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Original Research Article

COMPARING CLINICAL PARAMETERS AND THE ROLE OF ULTRASONOGRAPHY IN PREDICTING DIFFICULT INTUBATION

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ABSTRACT

Background: Accurate preoperative prediction of difficult intubation is critical in anaesthetic practice to prevent airway-related complications. Although conventional clinical parameters are widely used, their predictive accuracy is limited. Ultrasonography (USG), particularly the measurement of the skin-to-epiglottis distance (SED), has emerged as a promising noninvasive tool for airway assessment. This study aimed to compare the effectiveness of traditional clinical parameters with ultrasonographic SED in predicting difficult intubation and to evaluate whether SED enhances the overall accuracy of the airway assessment. **Materials and Methods:** This prospective observational study included 60 patients undergoing elective surgery under general anaesthesia at Government Rajaji Hospital, Madurai. Clinical assessments included the mentohyoid distance, mandibular subluxation, and head extension. Ultrasonographic measurements of SED were performed using a high-frequency linear probe. The laryngoscopic view was graded according to the Cormack-Lehane (CL) classification. The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy of each method were determined. **Result:** Of the 60 patients, clinical predictors identified 13% of patients as having difficult airways, whereas ultrasound-based SED assessment identified 22%. Direct laryngoscopy revealed difficult views (Cormack–Lehane grade III/IV) in 13% of the patients. SED showed higher sensitivity (88.89% vs. 71.43%) and NPV (97.96% vs. 96.30%) than clinical predictors, whereas clinical predictors demonstrated slightly higher specificity (98.11% vs. 94.12%) and accuracy (95.00% vs. 93.33%). **Conclusion:** Ultrasonographic SED measurement is a valuable adjunct to traditional clinical assessments, offering improved sensitivity and reliability in the prediction of difficult intubation. Incorporating USG into routine preoperative evaluations can enhance airway safety.

INTRODUCTION

Airway management involves the strategic use of procedures and devices to maintain ventilation, particularly in patients under general anaesthesia, those experiencing respiratory failure, and those with acute airway obstruction. Tracheal intubation, usually performed via the oral route with a balloon-secured tube, ensures airway patency, supports ventilation, and prevents obstruction.[1] Failure to effectively manage the airway can lead to hypoxia, brain injury, and death. Point-of-care ultrasound (POCUS) is a valuable tool in airway management, and it plays a role in predicting difficult airways, confirming intubation, and guiding emergency procedures to improve patient safety. POCUS offers noninvasive, accessible benefits in perioperative care, with established advantages over traditional exams (e.g., clinical airway predictors).[2]

Common clinical predictors of difficult intubation, such as the Mallampati score, thyromental and sternomental distances, mentohyoid distance (MHD), inter-incisor gap, and upper lip bite test, are quick to perform but often lack sensitivity. In contrast, ultrasonographic measures such as skin-to-hyoid distance, thyroid isthmus depth, tongue thickness, and particularly skin-to-epiglottis distance (SED), provide real-time, noninvasive evaluations. Among these, SED demonstrates superior sensitivity and specificity, making it a valuable complement to

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traditional airway assessment. Intubation occurs in approximately 5–10% of general anaesthesia cases, with failed intubation rates ranging between 0.05–0.35%. In elective surgeries, the incidence of difficult intubation varies from 1.5% to 13% and is influenced by patient-related and clinical factors. Therefore, effective airway assessment and planning are critical to avoid adverse outcomes.[3]

Conventional predictors, such as the Mallampati score, although commonly used, have notable limitations. In contrast, ultrasonography (USG) has emerged as a valuable, noninvasive, and real-time modality for airway evaluation. POCUS is portable, user-friendly, and capable of enhancing difficult airway prediction through targeted measurements of anterior neck structures.[4] It plays a key role in confirming endotracheal tube (ETT) placement, especially in settings where capnography may be unreliable, such as in cardiac arrest.[5] With technological advances such as video-assisted intubation and high-flow nasal oxygen, evaluations must be adapted. Incorporating device feasibility and addressing human, team, and environmental factors is essential for comprehensive, effective airway management and improved patient safety.[6] The combined use of ultrasound-measured tongue volume and anterior cervical soft tissue thickness to predict difficult laryngoscopy offers a novel, more comprehensive approach than traditional assessments.[7]

Traditional preoperative airway assessments often lack predictive accuracy. Recent studies support the use of USG to measure SED, enhancing difficult laryngoscopy prediction when combined with standard clinical assessments.[8] This integrated method improves preoperative planning and patient safety. Endotracheal intubation may encounter unexpected difficulties. Traditional clinical predictors lack accuracy, while ultrasound offers a noninvasive alternative.[9] Additionally, preoperative USG assessment of the anterior neck soft tissues, specifically the skin-to-hyoid and skin-to-thyroid isthmus distances, has shown promise as a reliable, noninvasive predictor of difficult laryngoscopy. These sonographic parameters may complement or even improve the clinical predictors of airway difficulty. Nevertheless, larger, more varied population studies are required to standardise USG protocols for airway evaluation.[10]

Combining ultrasound-based SED with conventional clinical predictors significantly improves the accuracy and sensitivity of difficult intubation identification. This study is essential because traditional clinical assessments often lack reliability, and practical evidence suggests that missed difficult airways can lead to critical complications such as hypoxia, failed intubation, and increased perioperative risk. By enhancing preoperative airway evaluation, this study aims to improve patient safety and clinical outcomes. Patients with ASA I–III undergoing elective surgery were selected to ensure a standardised setting for airway assessment and to minimise variability due to systemic illness.

Objectives: This study aimed to compare the prediction of difficult intubation using ultrasound and clinical parameters and to assess whether incorporating ultrasound-based measurements of SED improves predictive accuracy.

MATERIALS AND METHODS

This prospective observational study was conducted in 60 patients over four months at the Department of General Anaesthesia, Government Rajaji Hospital, Madurai. Informed consent was obtained from the patients, and approval was obtained from the ethics committee.

Inclusion criteria

Patients aged 18–65 years of either sex with ASA physical status I to III scheduled for elective surgery under general anaesthesia requiring tracheal intubation were included.

Exclusion criteria

Patients with anatomical airway abnormalities, mouth opening ≤3 cm, or those undergoing emergency surgery were excluded.

Methods

Each patient underwent a standard pre-anaesthetic checkup, during which airway assessment was performed by trained anaesthesiologists using a standardised form. Three key clinical parameters were evaluated for airway assessment: MHD, mandibular subluxation, and head extension.

The MHD was measured with the patient in the sniffing position, which involved flexing the neck and fully extending the head. Using a ruler, the distance between the mentum (tip of the chin) and the hyoid bone was recorded. A distance of ≥ 4 cm generally indicated that intubation was likely to be easy, whereas a distance of ≤ 4 cm suggested a difficult airway due to a reduced submandibular space, which can hinder laryngoscopic visualisation.

Mandibular subluxation was assessed to evaluate temporomandibular joint mobility and the presence of functional dentition. The patient was asked to bite their upper lip using their lower incisors. If the patient could bite above the vermilion border of the upper lip, it was graded as +1 and considered easy. If the patient could bite below the border, it was graded as 0 and considered easy. However, if the patient was unable to bite the upper lip at all, it was graded as -1 and associated with difficult intubation.

Head extension was evaluated by asking the patient to lie supine on a 7-cm pillow and fully extend their head. The relative position of the upper incisors concerning an imaginary vertical line was used for the grading. When the incisors were positioned beyond the vertical line, it was graded as 1. If they aligned with the line, it was graded as 2, and if they fell short of the line, it was graded as 3. Grades 1 and 2 typically indicate an easy airway, whereas Grade 3 suggests potential difficulty, often due to restricted

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atlanto-occipital joint mobility. In addition to clinical parameters, USG was used to measure SED using a high-frequency linear probe (15–6 MHz). An SED measurement of ≥ 2.1 cm predicted difficult intubation.

On the day of surgery, standard fasting guidelines were followed, and premedication and intraoperative monitoring were ensured. Following the administration of Propofol and Suxamethonium, intubation was performed. The glottic view was evaluated using the Cormack-Lehane (CL) grading system during direct laryngoscopy with a Macintosh blade on the first attempt, without applying external laryngeal pressure. Grade 1 view indicated a full view of the vocal cords, whereas Grade 2 provided a partial view, typically of the posterior cords. Grade 3 revealed only the epiglottis, and grade 4 revealed neither the epiglottis nor the glottic opening. Grades 1 and 2 were indicative of easy intubation, whereas grades 3 and 4 were associated with difficult intubation.

Statistical analysis

Data are presented as frequencies and percentages. Statistical analysis was conducted using SPSS software to calculate the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy of each of the parameters.

RESULTS

There was a female predominance, with 34 (57%) female and 26 (43%) male patients. Regarding ASA physical status, 40% of patients were ASA I, 23% were ASA II, and 37% were ASA III [Table 1].

Table 1: Demographic characteristics distribution

		N (%)
Gender	Male	26 (43 %)
	Female	34 (57%)
ASA Classification	I	24 (40%)
	II	14 (23%)
	III	22 (37%)

Regarding airway assessment parameters, clinical predictors reported that 52(87%) patients had easy visualisation, and 8(13%) reported difficult visualisation of the larynx. Ultrasound-based SED reported that 78% of patients had easy and 22% had difficult visualisation of the larynx. In terms of CL grading, 30(50%) patients were graded as I, followed by 23(38%) in Grade II, 5(5%) in Grade III, and 2(3%) in Grade IV [Table 2].

Table 2: Distribution of Airway Assessment Parameters

		N (%)
Clinical Predictors	Easy visualisation of the larynx	52 (87%)
	Difficult visualisation of the larynx	8 (13%)
SED	Easy visualisation of the larynx	47 (78%)
	Difficult visualisation of the larynx	13 (22%)
CL Grading	Grade I	30 (50%)
	Grade II	23 (38%)
	Grade III	5 (5%)
	Grade IV	2 (3%)

The clinical predictors identified five true positives, one false positive, two false negatives, and 52 true negatives, yielding a sensitivity of 71.4%, specificity of 98.1%, PPV of 83.3%, NPV of 96.3%, and overall accuracy of 95.0% in predicting difficult intubation.

The ultrasound-based SED measurement identified eight true positives, three false positives, one false negative, and 48 true negatives, with a sensitivity of 88.9%, specificity of 94.1%, PPV of 72.7%, NPV of 97.9%, and overall accuracy of 93.3% [Table 3 & 4].

Table 3: Comparison of airway assessment methods against CL grading for predicting difficult laryngoscopy

Airway assessment method	CL difficult view laryngoscopy (DVL)	CL easy view laryngoscopy (EVL)
Clinical Predictors	5 (True Positive)	1 (False Positive)
	2 (False Negative)	52 (True Negative)
SED Assessment	8 (True Positive)	3 (False Positive)
	1 (False Negative)	48 (True Negative)

Table 4: Comparison of diagnostic accuracy between clinical predictors and SED for predicting difficult intubation

Parameters	Clinical Predictors (%)	SED (%)
Sensitivity	71.43%	88.89%
Specificity	98.11%	94.12%
PPV	83.33%	72.73%
NPV	96.30%	97.96%
Overall Accuracy	95.00%	93.33%

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DISCUSSION

This study aimed to compare the clinical predictors and ultrasonographic SED in predicting difficult intubation. Although clinical predictors effectively identified easy airways, they showed limitations in terms of sensitivity. The incorporation of SED significantly improved the prediction accuracy. In our study, 40% of patients were ASA I, 23% were ASA II, and 37% were ASA III, whereas Shah et al. reported 55.5% ASA I, 31.27% ASA II, and only 11.01% ASA III.[11] This reflects a higher proportion of patients with greater comorbidities in our study. The inclusion of ASA IV patients in their study may account for the differences in outcomes. Our study showed a higher proportion of ASA III patients (37%) than that of Oria et al., who reported only 3.8%.[12]

In our study, airway assessment revealed that both clinical predictors and ultrasound-based SED predominantly indicated easy visualisation of the larynx. CL grading further supported this, with most patients classified as Grade I or II. Similarly, Daggupati et al. reported that CL grading showed that most patients had Grade 1 (n=131) and Grade 2 (n=117), whereas only a few had Grade 3 (n=56) and Grade 4 (n=6), indicating generally easy laryngeal visualisation.[10]

In our analysis, ultrasound-based SED assessment identified more true difficult airways (n=8) than clinical predictors (n=5), although it also yielded more false positives (n=3 vs. n=1), reflecting a higher sensitivity but slightly reduced specificity. This may be attributed to anatomical variability or operator-dependent differences in the ultrasound technique. Anushaprasath et al. also noted that SED identified more true difficult airways (n=8) versus clinical predictors (n=5), with more false positives (n=3 vs. n=1), further supporting the sensitivity-specificity associated with ultrasound evaluation.[13-15]

Our study showed that the majority of patients were predicted to have an easy airway based on both clinical predictors (87%) and ultrasound-based SED assessments (78%). However, direct laryngoscopy revealed that 8% of patients had a difficult laryngeal view, classified as CL Grade III or IV. In a study by Andrews et al., the majority of patients were predicted to have easy airways using clinical predictors (87%) and ultrasound-based SED assessment (78%). However, direct laryngoscopy still revealed difficult laryngeal views in 8% of cases.[13] In contrast, a study by Mallick et al. reported high diagnostic accuracy for predicting difficult airways, with a sensitivity of 96.3% and specificity of 86.4%.[14]

Our findings highlight that ultrasonographic measurement of SED is a sensitive and effective complementary tool to traditional clinical predictors in enhancing the accuracy of difficult airway prediction. Dabo-Trubelja et al. emphasised that ultrasonographic measurement of DSE is a highly sensitive and effective tool for predicting difficult airways with 100% sensitivity, 66.2% specificity, and an NPV ranging from 95% to 97%. 4 Similarly, Sotoodehnia et al. observed significantly greater mean SED values in difficult intubation cases, with a sensitivity of 93.75%.[15] Fernández-Vaquero et al. further supported this by reporting a sensitivity of 91.3% and specificity of 96.9%, with a PPV of 89.36% and an NPV of 97.53% in identifying difficult laryngoscopy.[16] Abdelhady et al. also reported higher sensitivity (80%) and acceptable specificity (70.8%) of SED in predicting difficult airways, confirming its utility as a supportive tool. In line with these findings, Bhagavan and Nelamangala evaluated the distance from the skin to the epiglottis midpoint and reported that values above 2.03 cm were associated with difficult laryngoscopy, with a specificity of 89.77%.[18]

Limitations: The study was limited to 60 patients, which may limit the generalisability of the findings to a broader population. Expanding the sample size in future studies would enhance the reliability and significance of the results. Furthermore, as the research was conducted at a single centre, variations in patient demographics or medical practices at other institutions could influence the generalisability of the outcomes. Additionally, ultrasound measurements, such as SED, are highly dependent on the operator's proficiency and experience, potentially affecting the consistency of the results. Furthermore, the laryngoscopist was not blinded to airway assessments, which may have introduced observer bias.

CONCLUSION

Our study demonstrates that ultrasonographic measurement of SED is a sensitive tool for predicting difficult intubation and offers better detection of challenging airways than clinical predictors alone. Although clinical assessments maintain slightly higher overall accuracy and specificity, combining both approaches enhances the reliability of preoperative airway evaluation. Therefore, SED can be effectively used as a complementary tool alongside traditional clinical parameters to improve the prediction of difficult laryngoscopy. Further studies with larger and more diverse populations are required to validate these findings.

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