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COMPARATIVE EFFICACY OF SONOANATOMY PARAMETERS IN PREDICTING DIFFICULT INTUBATION: A PROSPECTIVE SINGLE-BLINDED STUDY

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ABSTRACT **Background:** Effective airway management is crucial in anaesthesiology. Ultrasound-guided (USG) assessment offers potential as a non-invasive tool for predicting difficult intubations, but no consensus exists on which sonoanatomical parameter is the most reliable. This study compares three USG parameters – Distance from Skin to Epiglottis (DSE), Hyomental Distance Ratio (HMDR), and Tongue Thickness (TT) – for their efficacy in predicting difficult intubation based on the Cormack-Lehane (CL) grading system. Methods: This prospective single-blinded study was conducted on 190 patients aged 18-80 undergoing elective surgeries requiring intubation. Each patient was assessed using three USG parameters: DSE at the level of the thyrohyoid membrane, HMDR in neutral and extended positions, and TT. The efficacy of each parameter in predicting difficult intubation was analyzed against the CL grading system. Statistical analyses included chi-square tests and Pearson correlation coefficients.**Results:** Among the study population, a significant association was observed between difficult intubation (CL grade III-IV) and both DSE and TT ($p < 0.001$). However, HMDR showed no significant correlation with difficult intubation. The most consistent predictor of difficult intubation was DSE (mean 1.97 cm ± 0.225), followed by TT (mean 4.07 mm ± 0.535). **Conclusion:** DSE and TT were found to be superior in predicting difficult intubation compared to HMDR. USG can provide an accurate, non-invasive preoperative assessment tool, aiding clinicians in identifying patients at higher risk of difficult airway management.

KEYWORDS : Endotracheal Inubation, Cormack-Lehane (CL) grading system, Distance from Skin to Epiglottis (DSE), Hyomental Distance Ratio (HMDR), and Tongue Thickness (TT).

INTRODUCTION

Airway management is a fundamental skill in anesthesiology, critical for ensuring patient safety during surgical procedures. The ability to predict difficult airway and intubation scenarios can significantly reduce the risk of complications, which include inadequate ventilation, esophageal intubation, and failed intubation attempts [1]. Despite various assessment tools, such as the Mallampati classification and thyromental distance, the predictability of difficult airways remains inconsistent. This has driven the exploration of newer methods, particularly the use of ultrasound (USG), to enhance airway assessments and reduce the incidence of unexpected difficult intubation [2,3].

Ultrasound-guided (USG) assessment of airway anatomy offers a non-invasive, real-time alternative to traditional methods. It allows clinicians to visualize and measure specific anatomical structures, providing valuable information for predicting difficult intubation. However, it remains unclear which sonoanatomy parameters are the most effective in identifying difficult intubations. This study aims to compare the efficacy of three USG parameters—Distance from Skin to Epiglottis (DSE), Hyomental Distance Ratio (HMDR), and Tongue Thickness (TT)—in predicting difficult intubation based on the Cormack-Lehane (CL) grading system [4,5]

The incidence of difficult intubation in routine anaesthesia practice ranges between 1.5% and 13% [6]. Failed intubation can lead to severe complications, including hypoxia, brain damage, and death. Accurate preoperative prediction of difficult intubation allows for better preparation and reduces the risks associated with airway management. Traditional methods, such as the Mallampati score and thyromental distance, have been widely used but are often limited by interobserver variability and low sensitivity [7,8].

Ultrasound, which has long been used in anaesthesiology for procedures such as nerve blocks and vascular access, is now being explored as a tool for airway assessment. Its advantages include being non-invasive, portable, and less expensive than other imaging modalities like computed tomography (CT) and magnetic resonance imaging (MRI). Studies suggest that USG can help visualize critical airway structures and may serve as an adjunct in predicting difficult airways [9,10].

Several sonoanatomy parameters have been studied for their role in predicting difficult intubation, including anterior neck soft tissue thickness, hyomental distance, tongue volume, and the distance from skin to epiglottis. However, no clear consensus has emerged regarding which parameters are most reliable [11,12]. This study seeks to address this gap by comparing three parameters—DSE, HMDR, and TT—and determining which is most effective in predicting difficult intubation based on CL grading [13,14].

Accurate prediction of difficult intubation remains a challenge in anaesthesia practice. Given the limitations of traditional airway assessment tools, there is a growing interest in non-invasive imaging techniques like ultrasound for preoperative evaluation. Ultrasound allows for direct visualization of anatomical structures that are otherwise assessed through clinical judgment, offering a more objective approach to airway evaluation [5,9].

The rationale behind this study is to determine which ultrasound-based sonoanatomical parameter is the most predictive of difficult intubation. While parameters such as DSE, HMDR, and TT have been individually studied, a comparative analysis will provide clearer insights into which of these parameters correlates best with the widely used CL grading system for intubation difficulty [11,14]. By identifying the most reliable predictor, this study aims to enhance preoperative planning and improve patient outcomes in airway management.

Moreover, ultrasound is portable and widely available, making it an ideal tool for use in diverse healthcare settings, including those with limited access to advanced imaging technologies. By validating the use of specific ultrasound parameters, this study could pave the way for routine use of USG in airway assessments, potentially reducing the incidence of unforeseen complications during anaesthesia [9,15].

OBJECTIVES

- To compare the efficacy of DSE, HMDR, and TT in predicting difficult intubation.
- To determine which USG parameter is the most reliable predictor of difficult airway based on CL grading.

MATERIALS AND METHODS

STUDY DESIGN

- Type of Study: Prospective, single-blinded observational study.
- Duration: Conducted over 18 months.
- Location: Tertiary care hospital in Kalaburagi, Karnataka.

STUDY PARTICIPANTS
- Total Number of Patients: 190

INCLUSION CRITERIA:
- Patients aged 18-80 years.
- American Society of Anaesthesiologists (ASA) Grades I and II.
- Scheduled for elective surgeries requiring endotracheal intubation.

EXCLUSION CRITERIA:
- Presence of oral or head and neck pathologies or tumours.
- History of restricted neck movements or previous head and neck surgeries.
- Mouth opening less than 2 fingers' width.

ULTRASOUND PARAMETERS

1. Distance from Skin to Epiglottis (DSE):
- Measured at the level of the thyrohyoid membrane using a curvilinear ultrasound probe.
- Patient in supine position with head in neutral position.
- Epiglottis identified as a curvilinear hypoechoic structure, and distance from skin to epiglottis recorded.

2. Hyomental Distance Ratio (HMDR):
- Measured using a high-frequency linear ultrasound probe.
- Measured in both neutral and extended head positions.
- Distance between the upper hyoid bone and lower border of mentum recorded in both positions.
- Ratio between neutral and extended positions calculated.

3. Tongue Thickness (TT):
- Measured using a linear ultrasound probe placed in the submental region.
- Maximal vertical dimension measured from submental skin to the tongue surface.

Intubation Grading
- Cormack-Lehane Grading System: Used to classify intubation difficulty.
- Grade I & II: Easy intubation.
- Grade III & IV: Difficult intubation.

PROCEDURE

All patients underwent a standardized preoperative evaluation on the day of surgery. After obtaining informed consent, each patient was positioned supine on the operating table, and ultrasound measurements were taken prior to the administration of anaesthesia. The ultrasound probe was applied to the neck region to measure the three key sonoanatomy parameters: Distance from Skin to Epiglottis (DSE), Hyomental Distance Ratio (HMDR), and Tongue Thickness (TT).

For the DSE measurement, a curvilinear probe was placed transversely at the level of the thyrohyoid membrane, identifying the epiglottis and measuring the distance from the skin surface to the anterior surface of the epiglottis. The HMDR was recorded using a high-frequency linear probe, with distances measured between the upper border of the hyoid bone and the lower border of the mentum in both neutral and extended head positions. The ratio of these two measurements was then calculated. Lastly, **TT** was measured by placing a linear probe under the chin in the submental region, and the maximal vertical dimension of the tongue was captured from the submental skin to the tongue surface.

Following these ultrasound assessments, all patients underwent direct laryngoscopy during the intubation process. The visibility of the vocal cords was graded using the Cormack-Lehane (CL) grading system, and intubation was classified as either easy (CL grades I and II) or difficult (CL grades III and IV). The ultrasound measurements were then compared to the CL grading to determine their predictive value for difficult intubation.

STATISTICAL ANALYSIS

Chi-square tests were employed to evaluate the association between sonoanatomy parameters and CL grades. Pearson correlation was used to assess the correlation between BMI and airway parameters. A p-value < 0.05 was considered statistically significant. All analyses were performed using SPSS version 26.0

RESULTS

The mean age of the participants was 43.25 years with a standard deviation of ±12.21 years, indicating a moderately broad age range. The average Body Mass Index (BMI) was 21.54 kg/m² (±3.91), which falls within the normal weight range according to WHO standards. In terms of gender distribution, 54.2% of the patients were male (105 patients) and 44.2% were female (85 patients), showing a balanced representation of both sexes. Most of the participants were classified as ASA Grade I (76.8%), which indicates that they were generally healthy or had mild systemic diseases, while 23.2% of the patients were classified as ASA Grade II, signifying the presence of moderate systemic disease. Mouth opening was measured to assess airway accessibility, with 93.7% of patients having a mouth opening greater than 2 fingers, and only 6.3% with less than 2 fingers, indicating that most participants had no significant airway restrictions. All patients (100%) were reported to have normal neck movements, which is essential for evaluating intubation difficulty.

Table 1: Baseline characteristics

Demographic Parameter	Total no of patients n=190 (%)
Mean Age (years)	43.25 ± 12.21
Mean BMI (kg/m²)	21.54 ± 3.91
Gender Male Female	 105 (54.2%) 85 (44.2%)
ASA Grade I II	 146 (76.8%) 44 (23.2%)
Mouth Opening > 2 Fingers < 2 Fingers	 180 (93.7%) 10 (6.3%)
Normal Neck Movements	190 (100%)

This table compares the efficacy of three ultrasound-guided airway assessment parameters—Distance from Skin to Epiglottis (DSE), Hyomental Distance Ratio (HMDR), and Tongue Thickness (TT)—in predicting difficult intubation based on the Cormack-Lehane (CL) grading system. The results show that DSE had a mean value of 1.97 cm (± 0.225 cm) and a highly significant chi-square value of 105.77 with a p-value < 0.001, indicating that it is a strong predictor of difficult intubation.

Tongue Thickness (TT), with a mean of 4.07 mm (± 0.535 mm), also showed a significant correlation with difficult intubation (Chi-Square: 83.70, $p < 0.001$). These findings suggest that both DSE and TT are effective parameters for predicting difficult airway situations.

However, Hyomental Distance Ratio (HMDR), both in the neutral and extended positions, did not demonstrate significant predictive value. The mean HMDR in the neutral position was 4.49 cm (± 0.61 cm) with a chi-square value of 26.78 and a p-value of 0.946, while in the extended position, it was 5.61 cm (± 0.53 cm) with a chi-square value of 22.97 and a p-value of 0.974. These high p-values indicate no significant correlation between HMDR and difficult intubation, making HMDR a less reliable predictor compared to DSE and TT.

Table 2: Comparison of Sonoanatomy Parameters with CL Grades

Parameter	Mean Value	Standard Deviation	Chi-Square Value	p-Value
Distance from Skin to Epiglottis (DSE)	1.97 cm	± 0.225 cm	105.77	< 0.001
Hyomental Distance Ratio (HMDR) (Neutral)	4.49 cm	± 0.61 cm	26.78	0.946
Hyomental Distance Ratio (HMDR) (Extended)	5.61 cm	± 0.53 cm	22.97	0.974
Tongue Thickness (TT)	4.07 mm	± 0.535 mm	83.70	< 0.001

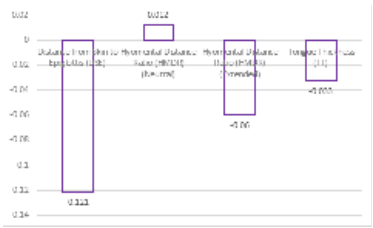
The Distance from Skin to Epiglottis (DSE) had a correlation coefficient of -0.121 and a p-value of 0.081, indicating a weak negative correlation that was not statistically significant. The Hyomental

Distance Ratio (HMDR) in the neutral position had a very weak positive correlation (0.012) with a p-value of 0.865, and in the extended position, a weak negative correlation (-0.060) with a p-value of 0.436. Neither correlation was statistically significant. Similarly, Tongue Thickness (TT) showed a weak negative correlation (-0.033) with a p-value of 0.688, also indicating no significant relationship with BMI. These findings suggest that the predictive value of DSE, HMDR, and TT for difficult intubation is largely independent of the patient's BMI, implying that these parameters can be effectively used across a wide range of body types.

Table 3: Correlation with BMI

Parameter	Correlation Coefficient	p-Value
Distance from Skin to Epiglottis (DSE)	-0.121	0.081
Hyomental Distance Ratio (HMDR) (Neutral)	0.012	0.865
Hyomental Distance Ratio (HMDR) (Extended)	-0.060	0.436
Tongue Thickness (TT)	-0.033	0.688

Figure 1: Correlation with BMI



DISCUSSION

The results of this study indicate that Distance from Skin to Epiglottis (DSE) and Tongue Thickness (TT) are the most reliable ultrasound-guided parameters for predicting difficult intubation based on the Cormack-Lehane (CL) grading system, while Hyomental Distance Ratio (HMDR) showed no significant correlation. These findings are consistent with and build upon similar studies that have evaluated the efficacy of ultrasound in airway assessment.

Distance from Skin to Epiglottis (DSE) The results showed that DSE had a strong predictive value for difficult intubation, with a statistically significant correlation ($p < 0.001$). This is in agreement with the study by Pinto et al., which also found that an increased DSE was associated with more difficult laryngoscopy and intubation. In their study, a cutoff value of 27.5 mm for DSE was able to predict difficult laryngoscopy with 74.3% accuracy, a sensitivity of 64.7%, and a specificity of 77.1% [2]. Similarly, our findings highlight that DSE is a robust predictor of airway difficulty, supporting the idea that increased anterior soft tissue depth impedes visualization of the laryngeal structures during intubation.

Tongue Thickness (TT) Tongue Thickness also showed a significant correlation with difficult intubation in our study ($p < 0.001$), reaffirming findings from studies such as those by Yao et al., which identified tongue thickness as a useful predictor of difficult airway management [4]. Their study demonstrated that increased tongue thickness (>6.1 cm) was an independent predictor of difficult intubation, with a sensitivity and specificity of 95%. This is in line with our results, where TT was the second most reliable predictor, suggesting that larger tongue volumes restrict the oropharyngeal space, thus complicating the intubation process. Similarly, Yadav et al. also found that tongue thickness had a sensitivity of 69.6% and a specificity of 77%, further supporting the relevance of this parameter in airway prediction [13].

Hyomental Distance Ratio (HMDR) In contrast to DSE and TT, the HMDR (in both neutral and extended positions) did not show a significant correlation with difficult intubation in our study. This is consistent with findings from several studies that have questioned the clinical utility of HMDR as a predictor of difficult airway. For instance, Wojtczak et al. found that although HMDR has been used in various studies, its predictive accuracy is variable, particularly in obese and non-obese populations [5]. The weak correlation in our study (p-values of 0.946 and 0.974 for neutral and extended positions, respectively) supports the idea that HMDR may not be a reliable or consistent parameter for predicting airway difficulty. It's worth noting that while some smaller studies have suggested a role for HMDR, particularly in specific populations, these findings have not been universally replicable.

Correlation with BMI The lack of significant correlation between BMI and the ultrasound parameters in our study is notable, as it suggests that DSE, TT, and HMDR are largely independent of body mass index in predicting difficult intubation. This aligns with results from previous studies, including those by Wu et al., who found that while BMI is often considered a risk factor for difficult intubation, ultrasound parameters related to airway anatomy do not necessarily correlate with a patient's BMI [14]. This suggests that USG measurements provide an additional layer of objectivity in airway assessment, independent of the patient's overall body habitus. This is particularly useful in clinical practice, as it indicates that these USG parameters can be reliably used across diverse patient populations, regardless of BMI [12].

The findings of this study suggest that DSE and TT are valuable, reliable, and easy-to-use parameters for preoperative assessment of the airway using ultrasound. Their strong correlation with difficult intubation makes them superior to HMDR and traditional airway assessment methods, which are often subject to variability. Incorporating these measurements into routine preoperative assessments could reduce the incidence of unexpected difficult airways, improving patient outcomes during anesthesia [7].

Further, the independence of these parameters from BMI highlights their broad applicability across different patient demographics. As ultrasound becomes more widely available, integrating USG-based airway assessments into routine clinical practice could significantly enhance the accuracy of preoperative airway evaluations, potentially reducing morbidity and mortality related to airway management failures [8].

While this study reinforces the importance of DSE and TT as reliable predictors, it is essential to recognize its limitations. The study population was limited to patients classified as ASA I and II, which may not fully represent higher-risk groups such as those with severe comorbidities. Additionally, the exclusion of patients with oral pathologies or head and neck surgery may have reduced the generalizability of the results to patients with anatomically challenging airways. Future research should focus on expanding the patient population to include higher-risk individuals and explore the potential role of combining multiple ultrasound parameters for a more comprehensive airway assessment.

CONCLUSION

This study demonstrates that ultrasound-guided airway assessment using Distance from Skin to Epiglottis (DSE) and Tongue Thickness (TT) are reliable predictors of difficult intubation, as classified by the Cormack-Lehane grading system. Both parameters showed significant correlations with intubation difficulty, making them valuable tools for preoperative airway evaluation. In contrast, Hyomental Distance Ratio (HMDR) did not exhibit significant predictive value, suggesting limited utility in clinical practice. The findings support the integration of ultrasound into routine airway assessments, particularly due to the objectivity and non-invasive nature of these measurements. Moreover, the weak correlation between these parameters and BMI suggests that they are broadly applicable across various patient populations, irrespective of body habitus. By incorporating DSE and TT into preoperative protocols, anaesthesiologists may be better equipped to anticipate difficult intubations, ultimately improving patient safety and outcomes during airway management. Future research should explore the utility of these parameters in more diverse populations, including those with higher comorbidities or anatomical challenges.

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