RESEARCH PAPER

Ultrasonographic Evaluation of Palatoglossal Space to Predict Difficult Mask Ventilation: A Prospective Observational Study

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ABSTRACT

Background: Difficult mask ventilation (DMV) is a significant anesthetic challenge that can lead to hypoxia and increased perioperative morbidity. Conventional assessment tools such as the Mallampati score, thyromental distance (TMD), and body mass index (BMI) offer inconsistent predictive value. Ultrasonography has emerged as a valuable tool for dynamic and anatomical evaluation of the airway. This study explores the utility of ultrasonographic measurement of the palatoglossal space (PGS) in predicting DMV.

Objectives: To compare ultrasonographic measurements of PGS with conventional airway assessment parameters (Mallampati score, TMD, BMI), and to determine the sensitivity, specificity, and predictive value of PGS ultrasound in predicting DMV.

Methods: A prospective observational study was conducted involving 60 patients scheduled for elective surgery under general anesthesia. Preoperative airway assessment included Mallampati score, TMD, BMI, and ultrasonographic measurement of the PGS. Mask ventilation was graded using the Han classification. Statistical analysis included sensitivity, specificity, PPV, NPV, and ROC curve.

Results: The present study were evaluated on 60 patients, 15 (25%) had DMV. The mean PGS was significantly lower in the DMV group (1.22 ± 0.23 cm) compared to the easy ventilation group (1.81 ± 0.34 cm, $p<0.001$). PGS demonstrated higher sensitivity (86.7%) and specificity (88.9%) than Mallampati, TMD, and BMI. ROC analysis showed an AUC of 0.91 for PGS.

Conclusion: Ultrasonographic evaluation of PGS is an accurate and reliable predictor of DMV. It outperforms traditional parameters and can be a valuable addition to airway assessment protocols.

Keywords: Difficult mask ventilation, Palatoglossal space, Ultrasonography, Airway assessment, Mallampati score, Thyromental distance.

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INTRODUCTION

Difficult mask ventilation (DMV) can complicate anesthetic induction, increasing the risk of hypoxia and other airway-related complications (Kundra *et al*., 2011). Early identification of patients at risk allows for appropriate preparation and intervention. Commonly used predictors such as the Mallampati classification, TMD, and BMI have shown moderate sensitivity and specificity. Ultrasound has become increasingly valuable for airway evaluation due to its ability to visualize soft tissue structures in real time (Fulkerson *et al*., 2017). The palatoglossal space (PGS) represents the airway dimension between the tongue and soft palate and may play an important role in determining the ease of mask

ventilation (Han et al., 2004). This study aimed to assess the value of ultrasound-based PGS measurement and compare its diagnostic accuracy with conventional clinical predictors of difficult mask ventilation.

Methods

This prospective observational study included 60 adult patients (18–65 years, ASA I–II) undergoing elective surgeries requiring general anesthesia. Exclusion criteria included emergency surgeries, oropharyngeal pathology, or prior airway surgery (Fulkerson *et al*., 2017). Preoperative airway evaluation included:

- Mallampati classification (Mallampati *et al*., 1985) - Thyromental distance (TMD, measured from mentum to thyroid notch) (Frerk, 1991) - BMI (kg/m²) (Mallampati *et al*., 1985; Frerk, 1991; Kundra et al., 2011) - Ultrasonographic measurement of the PGS (curvilinear probe, submental approach) (Adhikari *et al*., 2011) Mask ventilation was assessed during anesthesia induction and graded using the Han scale. Grades 3 and 4 were considered difficult (Han *et al*., 2004). Statistical analysis was performed using SPSS. Student's t-test compared continuous variables. Sensitivity, specificity, and predictive values were calculated. Receiver operating characteristic (ROC) curves were used to assess diagnostic performance (Bewick *et al*., 2004).

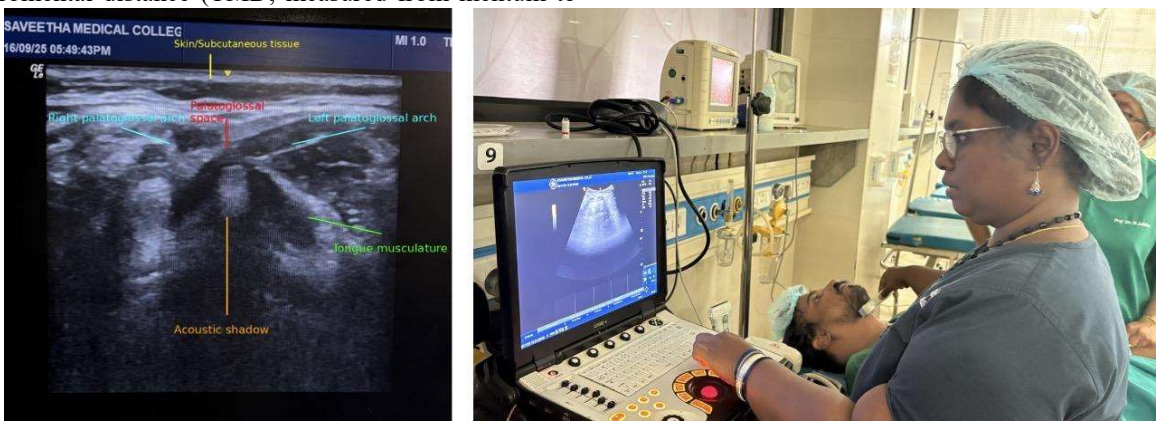

Figure 1: Coronal ultrasound image of the palatoglossal region obtained using a high-frequency linear transducer. The right and left palatoglossal arches (RPGA and LPGA) are visualised surrounding the palatoglossal space (PGS). Tongue musculature (T) is identified in the deeper plane, while posterior acoustic shadowing (AS) from air-containing pharyngeal structures is evident below.

Figure 2 : Patient positioning and probe placement during airway ultrasonography in a supine patient undergoing preoperative assessment prior to general anesthesia.

RESULTS

Out of 60 patients, 15 (25%) experienced difficult mask ventilation. Key characteristics are evaluated in **Table.1**.

Table.1 Demographic chart compared with easy and difficult ventilation of airway assessment

Parameter	Easy Ventilation (n=45)	Difficult Ventilation (n=15)	p-value	Statistical Test
Age (years)	42.3 ± 11.5	45.6 ± 12.1	0.32	t-test
BMI (kg/m²)	24.1 ± 3.2	28.4 ± 2.9	<0.01	t-test
Mallampati III–IV	18 (40%)	11 (73.3%)	0.03	Chi-square
TMD (cm)	6.9 ± 0.6	6.1 ± 0.5	<0.01	t-test
PGS (cm)	1.81 ± 0.34	1.22 ± 0.23	<0.001	t-test

A total of 60 patients were included in the analysis, of whom 45 (75%) had easy mask ventilation and 15 (25%) experienced difficult mask ventilation. The demographic and airway assessment parameters of the two groups are presented in **Table 1.** There was no statistically significant difference in age between patients with easy ventilation and those with difficult ventilation (42.3 ± 11.5 vs. 45.6 ± 12.1 years, $p = 0.32$). However, body mass

index (BMI) was significantly higher in the difficult ventilation group compared to the easy ventilation group (28.4 ± 2.9 vs. 24.1 ± 3.2 kg/m², $p < 0.01$). Airway assessment revealed a significantly greater prevalence of Mallampati grades III–IV among patients with difficult ventilation (73.3%) compared with those who were easily ventilated (40.0%) ($p = 0.03$). Similarly, thyromental distance (TMD) was significantly shorter in the difficult ventilation group (6.1 ± 0.5 cm) than in the easy ventilation group (6.9 ± 0.6 cm, $p < 0.01$). The preoperative glottic or pharyngeal space measurement (PGS) was also significantly reduced in patients with difficult ventilation (1.22 ± 0.23 cm) compared with patients with easy ventilation (1.81 ± 0.34 cm, $p < 0.001$). Among all evaluated variables, PGS demonstrated the strongest association with difficult mask ventilation. Overall, increased BMI, higher Mallampati grade, reduced TMD, and lower PGS values were significantly associated with difficult mask ventilation, whereas age did not significantly influence ventilation difficulty.

Table.2 Ultrasound-based PGS measurement showed the highest diagnostic accuracy for predicting DMV.

Parameter	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Mallampati III–IV	60.0	72.2	47.8	80.0
TMD <6.5 cm	53.3	75.0	44.4	81.1
BMI >27	66.7	70.0	50.0	82.6
PGS <1.5 cm	86.7	88.9	72.2	94.1

The diagnostic performance of various preoperative airway assessment parameters for predicting difficult mask ventilation (DMV) is summarized in Table.2. Among the evaluated predictors, ultrasound-based preoperative glottic space (PGS) measurement demonstrated the highest overall diagnostic accuracy. A PGS value of <1.5 cm yielded a sensitivity of 86.7% and specificity of 88.9%, indicating excellent ability to correctly identify both patients at risk of DMV and those likely to have uncomplicated ventilation. Furthermore, PGS exhibited the highest positive predictive value (72.2%) and negative predictive value (94.1%) among all assessed parameters, suggesting strong reliability as a screening tool. The assessment of Mallampati classification of III–IV demonstrated moderate predictive performance, with a sensitivity of 60.0% and specificity of 72.2%. Similarly, a thyromental distance (TMD) of <6.5 cm showed a sensitivity of 53.3% and specificity of 75.0%. Elevated body mass index (BMI >27 kg/m²) exhibited slightly higher sensitivity (66.7%) but relatively lower specificity (70.0%) than PGS measurement. Universally, ultrasound derived PGS measurement outperformed conventional airway assessment parameters in predicting difficult mask ventilation, highlighting its potential utility as an objective and non-invasive preoperative airway assessment tool (Frerk, 1991).

DISCUSSION

The effective mask ventilation is a critical component of airway management and remains a fundamental skill in anesthetic practice. Failure to establish adequate mask ventilation can rapidly lead to hypoxemia and is a major contributor to adverse airway-related events (Apfelbaum *et al*., 2022). Therefore, identification of predictors of difficult ventilation during preoperative assessment is essential.

In the present study, BMI was significantly higher among patients who experienced difficult ventilation. Obesity has been consistently identified as an independent risk factor for difficult mask ventilation due to increased upper airway soft tissue, reduced pharyngeal caliber, and decreased functional residual capacity (Kheterpal *et al*., 2006). Similar findings have been reported by Langeron *et al.*, (2000), who demonstrated a strong association between increased BMI and difficulty in mask ventilation. Mallampati classification also showed a significant relationship with ventilation difficulty. Patients with Mallampati grades III–IV were more likely to experience difficult ventilation than those with lower grades. Higher Mallampati grades reflect reduced visibility of oropharyngeal structures and have been associated with both difficult intubation and difficult mask ventilation in previous studies (Mallampati *et al*., 1985; Kheterpal *et al*., 2006). Thyromental distance emerged as another significant predictor in the present analysis. Patients with difficult ventilation exhibited significantly shorter TMD values, suggesting reduced mandibular space and less favorable airway anatomy. A shortened thyromental distance has been widely recognized as an indicator of difficult airway management and may reflect limited displacement of the tongue during mask ventilation and laryngoscopy (Frerk, 1991).

Notably, PGS demonstrated the strongest statistical association with difficult ventilation. Patients with difficult ventilation had significantly smaller PGS measurements than those with easy ventilation (Kheterpal *et al*., 2005; Frerk, 1991). Reduced pharyngeal or glottic

dimensions may predispose to upper airway collapse during induction of anesthesia, thereby increasing resistance to effective mask ventilation. This finding suggests that PGS may serve as a useful adjunctive airway assessment parameter and warrants further investigation in larger prospective studies (Apfelbaum *et al.,* 2022). Interestingly, age was not significantly associated with ventilation difficulty in the present cohort. Although advanced age has been reported as a risk factor in some studies, its predictive value appears inconsistent and may be influenced by the presence of other anatomical and physiological factors (Langeron *et al*., 2000).

Collectively, these findings indicate that elevated BMI, higher Mallampati grade, shorter thyromental distance, and reduced PGS are important predictors of difficult mask ventilation. Incorporating these parameters into routine preoperative airway evaluation may improve identification of at-risk patients and facilitate appropriate airway planning (Apfelbaum *et al.,* 2022). Our study demonstrates that ultrasonographic assessment of the palatoglossal space offers a reliable and non-invasive method to predict difficult mask ventilation. Among all parameters, PGS measurement had the highest diagnostic accuracy, consistent with previous findings by Riad *et al.* (2018) and Adhikari *et al*., (2011) who noted that ultrasound could enhance preoperative airway assessment. While Mallampati and TMD remain widely used, their subjectivity and limited anatomical insight reduce their predictive value. Our results showed PGS has an AUC of 0.91, higher than the AUCs reported for Mallampati (0.66) and TMD (0.70) in similar studies.

Earlier findings of Kheterpal *et al*.,(2006) revealed that the BMI was a significant predictor, our findings reaffirm BMI's role, although it was less accurate than ultrasound-based assessment. This supports integrating ultrasonography in airway evaluation protocols (Wojtczak, 2012). However, limitations include the single-center design and modest sample size. Future multicentric studies are needed to validate our results. Accurate prediction of difficult mask ventilation remains an important component of preoperative airway evaluation because failure to establish adequate ventilation can lead to serious perioperative complications (Kheterpal *et al*., 2006. Traditional airway assessment methods, including Mallampati classification, thyromental distance, and body mass index, are widely used; however, their predictive accuracy is often limited when used independently (Fulkerson *et al*., 2017; Apfelbaum *et al.,* 2022).

In the present study, ultrasound-based measurement of the preoperative glottic space (PGS) demonstrated superior diagnostic performance compared with conventional clinical predictors (Shiga *et al.,* 2005; Apfelbaum *et al.,* 2022). A PGS threshold of **<1.5 cm** achieved both high sensitivity (86.7%) and specificity (88.9%), indicating excellent discrimination between patients with easy and difficult mask ventilation. The high negative predictive value (94.1%) suggests that patients with a PGS greater than 1.5 cm are unlikely to experience ventilation difficulties, making this parameter particularly useful for preoperative risk stratification. These findings support the growing role of point-of-care ultrasonography in airway assessment. Unlike conventional bedside tests, ultrasound provides direct visualization of upper airway structures and objective anatomical measurements, thereby reducing interobserver variability and improving reproducibility (Fulkerson *et al*., 2017; Kundra *et al*., 2011). Several studies have demonstrated that ultrasonographic airway measurements correlate with difficult laryngoscopy and ventilation, reinforcing the value of ultrasound as an adjunct to routine airway evaluation (Adhikari *et al*., 2011; Wojtczak, 2012).

Although Mallampati grading, thyromental distance, and BMI were significantly associated with difficult mask ventilation, their diagnostic performance was inferior to that of PGS measurement. The relatively lower sensitivity observed with Mallampati classification and TMD suggests that these assessments may fail to identify a substantial proportion of patients at risk. This observation is consistent with previous reports indicating that no single clinical test possesses sufficient predictive accuracy when used in isolation (Shiga *et al*., 2005). The superior performance of PGS measurement observed in the present study may be attributed to its ability to directly reflect upper airway dimensions and potential airway collapsibility during anesthesia induction. A narrower glottic or pharyngeal space may predispose patients to increased airway resistance and upper airway obstruction, thereby contributing to difficult mask ventilation. Taken together, these findings suggest that ultrasound-based PGS assessment may serve as a valuable adjunct to conventional airway evaluation. Incorporation of this technique into routine preoperative assessment could enhance the identification of patients at risk for difficult mask ventilation and facilitate more effective airway management planning. Further large-scale prospective studies are warranted to validate these findings and establish standardized cutoff values for clinical practice.

- The occurrence of difficult mask ventilation was significantly associated with elevated body mass index, higher Mallampati classification, reduced thyromental distance, and smaller preoperative glottic space measurements.
- Among all evaluated airway assessment parameters, ultrasound-derived preoperative glottic space measurement demonstrated the greatest diagnostic

performance for identifying patients at risk of difficult mask ventilation.

- A preoperative glottic space threshold of less than 1.5 cm provided excellent predictive capability, with a sensitivity of 86.7% and specificity of 88.9% for the detection of difficult mask ventilation.
- These findings suggest that airway ultrasonography can serve as a valuable complementary tool to conventional bedside airway assessment methods, thereby enhancing preoperative risk stratification and airway management planning.
- The combined use of clinical airway predictors and ultrasonographic measurements may improve the accuracy of difficult airway prediction, facilitate timely preparation of airway management strategies, and ultimately contribute to enhanced patient safety during the perioperative period.

CONCLUSION

Preoperative glottic space emerged as the most discriminative airway parameter, demonstrating the largest effect size and highest statistical significance among the variables studied. These findings indicate that reduced PGS is independently associated with an increased risk of difficult mask ventilation and may enhance the predictive accuracy of routine preoperative airway assessment. Ultrasonographic evaluation of the palatoglossal space is a valuable, accurate, and reproducible method for predicting difficult mask ventilation. It outperforms traditional clinical predictors such as Mallampati score, thyromental distance, and BMI. Integration of airway ultrasonography into routine preoperative assessment may improve patient outcomes. Ultrasonographic measurement may serve as a reliable and clinically useful predictor of difficult mask ventilation during preoperative airway assessment.

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