mouth opening, modified Mallampati class, mento-hyoid distance and thyromental distance among patients undergoing elective surgical procedures under general anaesthesia. It also aims to predict difficult laryngoscopy using Cormack Lehane grading.

Methodology: Prospective observational study conducted among 80 participants, all patients were subjected for detailed preoperative airway evaluation on the day before surgery. Clinical assessment for difficult laryngoscopy like mouth opening, modified Mallampati grade, mento-hyoid distance and thyro-mental distance was noted and recorded for all patients. All patients were subjected to a detailed sonographic assessment by the same anesthesiologist who experienced in airway ultrasound and skin to hyoid and skin to thyrohyoid membrane distance and tongue thickness was noted and recorded on the day before surgery. On the day of surgery Cormack Lehae (CL) grading of laryngoscopic view was noted.

Results: The mallampati grading shows the sensitivity for difficult laryngoscopy was 71.43%and the specificity was 94.52%. The inter incisor distance, with cut off value of < 3.55 cm, has moderate sensitivity (57.1%) and greater specificity (82.2%), Also, the mentohyoid distance with a cut off of < 5.55 cm, demonstrates similar sensitivity (57.1%) and slightly higher specificity (84.9). The thyro-mental distance, with the cut-off <6.9 cm, displays the greater sensitivity (71.4%) but lower specificity (72.6%). Neck circumference, with a cutoff more than 37.75 cm, stands out with the highest sensitivity (85.7%) and specificity (86.3%). Tongue thickness shows the cut-off ≥ 5.65 cm had a sensitivity of 85.7% and the specificity was 87.7%, skin to hyoid bone distance shows the Cut-off value of ≥ 0.99 cm had a sensitivity of 85.7% and the 23 specificity was 86.3%. Skin to thyrohyoid membrane distance shows a cut off value of ≥ 0.705 cm had a sensitivity of 71.4% and the specificity was 20.5%.

Conclusion: Overall tongue thickness is the best predictor of difficult laryngoscopy with the high sensitivity and specificity in ultrasound parametersand neck circumference is the best predictor of difficult laryngoscopy in clinical parameters.

Keywords: Airway management, Intratracheal, Intubation, Laryngoscopy, Ultrasonography.

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INTRODUCTION

Airway management constitutes the foundation of anesthetic practice and the complexity of the issue is exaggerated in the case of difficult airway. The introduction of Ultrasonography (USG) in anesthetic practice has provided anesthesiologists with a new, non-invasive, point-of-care measure in their armamentarium. Ultrasonographic measurement of anterior neck soft tissue thickness, tongue thickness and distances from hyoid and thyrohyoid membrane to the tongue have been documented to predict difficult laryngoscopy [1, 2].

Difficult laryngoscopy prediction remains an imprecise science despite advances in airway management. Conventional clinical tests are operator-dependent, subjective and often suboptimal in difficult airways. Ultrasonography is a desirable substitute with the potential to provide objective, reproducible measurements of airway dimensions. By using ultrasound-derived in preoperative evaluation, clinicians can improve the accuracy of evaluation and possibly decrease the number of unexpected difficulties.

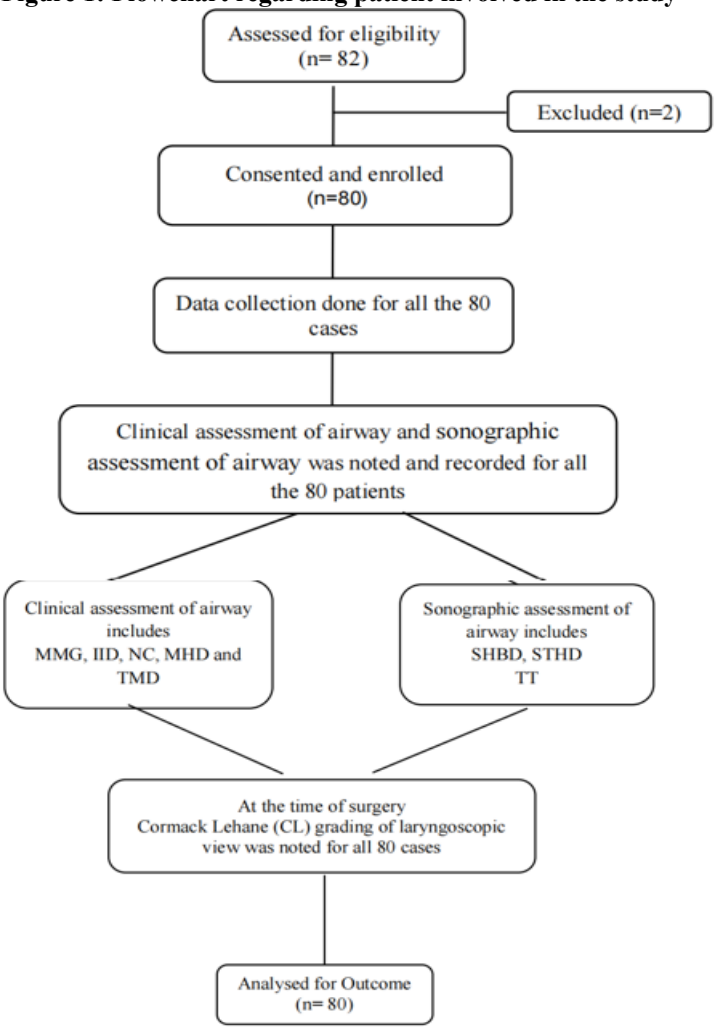
This research aims to be part of the body of evidence favouring the use of ultrasonography in daily anesthetic practice. By comparing systematically ultrasound measurements to traditional clinical measurements, we hope to have a complete overview of their function in predicting difficult laryngoscopy and improving patient outcome.

METHODOLOGY

Written informed consent was obtained from all patients who were scheduled to undergo surgery under general anesthesia requiring laparoscopy and endotracheal intubation and fulfilling the inclusion criteria was enrolled in the study (Figure 1).

All patients were subjected for detailed preoperative airway evaluation on the day before surgery. Mouth opening, modified Mallampati grade, mento-hyoid distance and thyro-mental distance was noted and recorded for all patients [3]. All patients were subjected to a detailed sonographic assessment by the same anesthesiologist who was experienced in airway ultrasound and skin to hyoid and skin to thyrohyoid membrane distance and tongue thickness were noted and recorded on the day before surgery. For sonographic assessment of airway, patient was made to lie in the supine position with head in the extended position with mouth closed and the tongue on the floor of the mouth without any movement. Skin to hyoid bone distance was measured and skin to thyrohyoid membrane distance was measured at the midpoint of thyrohyoid membrane using curvilinear low - frequency probe (frequency 2-5 Mhz) of an ultrasound machine sonosite (fujifilmsonosite edge 2, Bothell, WA, USA).The tongue thickness was measured by recording the geniohyoid muscle thickness using a curvilinear probe (2-5 Mhz.) of an ultrasound machine sonosite, in the midline sagittal plane. All the measurements were recorded by a single anesthesiologist trained in airway ultrasound and blinded to laryngoscopy view. On the day of surgery, the patient was shifted to the operating room, baseline monitors of electrocardiogram, non-invasive blood pressure and pulse oximetry was connected and values were noted. After preoxygenation for 3 min, intravenous (IV) midazolam 1 mg and fentany l2 mcg/kg was administered. Anesthesia was induced with injection propofol 2 mg/kg IV. After muscle relaxation with injection vecuronium 0.1 mg/kg IV or injection atracurium 0.5 mg/kg IV and ventilation with oxygen and sevoflurane 2% for 3 min, direct laryngoscopy was performed by an experienced anesthesiologist. The laryngoscopic view was graded according to the Cormack Lehane (CL) using a curved Macintosh blade of appropriate size and the Cormack Lehane (CL)
grading of laryngoscopic view was noted [4].

Figure 1: Flowchart regarding patient involved in the study



Note: MMG - Modified Mallampati Grade, IID -Inter-incisor distance, NC - Neck circumference, MHD - Mento-hyoid distance and TMD - Thyro-mental distance,

SHBD - Skin to Hyoid Bone Distance, STHD - Skin to Thyrohyoid Membrane
Distance and TT – TT and CL - Cormack Lehane Grading

RESULTS

Table 1: Descriptive analysis of sex, age, height, weight, BMI, ASA among study population (N=80)

Basic characteristic	Number	Percentage
Gender		
Male	30	37.5 %
Female	50	62.5 %
Median Age (IQR)	34 (24 – 40)	
Mean Height ± Sd. Deviation (cms)	158.55± 8.011	
Mean Weight ± Sd. Deviation (cms)	63.98± 9.07	
Mean BMI ± Sd. Deviation (Kg/m^2)		
American Society of Anesthesiologists Physical Status (ASA PS)		
1	40	50.0 %
2	40	50.0 %
Total	**80**	**100.0 %**

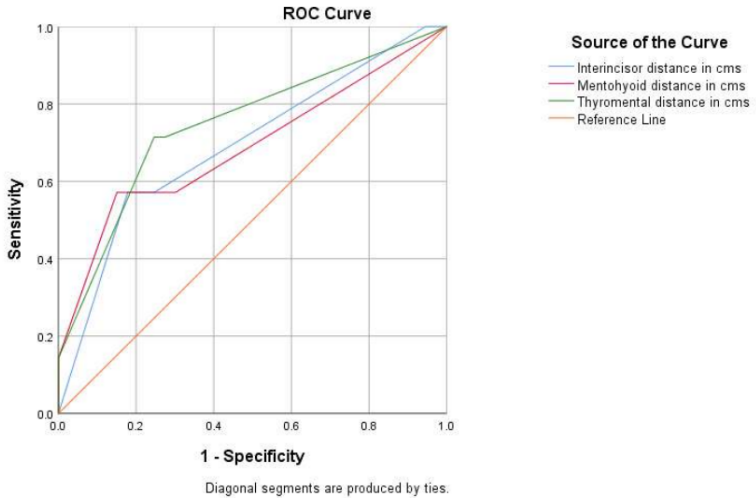
Out of 80 patients, 30 (37.5%) were males and 50 (62.5%) were females. The
median age of the study participant was 34 (IQR = 24 – 40) years. The minimum age
reported was 18 years and the maximum age observed was 53 years. Majority of the
participants belongs to the age category 30 to 40 years which is 32 (40%) cases. The
mean height distribution among study participant was 158.55 ± 8.01 cms. The
minimum height observed was 141 cms and the maximum height observed was 178 cms. The mean weight among the study participant was 63.98 ± 9.07 kgs.
The minimum weight observed was 45 kgs and the maximum weight observed was 87
kgs. The mean BMI distribution among study participant was 25.43 ± 2.93 kg/m2. The
minimum BMI observed was 18.78 kg/m2 and the maximum BMI observed was 33.30
kg/m2 .Among 80 cases, 40 (50%) cases representing ASA PS 1 and 40 (50%) cases
representing ASA PS 2 (Table 1).

Table 2: Sonographic assessment of airway among study participants (N=80)

Sonographic assessment of airway		Skin to hyoid bone distance (SHBD) in cms	Skin to thyrohyoid membrane distance (STHD) in cms	Tongue Thickness (TT) in cms
Mean		0.7538	0.94	5.30
± Std. Deviation		± 0.09	± 0.21	± 0.42
Range		0.74	1.42	2.68
Minimum		0.60	0.72	3.52
Maximum		1.34	2.14	6.20
Percentiles	25	0.71	0.84	5.00
	50 (median)	0.74	0.88	5.20
	75	0.79	0.97	5.60

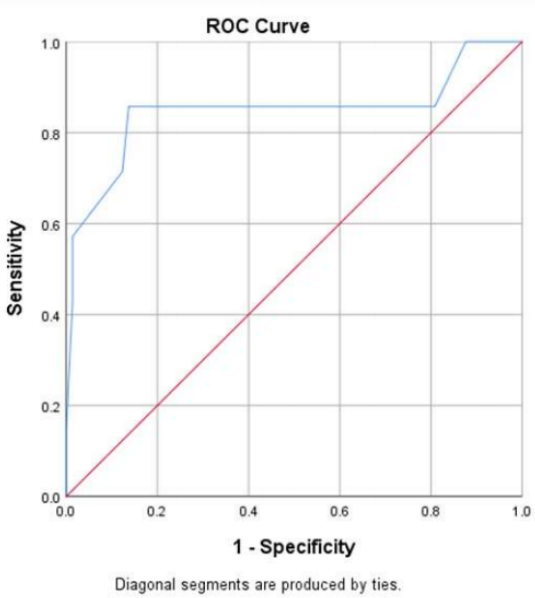
Table 2 shows median SHBD among the participant was 0.74 (IQR = 0.71 – 0.79) cms. The minimum SHBD observed was 0.60 cms and the maximum observed was 1.34 cms. The median STHD distance among the participant was 0.88 (IQR = 0.784 – 0.97) cms. The minimum STHD observed was 0.72 cms and the maximum observed was 2.14 cms. The median TT distance among the participant was 5.20 (IQR = 5.00 – 5.60) cms. The minimum TT observed was 3.52 cms and the maximum observed was 6.20 cms.

Graph 1: Receiver operated characteristic (ROC) curve analysis to predict difficult laryngoscopy based on CL grading of patients with clinical assessment Parameters



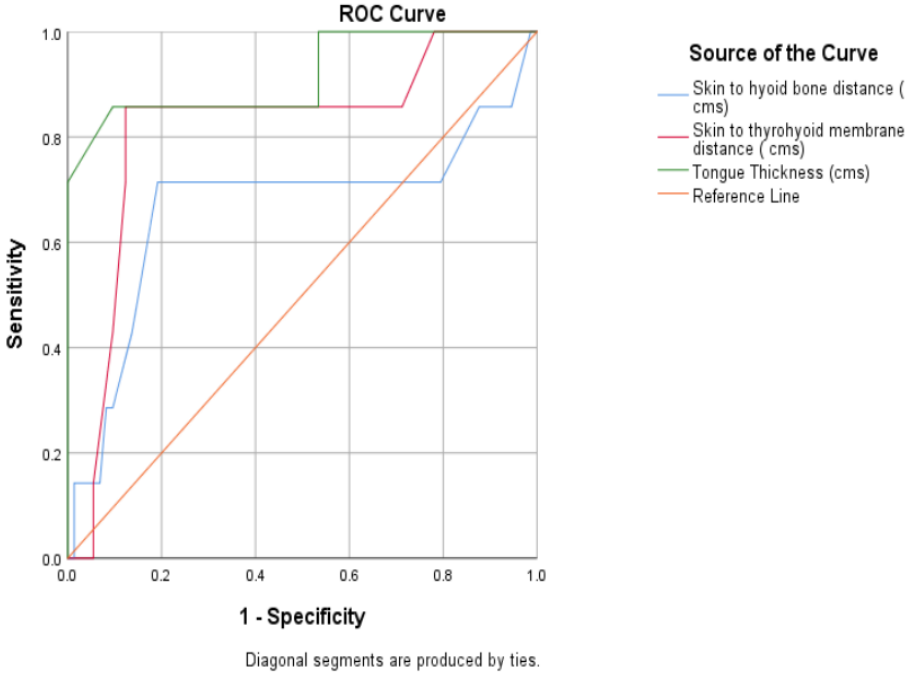
Graph 1 illustrates the ROC curve analysis to predict difficult laryngoscopy based on CL grading of patients with clinical assessment parameter.

Graph 2: Receiver operated characteristic (ROC) curve analysis to predict difficult laryngoscopy based on CL grading of patients with neck circumference values



The above ROC curve analysis was conducted to assess the predictive ability of clinical airway assessment parameters in determining difficult laryngoscopy based on CL grading. This analysis included four key measurements: IID, MHD, TMD and NC. Among these, NC demonstrated the highest diagnostic accuracy with an area under the curve (AUC) of 0.847 and a statistically significant p-value of 0.003, suggesting strong predictive value. TMD also showed a notable AUC of 0.748 with a p-value of 0.031, indicating moderate predictive accuracy. However, IID and MHD had lower AUC values of 0.694 and 0.689, respectively, with p-values above 0.05, suggesting weaker predictive power.

Graph 3: Receiver operated characteristic (ROC) curve analysis to predict difficult laryngoscope based on CL grading of patients with sonographic assessment of airway values.



Graph 3 illustrates receiver operated characteristic analysis to predict difficult laryngoscope based on CL grading of patients with sonographic assessment of airway values.

Table 4: Comparion between various sonographically assessed parameters to predict difficult laryngoscopy

Sonographic assessment of airway	Cut off value	Sensitivity	Specificity	Positive predictive value	Negative predictive value
SHBD in cms	≥ 0.705 cm	71.4%	20.5%	7.9%	88.2%
STHD in cms	≥ 0.99cm	85.7%	86.3%	37.5%	98.4%
TT in cms	≥ 5.65cm	85.7%	87.7%	40%	98.5%

DISCUSSION

Mallampati Grade 2 patients made up 57.5% of the study population, followed by Grade 1 patients (31.3%) and Grade 3 patients (11.3%) [3]. According to research by Shiga et al., the Mallampati score is helpful but insufficient as a stand-alone predictor of difficult intubation [3, 5]. The modified Mallampati classification showed high specificity (94.5%) but only moderate sensitivity (71.4%). The study's clinical airway parameters revealed significant differences between individuals with easy and difficult laryngoscopy in terms of neck circumference ($p = 0.002$), thyromental distance ($p = 0.008$), and inter-incisor distance ($p = 0.041$). Mallampati classification exhibited a sensitivity of 71.43% and specificity of 94.52% when comparing clinical parameters with CL grading [3].

The present study found that among traditional clinical parameters, Neck circumference had the highest area under the curve (AUC = 0.847, $p = 0.003$), with a sensitivity of 85.7%, specificity of 86.3%, positive predictive value (PPV) of 37.5%, and negative predictive value (NPV) of 98.4%, indicating a strong predictive value. This finding aligns with studies by Yuan et al. and Alessandro et al., which identified increased neck circumference as a significant risk factor for difficult laryngoscopy thyromental distance (AUC = 0.748, $p = 0.031$) was moderately predictive, which contrasts with the findings of Suvarna et al., who reported a higher predictive value [6-8].

In the present study, Sonographic Airway Parameters: the mean skin-to-hyoid bone
distance (0.75 ± 0.09 cm) and skin-to-thyrohyoid membrane distance (0.94 ± 0.21 cm)
closely matched the findings of Wojtczak et al., who reported that reduced HMDR
was significantly associated with difficult intubation, with HMDR values averaging
1.02 ± 0.01 in difficult intubation cases compared to 1.14 ± 0.02 in easy intubations [9].

In our analysis, the mean TT (5.30 ± 0.42 cm) aligns with observations by Pinto et al., who found that patients with difficult intubation had significantly higher TT (4.83 ± 0.62 cm) compared to those with easy intubation (4.38 ± 0.65 cm) [10].

Adhikari et al. demonstrated that skin-to-hyoid distance (1.08 ± 0.41 cm) and TT (4.83 ± 0.62 cm) are reliable predictors of difficult laryngoscopy, with ultrasound measurements correlating strongly with CL grading [11]. In our study, the median skin-to-hyoid bone distance among patients with difficult laryngoscopy was 0.80 cm (IQR: 0.70–0.84 cm) compared to 0.74 cm (IQR: 0.71–0.77 cm) in those with easy laryngoscopy. The TT showed the highest predictive accuracy with an AUC of 0.92 ($p < 0.001$) in our ROC analysis.

Our analysis of data reported a significant association between STHD, STTD, and TT with difficult laryngoscopy, which is consistent with the findings of Gupta et al. [12]. They found that increased pre-tracheal soft tissue thickness (1.92 ± 0.15 cm) at the level of the hyoid was associated with CL grade III/IV views, supporting the hypothesis that increased anterior neck soft tissue impairs glottic visualization.

One of the key strengths of our study is the use of ROC curve analysis to assess the predictive power of both ultrasound and clinical parameters. Similar to findings by Adi et al., the present study demonstrated that ultrasound-based measurements, particularly skin-to-hyoid distance> 0.8 cm and TT > 5.5 cm, had higher sensitivity (~75.6%) and specificity (~83.3%) compared to traditional clinical assessments. Skin-to-thyrohyoid membrane distance (STHD), with a cut off of ≥ 0.99 cm, also performed well, showing a sensitivity of 85.7%, specificity of 86.3%, PPV of 37.5%, and NPV of 98.4% [13]. This supports findings by Wojtczak, who identified TT as a strong predictor of difficult intubation [9]. The cut-off value of ≥ 5.75 cm in our study yielded a sensitivity of 85.7% and specificity of 90.4%, reinforcing its potential clinical utility.

The findings support the integration of ultrasound-based airway assessment into routine preoperative evaluations, particularly for high-risk patients. In our study TT emerged as the most reliable predictor of difficult laryngoscopy with a median value of 6.10 cm, suggesting that its measurement could enhance airway assessment protocols.

CONCLUSION

This study identifies ultrasound assessments, such as skin to hyoid bone distance and tongue thickness, correlate well with airway visualisation, with tongue thickness being the best predictor overall. The study highlights the importance of combining clinical and sonographic evaluations to enhance predictions of difficult laryngoscopy.

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