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Original Article

# Preoperative Ultrasound Imaging of the Airway: A New Tool in Anticipating Difficult Airway in Clinical Practice

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## Abstract

**Background:** Conventional bedside airway assessment tests have limited accuracy in predicting difficult laryngoscopy. Point-of-care airway ultrasound provides objective anatomical information and may improve preoperative airway evaluation. This study evaluated the role of ultrasonographic airway measurements alone and in combination with conventional clinical assessment in predicting difficult laryngoscopy.

**Methods:** In this prospective observational study, 40 adult patients undergoing elective lumbar spine surgery under general anaesthesia underwent preoperative airway evaluation using Modified Mallampati classification, sternomental distance, mentothyroid distance, and mentohyoid distance. Airway ultrasound was performed using a high-frequency linear probe to measure skin-to-epiglottis distance (SED) and skin-to-midpoint of the vocal cords distance (SVD). Direct laryngoscopy was performed by an anaesthesiologist blinded to the airway assessment findings, and laryngoscopic view was graded using the Cormack-Lehane classification. Logistic regression and receiver operating characteristic (ROC) analyses were used to determine predictive performance.

**Results:** Thirteen patients (32.5%) had difficult laryngoscopy. Among the ultrasonographic parameters, SED was the strongest independent predictor of difficult laryngoscopy (p=0.035). Ultrasound-based assessment demonstrated higher diagnostic accuracy than conventional clinical tests alone. The combined clinical-ultrasound model achieved the best performance with a sensitivity of 92.3%, specificity of 96.2%, positive predictive value of 85.7%, and negative predictive value of 96.2%.

**Conclusion:** Airway ultrasound complements conventional bedside assessment and improves prediction of difficult laryngoscopy. Incorporation of SED into routine preoperative airway evaluation may facilitate better airway planning and enhance patient safety.

**Keywords:** Airway ultrasound, Difficult airway, Difficult laryngoscopy, Skin-to-epiglottis distance, Preoperative airway assessment.

## Introduction

Unexpected difficult laryngoscopy remains an important cause of airway-related complications during general anaesthesia despite advances in airway equipment and the availability of evidence-based difficult airway guidelines [1]. Failure to identify patients at risk before induction may result in repeated laryngoscopy attempts, airway trauma, hypoxaemia, aspiration, and increased perioperative morbidity [2]. Therefore, reliable preoperative airway assessment

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continues to be a fundamental component of safe anaesthetic practice.

Several bedside airway assessment tests, including the Modified Mallampati classification, thyromental distance, sternomental distance, and mentohyoid distance, are routinely used to predict difficult laryngoscopy. Although simple and inexpensive, these tests demonstrate variable sensitivity and specificity, and none has consistently shown sufficient diagnostic accuracy when used alone [2,3]. Their performance is influenced by patient cooperation, examiner experience, and anatomical variations, limiting their ability to reliably identify difficult airways.

Point-of-care ultrasound has emerged as a valuable extension of clinical examination in anaesthesia. Besides its established applications in vascular access and regional anaesthesia, airway ultrasound enables real-time visualization of upper airway anatomy without radiation exposure [4]. Measurements such as anterior neck soft tissue thickness, tongue thickness, hyomental distance, skin-to-epiglottis distance, and skin-to-vocal cord distance have been investigated as potential predictors of difficult laryngoscopy [5–8]. Among these, skin-to-epiglottis distance has consistently demonstrated promising diagnostic performance across several observational studies and systematic reviews [7,8].

We hypothesised that combining objective ultrasonographic measurements with conventional clinical airway assessment would improve prediction of difficult laryngoscopy. This study therefore compared the diagnostic performance of skin-to-epiglottis distance and skin-to-midpoint of the vocal cords with conventional airway assessment and evaluated whether a combined approach provides superior predictive accuracy.

## Methodology

After approval from the Institutional Ethics Committee and obtaining written informed consent, this prospective observational study enrolled 40 adult patients aged 18–70 years with ASA physical status I–III scheduled for elective lumbar spine surgery under general anaesthesia. Patients with previous cervical spine surgery, cervical spine instability, rheumatoid arthritis, ankylosing spondylitis, maxillofacial deformity, restricted mouth opening, or body mass index greater than 30 kg/m$^2$ were excluded.

Preoperative airway assessment was performed by an experienced anaesthesiologist using Modified Mallampati classification, sternomental distance, mentothyroid distance, and mentohyoid distance. Ultrasound examination of the airway was subsequently performed using a high-frequency (5–13 MHz) linear transducer with patients positioned supine in the sniffing position. Two ultrasonographic measurements were recorded: skin-to-epiglottis distance (SED) and skin-to-midpoint of the vocal cords distance (SVD), using previously described techniques [4,5].

General anaesthesia was induced using a standardized protocol. Following adequate neuromuscular blockade, direct laryngoscopy was performed by a second anaesthesiologist who was blinded to both clinical and ultrasonographic airway findings. Laryngoscopic view was graded according to the Cormack-Lehane classification. Grades I and II were considered easy laryngoscopy, whereas Grades III and IV were classified as difficult laryngoscopy.

Continuous variables are expressed as mean ± standard deviation or median (interquartile range), while categorical variables are presented as frequencies and percentages. Logistic regression analysis was used to identify independent predictors of difficult laryngoscopy. Receiver operating characteristic (ROC) curves were constructed to compare the diagnostic performance of clinical, ultrasonographic, and combined assessment models. Sensitivity, specificity, positive predictive value, negative predictive value, and area under the ROC curve (AUC) were calculated. A p-value <0.05 was considered statistically significant.

## Results

Forty patients undergoing elective lumbar spine surgery were included in the study. Difficult laryngoscopy (Cormack-Lehane Grade III) occurred in 13 patients (32.5%), while 27 patients (67.5%) had easy laryngoscopy. Baseline demographic characteristics and airway assessment variables are summarised in Table 1. There were no significant differences between the groups with respect to age, sex, body mass index, height or weight.

Among the patients with difficult laryngoscopy, three (23.1%) had a history of snoring and five (38.5%) had a Mallampati Class III airway. Patients with difficult laryngoscopy demonstrated greater mentothyroid distance

**Table 1: Baseline characteristics and airway assessment of patients according to laryngoscopic view**

| Variable | Overall (n = 40) | Easy laryngoscopy (n = 27) | Difficult laryngoscopy (n = 13) |
|---|---|---|---|
| Age (years), mean ± SD | 50.1 ± 15.4 | 47.7 ± 15.2 | 51.3 ± 15.7 |
| Male sex, n (%) | 18 (45.0) | 14 (51.9) | 8 (61.5) |
| BMI (kg/m$^2$), mean ± SD | 26.6 ± 2.2 | 26.6 ± 2.1 | 26.7 ± 2.3 |
| History of snoring, n (%) | 3 (7.5) | 0 (0) | 3 (23.1) |
| Mallampati class III, n (%) | 9 (22.5) | 4 (14.8) | 5 (38.5) |
| Sternomental distance (cm), mean ± SD | 11.3 ± 1.4 | 11.0 ± 1.0 | 12.0 ± 1.9 |
| Mentothyroid distance (cm), mean ± SD | 6.4 ± 2.2 | 5.8 ± 1.9 | 7.5 ± 2.3 |
| Mentohyoid distance (cm), mean ± SD | 4.2 ± 1.1 | 3.9 ± 1.0 | 4.7 ± 1.1 |
| Skin-to-epiglottis distance (cm), mean ± SD | 0.72 ± 0.15 | 0.67 ± 0.12 | 0.83 ± 0.14 |
| Skin-to-midpoint of vocal cords distance (cm), mean ± SD | 1.61 ± 0.11 | 1.58 ± 0.10 | 1.68 ± 0.08 |
| Cormack–Lehane Grade I/II/III/IV, n | 8 / 19 / 13 / 0 | 8 / 19 / 0 / 0 | 0 / 0 / 13 / 0 |

(7.5 ± 2.3 vs 5.8 ± 1.9 cm), mentohyoid distance (4.7 ± 1.1 vs 3.9 ± 1.0 cm), skin-to-epiglottis distance (0.83 ± 0.14 vs 0.67 ± 0.12 cm), and skin-to-midpoint of the vocal cords distance (1.68 ± 0.08 vs 1.58 ± 0.10 cm) compared with patients with easy laryngoscopy (Table 1).

Logistic regression analysis demonstrated that the predictive ability of the Mallampati score alone was limited (Tjur's $R^2$ = 0.12), although increasing Mallampati class was significantly associated with difficult laryngoscopy (p = 0.035). A model incorporating conventional clinical airway measurements (sternomental and mentothyroid distances) showed only moderate explanatory power (Tjur's $R^2$ = 0.18), with neither variable independently predicting difficult laryngoscopy.

In contrast, the ultrasonographic model demonstrated substantially better performance (Tjur's $R^2$ = 0.38). Among the ultrasonographic parameters, skin-to-epiglottis distance emerged as the only independent predictor of difficult laryngoscopy (log odds 6.72; 95% CI 0.80–13.65; p = 0.035), whereas skin-to-vocal cord distance showed a positive but non-significant association (p = 0.070).

When clinical and ultrasonographic variables were analysed together, the combined model demonstrated the highest explanatory power (Tjur's $R^2$ = 0.46). Within this model, skin-to-epiglottis distance remained the only statistically significant independent predictor (log odds 10.33; 95% CI 2.06–22.45; p = 0.038), while the conventional clinical measurements did not independently predict difficult laryngoscopy.

Receiver operating characteristic analysis confirmed these findings (Fig. 1). The combined clinical-ultrasound model demonstrated the highest diagnostic accuracy, with a sensitivity of 92.3%, specificity of 96.2%, positive predictive value of 85.7%, and negative predictive value of 96.2% (Table 2). The ultrasound-only model also performed well, achieving a sensitivity of 92.3% and specificity of 95.2%, whereas the clinical model and Mallampati classification alone demonstrated lower predictive performance.

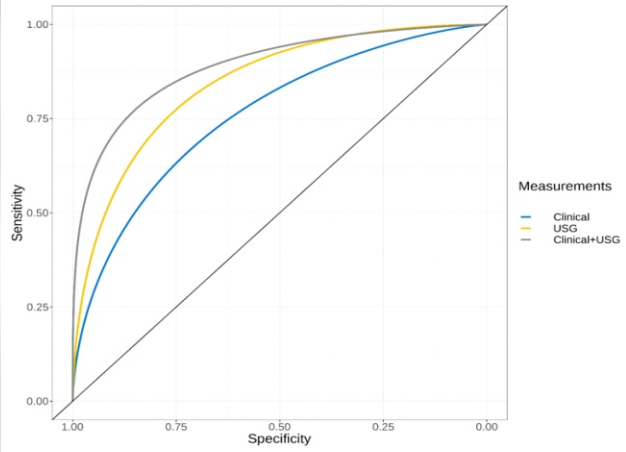


**Figure 1: Receiver operating characteristic curves for the three models**

Among the individual measurements, skin-to-midpoint of the vocal cords distance demonstrated the highest area under the ROC curve (AUC 0.86), followed by skin-to-epiglottis distance (AUC 0.81). Optimal cut-off values for predicting difficult laryngoscopy were 16.4 mm for skin-to-midpoint of the vocal cords distance and 6.5 mm for skin-to-epiglottis distance.

## Discussion

This prospective observational study demonstrates that preoperative airway ultrasound significantly improves the prediction of difficult laryngoscopy when incorporated into conventional bedside airway assessment. Among the ultrasonographic parameters evaluated, skin-to-epiglottis distance was the strongest independent predictor, while the combination of clinical examination and ultrasound provided the highest overall diagnostic accuracy.

Conventional bedside airway tests remain the cornerstone of preoperative airway evaluation because they are simple, rapid, and inexpensive. However, their predictive accuracy has consistently been reported as modest, with no single clinical test reliably identifying difficult laryngoscopy [2,9]. Our findings support this observation, as conventional airway assessments alone showed limited discrimination between easy and difficult laryngoscopy.

Ultrasonography overcomes many of these limitations by providing objective visualization of anterior airway anatomy. Previous investigators have demonstrated that increased anterior neck soft tissue thickness, particularly at the level of the epiglottis, is associated with poor laryngoscopic view [5,7,8]. Our results are consistent with these reports and further demonstrate that SED independently predicts difficult laryngoscopy. Although SVD also showed good discriminatory ability on ROC analysis, it did not remain an independent predictor after multivariable analysis, suggesting that SED may be the more clinically useful measurement.

The most important finding of our study is that combining ultrasonographic measurements with conventional clinical assessment substantially improved diagnostic performance. The high sensitivity and excellent negative predictive value indicate that the combined model may be particularly useful

**Table 2: Diagnostic performance of clinical and ultrasonographic airway assessment**

| Model | Sensitivity | Specificity | PPV | NPV | AUC |
|---|---|---|---|---|---|
| Mallampati | 38.5 | 85.2 | 55.6 | 74.2 | — |
| Clinical model | 84.6 | 63 | 52.4 | 89.5 | — |
| Ultrasound model | 92.3 | 95.2 | 62.2 | 95.2 | — |
| Combined model | 92.3 | 96.2 | 85.7 | 96.2 | Highest |

in identifying patients unlikely to have difficult laryngoscopy while also improving recognition of patients requiring advanced airway preparation. Rather than replacing established bedside assessment, airway ultrasound should be considered an adjunct that enhances clinical decision-making.

The study has several limitations. It was conducted at a single centre with a relatively small sample size and excluded patients with obesity and significant cervical spine pathology, limiting generalisability. In addition, ultrasound measurements were obtained by experienced operators, and interobserver variability was not assessed. Larger multicentre studies are required to validate optimal cut-off values and determine the role of airway ultrasound across diverse patient populations.

**Conclusion**

Preoperative airway ultrasound provides objective anatomical information that complements conventional bedside airway assessment. Skin-to-epiglottis distance is a reliable independent predictor of difficult laryngoscopy, and combining ultrasonographic measurements with routine clinical assessment significantly improves predictive accuracy. Incorporation of airway ultrasound into preoperative airway evaluation may facilitate better airway planning and improve patient safety.

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**Declaration of patient consent:** The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given his/her consent for his/her images and other clinical information to be reported in the Journal. The patient understands that his/her name and initials will not be published, and due efforts will be made to conceal his/her identity, but anonymity cannot be guaranteed.

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