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Ultrasonographic Evaluation of Palatoglossal Space to Predict Difficult Mask Ventilation

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ABSTRACT

Background: Face-mask ventilation is fundamental to anaesthetic practice, yet difficult mask ventilation remains challenging to predict. Ultrasonographic evaluation of palatoglossal space represents a novel approach for airway assessment. This study evaluated the predictive utility of palatoglossal space measurement for difficult mask ventilation.

Methods: This prospective observational study included 62 adults aged 18-60 years undergoing general anaesthesia. Palatoglossal space was measured ultrasonographically using a curvilinear probe in the coronal plane. Face-mask ventilation was graded using the Han scale, with grades 2-4 classified as difficult mask ventilation.

Results: The study population had mean age 42.5 ± 15.2 years with 51.6% males. Easy mask ventilation (Han score 1) occurred in 80.6% of patients, while 19.4% had difficult mask ventilation (Han score 2). Mean palatoglossal space was 0.78 ± 0.12 cm in easy ventilation group versus 0.73 ± 0.13 cm in difficult ventilation group, showing a trend but no statistical significance ($p = 0.207$). ROC analysis revealed limited discriminatory ability (AUC = 0.612, $p = 0.207$) with optimal cut-off of ≤0.75 cm yielding sensitivity 58.3%, specificity 64.0%, PPV 28.0%, and NPV 86.5%.

Conclusion: Ultrasonographic palatoglossal space measurement showed a clinically plausible trend toward smaller dimensions in difficult mask ventilation cases but lacked statistical significance. The technique is feasible and safe, warranting investigation in larger, higher-risk populations to establish clinical utility.

Keywords: Ultrasonography, palatoglossal space, difficult mask ventilation, airway assessment, anaesthesia.

INTRODUCTION:

Airway management constitutes the cornerstone of safe anaesthetic practice, with face-mask ventilation serving as both a primary ventilation technique and a crucial rescue method during airway emergencies. The ability to provide effective mask ventilation is fundamental to anaesthesia providers, representing the first line of airway support following induction of general anaesthesia and serving as a vital bridge technique during failed intubation scenarios (1). Despite its apparent simplicity, face-mask ventilation can present significant challenges, with the incidence of difficult mask ventilation ranging from 0.08% to 15.5% across various patient populations (2).

The concept of difficult mask ventilation was first systematically characterized by Langeron et al. in 2000, who identified key predictive factors and established the clinical significance of this phenomenon (3). Subsequently, the Han grading scale was developed to provide a standardized classification system for mask ventilation quality, ranging from grade 1 (easy ventilation) to grade 4 (impossible mask ventilation), with grades 3 and 4 representing clinically significant difficult mask ventilation (4). This classification system has become widely adopted in clinical practice and research, providing a consistent framework for assessing ventilation quality and comparing outcomes across studies.

The physiological basis of mask ventilation involves creating an effective seal between the face mask and patient's face while maintaining airway patency through proper head positioning and, when necessary, airway adjuncts. The process requires coordination of multiple factors including appropriate mask size and fit, optimal head and neck positioning, adequate jaw thrust maneuvers, and sometimes the insertion of oropharyngeal or nasopharyngeal airways (5). Failure in any of these components can result in inadequate ventilation, leading to hypoxemia, hypercarbia, and potential patient harm.

Traditional predictive factors for difficult mask ventilation include patient characteristics such as advanced age, elevated body mass index, presence of beard, edentulous state, history of snoring or sleep apnea, Mallampati class III or IV, limited jaw protrusion, and neck radiation changes. However, these clinical predictors often lack the precision required for reliable preoperative assessment, with sensitivity and specificity values that may be inadequate for routine clinical decision-making (6). This limitation has prompted investigation into more objective and reliable assessment methods.

The advent of point-of-care ultrasonography in anaesthesia has revolutionized preoperative airway assessment, offering real-time visualization of anatomical structures critical for airway management. Ultrasound-based airway evaluation has gained significant attention due to its non-invasive nature, immediate availability, and ability to provide quantitative measurements of airway structures. Various ultrasonographic parameters have been investigated for predicting difficult laryngoscopy, including measurements of tongue thickness, skin-to-hyoid distance, skin-to-epiglottis distance, and skin-to-vocal cord distance (7).

The palatoglossal space represents a novel ultrasonographic parameter specifically relevant to mask ventilation assessment. This anatomical space, located between the posterior aspect of the tongue and the soft palate, plays a crucial role in maintaining upper airway patency during spontaneous breathing and assisted ventilation. The PGS can be visualized and measured using ultrasound in the coronal plane, providing an objective assessment of the potential for airway collapse during mask ventilation attempts (8).

The theoretical basis for using PGS as a predictor of difficult mask ventilation lies in the understanding of upper airway dynamics during anaesthesia induction. Following administration of anaesthetic agents and neuromuscular blocking drugs, there is a loss of upper airway muscle tone, leading to posterior displacement of the tongue and potential collapse of the palatoglossal space. Patients with reduced baseline PGS dimensions may be at higher risk for airway obstruction following induction, as the already compromised space becomes further reduced (9).

Current evidence supporting the use of ultrasonographic airway assessment has been primarily focused on predicting difficult laryngoscopy rather than difficult mask ventilation. While these studies have demonstrated the utility of ultrasound in airway evaluation, there remains a significant gap in research specifically addressing mask ventilation prediction. The few studies that have examined ultrasound parameters for mask ventilation assessment have shown promising results, but larger, well-designed investigations are needed to establish the clinical utility of these measurements (10).

The clinical implications of developing reliable predictors for difficult mask ventilation extend beyond individual patient safety to broader healthcare system considerations. Early identification of patients at risk for DMV allows for appropriate preparation, including ensuring availability of airway adjuncts, considering alternative induction techniques, and having experienced personnel present during airway management. This proactive approach can reduce the incidence of airway emergencies, minimize patient morbidity, and improve overall perioperative outcomes.

Furthermore, the integration of ultrasonographic airway assessment into routine preoperative evaluation represents a shift toward more objective, evidence-based airway management strategies. Unlike subjective clinical assessments that may vary between practitioners, ultrasound measurements provide quantifiable data that can be standardized across institutions and integrated into clinical decision algorithms. This standardization has the potential to improve consistency in airway management approaches and reduce variability in patient outcomes.

The present study addresses the critical need for objective, reliable predictors of difficult mask ventilation by investigating the utility of ultrasonographic measurement of palatoglossal space. By focusing specifically on mask ventilation rather than laryngoscopy, this research fills an important gap in the current literature and provides valuable insights for clinical practice. The findings have the potential to enhance preoperative airway assessment protocols and contribute to improved patient safety during anaesthesia induction and airway management procedures.

AIMS AND OBJECTIVES

The primary aim of this study was to evaluate the diagnostic accuracy of ultrasonographic measurement of palatoglossal space in predicting difficult mask ventilation in patients undergoing general anaesthesia. The specific objectives included determining the sensitivity and specificity of palatoglossal space measurements for predicting difficult mask ventilation and assessing the correlation between palatoglossal space measurements and the Han grading scale for mask ventilation quality. Additionally, the study aimed to evaluate the feasibility and safety of palatoglossal space measurement using point-of-care ultrasonography in the preoperative setting.

MATERIALS AND METHODS

Study Design and Setting

This prospective observational study was conducted at the S.S. Institute of Medical Sciences and Research Centre, Davangere, Karnataka, India, following approval from the Institutional Ethics Committee. The study was conducted in accordance with the Declaration of Helsinki and Good Clinical Practice guidelines.

Sample Size Calculation

The sample size was calculated using the formula for diagnostic accuracy studies: $n = (Z\alpha^2 \times p \times q) / d^2$, where $Z\alpha = 1.96$ for $\alpha = 0.05$, p = expected incidence of difficult mask ventilation (15.5%), q = 100 - p (84.5%), and d = absolute precision (9%). Based on this calculation, a minimum sample size of 62 patients was required and enrolled in the study.

Inclusion and Exclusion Criteria

Adults aged 18-60 years undergoing surgery under general anaesthesia requiring endotracheal intubation, supraglottic airway insertion, and bag mask ventilation were included in the study. Patients were required to provide written informed consent for participation.

Exclusion criteria included patients with craniofacial fractures, presence of facial hair or beard, edentulous patients, emergency surgical procedures, pregnancy, and patients with contraindications to general anaesthesia.

Ultrasonographic Assessment

Preoperative ultrasonographic evaluation was performed using a portable ultrasound system equipped with a curvilinear probe (1-8 MHz). Using the curvilinear ultrasound probe, the palatoglossal space (PGS) was measured at midway between the mentum and hyoid bone in the coronal plane with the mouth closed. Measurements were taken in centimeters using the ultrasound system's built-in calipers.

Anaesthetic Management and Mask Ventilation Assessment

All patients underwent standardized premedication and general anaesthesia induction with intravenous propofol 2 mg/kg, followed by assessment of mask ventilation before administration of neuromuscular blocking agents.

Face-mask ventilation was assessed and graded according to the Han scale: Grade 1 (ventilated by mask without difficulty), Grade 2 (ventilated by mask with oropharyngeal or nasopharyngeal airway), Grade 3 (difficult ventilation requiring two providers), and Grade 4 (unable to mask ventilate). For the purpose of this study, Grade 1 was classified as easy mask ventilation, while Grades 2, 3, and 4 were classified as difficult mask ventilation.

Statistical Analysis

The data was analyzed using SPSS version 25.0. Qualitative variables were expressed as frequencies and percentages, and quantitative variables as range and mean ± standard deviation. A receiver operating characteristic (ROC) analysis was performed to determine the optimal cut-off value for PGS. Comparison between groups was performed using independent t-tests for continuous variables and chi-square tests for categorical variables. A p-value of less than 0.05 was considered statistically significant.

RESULTS

A total of 62 patients were enrolled and successfully completed the study protocol. All palatoglossal space measurements were obtained without technical difficulties or complications.

The demographic characteristics revealed a diverse adult population with mean age of 42.5 ± 15.2 years, ranging from 19 to 60 years. Male patients comprised 51.6% of the study population. The mean body mass index was 24.8 ± 4.2 kg/m², with most patients falling within normal to overweight categories. Neck circumference averaged 37.6 ± 4.6 cm. Mallampati classification showed 67.7% of patients with Class I-II and 32.3% with Class III-IV. Most patients (77.4%) had ASA physical status I-II, reflecting a relatively healthy study population.

Face-mask ventilation assessment using the Han grading scale revealed that the majority of patients (50 patients, 80.6%) achieved easy mask ventilation (Han score 1), requiring no airway adjuncts. Twelve patients (19.4%) experienced difficult mask ventilation (Han score 2), necessitating oropharyngeal or nasopharyngeal airway insertion. Notably, no patients in this study experienced severe mask ventilation difficulties (Han scores 3 or 4), indicating absence of cases requiring two providers or impossible mask ventilation scenarios.

Ultrasonographic palatoglossal space measurements were successfully obtained in all patients with a mean measurement of 0.77 ± 0.12 cm overall. The measurements ranged from 0.52 cm to 1.05 cm, demonstrating considerable inter-individual variation. When stratified by mask ventilation difficulty, patients with easy mask ventilation had mean palatoglossal space of 0.78 ± 0.12 cm, while those with difficult mask ventilation had mean palatoglossal space of 0.73 ± 0.13 cm. This represented a 0.05 cm difference favoring larger palatoglossal space in easy ventilation cases, though the difference did not achieve statistical significance ($p = 0.207$).

Receiver operating characteristic curve analysis was performed to evaluate the discriminatory ability of palatoglossal space measurement for predicting difficult mask ventilation. The analysis yielded an area under the curve of 0.612 (95% CI: 0.423-0.801), indicating limited predictive capability. The p-value of 0.207 confirmed that the discriminatory ability was not statistically significant. Multiple cut-off values were analyzed to determine optimal diagnostic performance parameters.

Clinical feasibility assessment demonstrated excellent practical applicability of the ultrasonographic technique. All 62 measurements (100%) were successfully completed with mean acquisition time of 4.1 ± 0.8 minutes per patient. No patients experienced discomfort during the procedure, and no technical complications were encountered. The probe positioning and image acquisition were straightforward, suggesting good reproducibility for clinical implementation.

Table 1: Demographic and Clinical Characteristics of Study Population

Parameter	**Value**	**Range/Distribution**
Age (years)	42.5 ± 15.2	19-60
Male gender, n (%)	32 (51.6%)	-
Female gender, n (%)	30 (48.4%)	-
Weight (kg)	68.3 ± 12.4	45-95
Height (cm)	164.2 ± 8.7	150-182
BMI (kg/m²)	24.8 ± 4.2	18.2-34.1
Neck circumference (cm)	37.6 ± 4.6	28-48
Mallampati Classification		
Class I, n (%)	18 (29.0%)	-
Class II, n (%)	24 (38.7%)	-
Class III, n (%)	15 (24.2%)	-
Class IV, n (%)	5 (8.1%)	-
ASA Physical Status		
ASA I, n (%)	28 (45.2%)	-
ASA II, n (%)	20 (32.3%)	-
ASA III, n (%)	14 (22.6%)	-
Comorbidities		
Hypertension, n (%)	18 (29.0%)	-
Diabetes mellitus, n (%)	12 (19.4%)	-
Previous surgery, n (%)	22 (35.5%)	-

Table 2: Han Scale Distribution and Mask Ventilation Outcomes

Han Scale Score	**Number of Patients**	**Percentage**	**Clinical Description**
Grade 1	50	80.6%	Easy mask ventilation, no adjuncts required
Grade 2	12	19.4%	Difficult ventilation, airway adjuncts needed
Grade 3	0	0%	Very difficult, requires two providers
Grade 4	0	0%	Impossible mask ventilation
Total	**62**	**100%**	

Table 3: Palatoglossal Space Measurements by Ventilation Difficulty

Parameter	Easy Ventilation (Han 1) n=50	Difficult Ventilation (Han 2) n=12	p-value
Mean PGS (cm)	0.78 ± 0.12	0.73 ± 0.13	0.207
Median PGS (cm)	0.77	0.74	-
Range (cm)	0.52 - 1.05	0.55 - 0.95	-
95% CI	0.74 - 0.81	0.65 - 0.81	-

Table 4: ROC Curve Analysis - Diagnostic Performance at Various Cut-off Values

Cut-off Value (cm)	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
≤ 0.65	25.0	92.0	42.9	82.1	80.6
≤ 0.70	41.7	80.0	35.7	83.3	74.2
≤ 0.75	58.3	64.0	28.0	86.5	62.9
≤ 0.80	75.0	48.0	25.7	88.9	53.2
≤ 0.85	91.7	32.0	23.4	94.1	43.5

Table 5: ROC Curve Summary Statistics

Parameter	Value	95% Confidence Interval
Area Under Curve (AUC)	0.612	0.423 - 0.801
Standard Error	0.096	-
p-value	0.207	-
Optimal Cut-off (Youden Index)	**≤ 0.75 cm**	
Sensitivity at Optimal Cut-off	**58.3%**	
Specificity at Optimal Cut-off	**64.0%**	

Table 6: Technical Feasibility and Safety Assessment

Parameter	Result	Percentage
Successful measurements	62/62	100%
Mean measurement time (minutes)	4.1 ± 0.8	-
Failed measurements	0/62	0%
Patient discomfort	0/62	0%
Technical complications	0/62	0%
Image quality (good/excellent)	58/62	93.5%

DISCUSSION

The present study investigated ultrasonographic measurement of palatoglossal space as a potential predictor of difficult mask ventilation in 62 adult patients undergoing general anaesthesia. While the results demonstrated a clinically plausible trend toward smaller palatoglossal space dimensions in patients with difficult mask ventilation, this difference failed to achieve statistical significance, limiting the clinical utility of this parameter as a standalone predictor.

The study population characteristics revealed important insights into the epidemiology of mask ventilation difficulties. The observed incidence of difficult mask ventilation was 19.4%, which falls within the reported range of 15.5% in previous literature but represents a relatively homogeneous, low-risk population. The absence of Han grades 3 and 4 cases suggests that the exclusion criteria effectively eliminated high-risk patients, potentially limiting the discriminatory power of the palatoglossal space measurement. This finding contrasts with studies by Kheterpal et al. and Langeron et al., who reported higher incidences of severe mask ventilation difficulties in unselected patient populations (11,12).

The mean palatoglossal space measurements observed in this study (0.78 ± 0.12 cm for easy ventilation versus 0.73 ± 0.13 cm for difficult ventilation) represent the first reported normative values for this parameter in the context of mask ventilation assessment. The 0.05 cm difference, while not statistically significant, demonstrates a consistent directional trend that aligns with the physiological understanding of upper airway dynamics during anaesthesia induction. The palatoglossal space serves as a critical anatomical corridor for airflow, and its reduction may predispose to airway collapse following loss of muscle tone (13).

The receiver operating characteristic analysis yielded disappointing results with an area under the curve of 0.612, indicating limited discriminatory ability. This finding suggests that palatoglossal space measurement alone lacks sufficient predictive accuracy for routine clinical decision-making. The ROC analysis revealed that at the optimal cut-off value of ≤0.75 cm, the sensitivity was 58.3% and specificity was 64.0%, with positive predictive value of 28.0% and negative predictive value of 86.5%. These diagnostic performance parameters fall below the threshold typically considered acceptable for clinical screening tools (14).

Previous ultrasonographic studies for difficult laryngoscopy prediction have reported AUC values ranging from 0.7 to 0.9, indicating superior predictive performance for intubation compared to mask ventilation assessment. The lower predictive accuracy observed in this study may reflect the different anatomical and physiological factors that contribute to mask ventilation difficulties compared to laryngoscopy challenges (15).

Several methodological factors may have contributed to the limited predictive performance observed. The static measurement technique with the mouth closed may not adequately reflect the dynamic changes that occur during mask ventilation attempts, particularly following muscle relaxation and positive pressure ventilation. Future studies might benefit from dynamic assessment protocols or measurements obtained under conditions that better simulate the clinical scenario of anaesthesia induction (16).

The study population characteristics also warrant consideration in interpreting these results. The exclusion of patients with beards, edentulous patients, and those with craniofacial abnormalities eliminated traditional high-risk factors for difficult mask ventilation, potentially creating a more homogeneous population with limited outcome variability. Additionally, the expertise of the anaesthesia providers and standardized approach to mask ventilation may have minimized the incidence of severe ventilation difficulties, further limiting the discriminatory power of the measurement (17).

Despite the limited predictive accuracy, the technical feasibility results were encouraging. The 100% success rate in obtaining measurements, rapid acquisition time (4.1 ± 0.8 minutes), and absence of complications demonstrate that palatoglossal space assessment is practical for clinical implementation. These characteristics support the continued investigation of ultrasonographic airway assessment, potentially using multiparameter approaches or refined measurement techniques (18).

The implications of these findings for clinical practice suggest that palatoglossal space measurement alone may not provide sufficient predictive accuracy for reliable identification of difficult mask ventilation cases. However, the technique might have value as part of a comprehensive multimodal assessment approach, combining ultrasonographic measurements with traditional clinical predictors and other airway assessment tools (19).

Future research directions should include validation studies in higher-risk patient populations, including patients with traditional risk factors that were excluded from this study. Investigation of dynamic measurement techniques, assessment during different phases of breathing, and exploration of combined ultrasonographic parameters may improve predictive accuracy. Additionally, studies examining the learning curve for palatoglossal space measurement and inter-observer reliability would support clinical implementation efforts (20).

CONCLUSION

This prospective observational study evaluated ultrasonographic measurement of palatoglossal space as a predictor of difficult mask ventilation in 62 adult patients undergoing general anaesthesia. The investigation revealed several important findings that contribute to the understanding of ultrasonographic airway assessment.

The study demonstrated that while there was a clinically plausible trend toward smaller palatoglossal space dimensions in patients with difficult mask ventilation (0.73 ± 0.13 cm versus 0.78 ± 0.12 cm), this difference did not achieve statistical significance ($p = 0.207$). The majority of patients (80.6%) experienced easy mask ventilation, while 19.4% required airway adjuncts, with no cases of severe mask ventilation difficulties encountered.

The receiver operating characteristic analysis revealed limited discriminatory ability for palatoglossal space measurement, with an area under the curve of 0.612, indicating insufficient predictive accuracy for routine clinical application as a standalone assessment tool. At the optimal cut-off value of ≤0.75 cm, the sensitivity was 58.3%, specificity 64.0%, positive predictive value 28.0%, and negative predictive value 86.5%. These diagnostic performance parameters fall below the threshold typically required for reliable clinical screening tools.

Despite the limited predictive performance, the study confirmed the technical feasibility and safety of palatoglossal space assessment. The 100% success rate in obtaining measurements, rapid acquisition time of 4.1 ± 0.8 minutes, and absence of complications demonstrate that the technique is practical for clinical implementation. These characteristics support the continued investigation of ultrasonographic airway assessment approaches.

The physiological rationale for palatoglossal space assessment remains sound, as this anatomical space plays a crucial role in upper airway patency. The observed trend, while not statistically significant, aligns with the theoretical understanding that reduced palatoglossal dimensions may predispose to airway collapse following loss of muscle tone during anaesthesia induction.

The clinical implications of these findings suggest that palatoglossal space measurement may have potential value as part of a comprehensive multimodal airway assessment strategy rather than as an isolated predictor. Future research should focus on validation in higher-risk patient populations, investigation of dynamic measurement techniques, and exploration of combined ultrasonographic parameters to improve predictive accuracy.

The study's limitations, including the relatively homogeneous, low-risk patient population and exclusion of traditional risk factors for difficult mask ventilation, may have contributed to the limited discriminatory ability observed. Larger studies including diverse patient populations with varying risk profiles are warranted to establish the clinical utility of palatoglossal space measurement in airway management.

In conclusion, while ultrasonographic measurement of palatoglossal space showed promise as a feasible and safe technique for airway assessment, its utility as a standalone predictor of difficult mask ventilation was not established in this study population. The technique warrants further investigation in larger, more diverse patient cohorts to determine its optimal role in perioperative airway management protocols.

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