Original Article

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Prediction of Difficult Laryngoscopy in Obese Patients by Ultrasound of Tongue Thickness: A Prospective Observational Study

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Abstract:

Objective: Tongue thickness, measured by ultrasonography, has been used to predict difficult tracheal intubation in normal-weight patients. This study investigated the predictive value of tongue thickness for difficult laryngoscopy in obese Thai patients.

Material and Methods: Eighty-five obese adult patients (body mass index [BMI] ≥30 kg/m^2) who underwent elective general anesthesia with tracheal intubation were enrolled in the study between January and May 2019. Tongue thickness was measured preoperatively using submental ultrasonography in the median sagittal plane, both in the closed- and open-mouth supine positions. The primary outcome was a difficult laryngoscopy, defined as a laryngoscopic view of grade 3 or 4 on the Cormack-Lehane scale. Multivariate logistic regression and receiver operating characteristic curve were used for the statistical analysis.

Results: The mean BMI of the 85 patients was 38.68 kg/m^2 (range: 30.00–64.96 kg/m^2). The incidence of difficult laryngoscopy was 17.65% (15/85 patients). Univariate analysis showed that a tongue thickness greater than 58 mm in the closed-mouth position was an independent predictor of difficult laryngoscopy, with a sensitivity of 0.73 and specificity of 0.63. Multiple logistic regression analysis revealed that age 45 years or older and an inter-incisor gap less than 45 mm were also predictors for difficult laryngoscopy. The combination of these three factors improved the prediction of difficult laryngoscopy, yielding a sensitivity of 0.87 and specificity of 0.67.

Conclusion: Tongue thickness greater than 58 mm, measured in the closed-mouth position by ultrasonography, can predict difficult laryngoscopy in obese Thai patients.

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Keywords: difficult intubation, difficult laryngoscopic view, obesity, tongue thickness, ultrasonography

Introduction

Airway management is often more difficult in obese patients. The overall incidence of difficult intubation is 15.8%, compared with 6.2% in normal patients, excluding obstetric and obese patients[1]. Obese patients have increased adipose tissue deposition in the oropharyngeal airspace, which reduces airway size and may contribute to airway obstruction. Therefore, greater difficulty can be expected during direct laryngoscopy for endotracheal intubation under general anesthesia[2].

Many standard preoperative airway assessments can predict difficult airway, but they are not reliably accurate. The sensitivities of the modified Mallampati test, inter-incisor gap measurement, upper-lip bite tests, and thyromental distance are 47.3%, 31.5%, 28.9%, and 10.5%, respectively[3]. Finding a more accurate method is still essential for anesthesiologists.

Ultrasound has recently emerged as a tool for predicting difficult airway in normal-weight and obese patients, as it is portable and provides a safe, noninvasive method for rapid airway assessment[4,5]. An ultrasound measurement greater than 28 mm of the anterior pretracheal soft tissue at the level of the vocal cords has been shown to be a good predictor for difficult laryngoscopy in obese patients[6]. Preoperative assessment of hyomental distances and ratios using portable sonography has also been shown to predict difficult laryngoscopy, resulting in difficult intubation[7].

Increased tongue thickness has been found to negatively affect laryngoscopy and tracheal intubation, increasing the risk of difficult airway[8,9]. A tongue thickness greater than 61 mm, measured by ultrasonography, has demonstrated a significant predictive ability for difficult tracheal intubation in normal-weight patients, with a sensitivity of 0.75 and specificity of 0.72[10]. However, no studies have specifically focused on obese patients. Hence, the purpose of this study was to investigate the predictive value of tongue thickness to predict difficult laryngoscopy in obese Thai patients.

Material and Methods

Ethical consideration

This prospective observational study was approved by the Office of Human Research Ethics Committee, Faculty of Medicine, Prince of Songkla University, Thailand, on September 27, 2018 (REC 61-205-08-1). Informed consent was obtained from all participants in the study.

Study setting and population

The data were collected from January to May 2019 at Songklanagarind Hospital, Thailand. The inclusion criteria were obese patients (body mass index [BMI] ≥30 kg/m^2) who required elective surgery under general anesthesia with oral endotracheal intubation in operating theaters, aged between 18 and 60 years, and American Society of Anesthesiologists (ASA) Physical Status 2 to 3. The exclusion criteria included pregnancy, tracheostomy status, abnormalities of the face, throat, or oral cavity, cervical disease or cervical spine injury, head or neck tumors, patients requiring rapid sequence induction for intubation, and those unable to provide informed consent.

Study protocol

Before data collection, the investigator was trained to measure tongue thickness in clinical screening tests using a Philips Lumify ultrasonographic curved transducer probe under the guidance of expert Michael Seltz Kristensen, M.D. The results were validated by two senior anesthesiologists

experienced in ultrasound airway assessment, using 25 volunteers.

One day before surgery, the investigator, who was not involved in patient intubation, recorded the history of obstructive sleep apnea syndrome, BMI, measured the standard parameters of airway assessment, and performed the modified Mallampati test[11].

To measure tongue thickness using ultrasonography, the patient was placed in the supine position without a pillow, with the neck stretched. The status of the tongue was obtained from two images. The patient was first asked to keep their mouth closed and to slightly touch the incisors with the tip of the tongue while maintaining a relaxed tongue and no phonation (Figure 1A). The patient was then asked to open their mouth and protrude the tip of the tongue out with no phonation (Figure 1B).

The ultrasound probe was positioned beneath the chin along the median sagittal plane and adjusted until the entire outline of the tongue was clearly visualized. The image was then frozen. Tongue thickness was defined as the maximum vertical distance from the tongue surface to the submental skin (Figure 2).

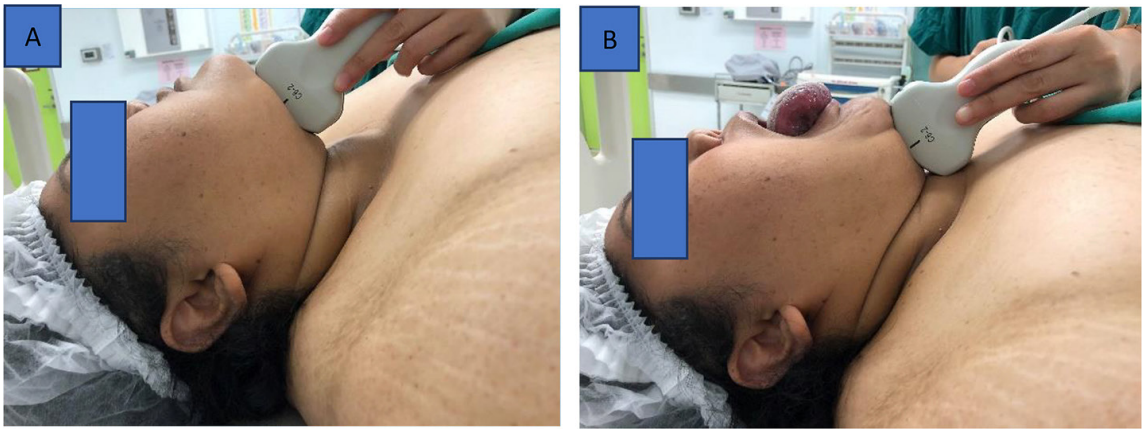


Figure 1 (A) Closed-mouth position (B) Open-mouth, tongue-protruded position

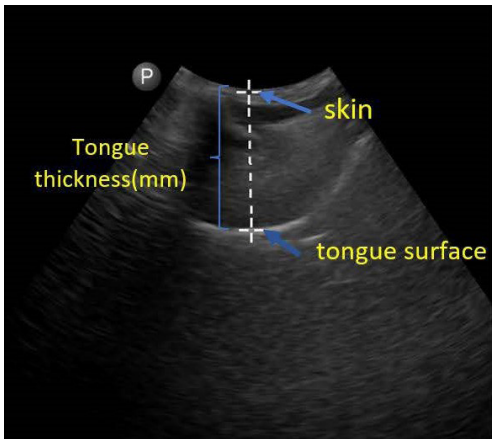


Figure 2 Ultrasound view for the tongue thickness measurement: The maximal vertical dimension is measured from the tongue surface to the submental skin in the median sagittal plane.

On the day of surgery, patients were placed in the supine position. The standard ASA monitors were applied, and end-tidal carbon dioxide was monitored. Preoxygenation was performed by administering 100% oxygen at 6 L/min via an anesthetic facemask for 5 minutes. Fentanyl (1-3 mcg/kg), propofol (2 mg/kg), and cisatracurium (0.15 mg/kg) were used for induction and intubation. The drug doses were calculated based on lean body weight using the Boer formula. The tracheal tube size was selected by anesthesiologists. The endotracheal intubations were performed after 5 minutes of cisatracurium administration by an anesthesiologist with at least one year of experience (attending anesthesiologist, anesthetic resident, or certified nurse anesthetist), using a conventional number 3 Macintosh laryngoscope blade. The grade of laryngoscopic view, using the Cormack-Lehane classification system[12], was recorded by the anesthesiologist who performed the endotracheal intubation. To improve the glottic view, external laryngeal manipulation was allowed. Cormack-Lehane grades 1 or 2 were categorized as easy laryngoscopy and grades 3 or 4 as difficult laryngoscopy. The laryngoscopic view, number, and duration of tracheal intubation attempts were recorded. If the anesthesiologist could not intubate on the third attempt with the conventional number 3 Macintosh laryngoscope blade, the airway was further managed following the American Society of Anesthesiologists Task Force on Management of the Difficult Airway 2013[13].

Sample size calculation and statistical analysis

Sample size was calculated from previous data[10] using the two independent population mean formula. A dropout rate of 10% was accounted for. It required 89 patients to achieve a 95% confidence interval and power of 80% to detect differences between the groups.

Statistical analysis was performed using STATA software. To assess the normality of the findings, the Shapiro-Wilk test was used. Continuous variables were presented as mean and standard deviation (S.D.). Categorical variables were presented as the number of patients and percentages. Continuous variables were analyzed using the paired t-test or the Wilcoxon rank-sum test. Univariate comparisons between patients with easy laryngoscopy and difficult laryngoscopy were performed using Fisher's exact tests.

Variables that were significant in univariate logistic regression were included in a multivariable logistic regression. A p-value less than 0.05 was considered statistically significant. The optimal cut-point of tongue thickness was identified by a receiver operating characteristic (ROC) curve and the area under the curve (AUC).

Results

Eighty-nine patients were eligible for the study from January to May 2019. Four patients were excluded: two due to operation cancellations and two due to a change in plan to rapid sequence induction techniques. Finally, 85 patients were enrolled. Fifteen patients (17.65%) had difficult laryngoscopy (Cormack-Lehane grade 3 in 13, grade 4 in 2). All were successfully intubated: 10 on the first attempt using a size 3 McIntosh blade and 5 on the second attempt—3 with a size 3 blade and 2 with a size 4 blade. No intubation failures or difficult mask ventilation occurred. Baseline characteristics of the 85 patients are summarized in Table 1.

Using univariate analysis, tongue thickness in the closed-mouth position was the only independent predictor of difficult laryngoscopy (p-value=0.023). ROC analysis showed that a tongue thickness greater than 58 mm provided the best sensitivity (0.73) and specificity (0.63) for predicting difficult laryngoscopy (Table 2, Figure 3).

Multivariate logistic regression analysis was conducted to identify the relationship of tongue thickness greater than 58 mm in the closed-mouth position with other variables. The combination of two tongue thickness variables (age ≥45 years and inter-incisor gap <45 mm)

was found to be a statistically significant predictor of difficult laryngoscopy (Table 3).

ROC curve analysis revealed that the combined three significant predictors (i.e., age ≥45 years old, inter-incisor gap <45 mm, and tongue thickness in the closed-mouth position >58 mm) gave a good discriminative prediction of difficult laryngoscopy with an AUC of 0.82 and a sensitivity and specificity of 0.87 and 0.67, respectively (Figure 4).

Table 1 Demographic characteristics of the participants (n=85)

Variables	Mean±S.D. or number (%)
[b]Gender	
Female	70 (82.4)
Male	15 (17.6)
[a]Age (years)	41.66±10.00
[b]ASA classification	
II	30 (35.3)
III	55 (64.7)
[a]BMI (kg/m^2)	38.68 ± 9.05
[b]OSA test	
Yes	31 (36.5)
No	54 (63.5)
[b]Department	
General Surgery	43 (50.6)
Gynecology	19 (22.4)
Ear Nose Throat	7 (8.2)
Neurology	7 (8.2)
Orthopedics	2 (2.4)
Plastic Surgery	2 (2.4)
Ophthalmology	1 (1.2)
Others	4 (4.7)

[a]=Data are presented as mean±S.D., [b]=Data are presented as number (%), ASA=American Society of Anesthesiologists, BMI=body mass index, OSA=obstructive sleep apnea

Discussion

Standard clinical preoperative predictors of difficult airway have limited sensitivity and specificity. Recently, airway ultrasound has gained popularity as a tool for predicting difficult airway. Combining airway ultrasound with conventional airway assessments may improve the prediction and facilitate better airway management in obese patients.

This prospective observational study demonstrated that tongue thickness greater than 58 mm in the closed-mouth position, measured by ultrasonography, is a useful predictor of difficult laryngoscopy in obese patients. A previous study also identified a tongue thickness greater than 61 mm, measured by ultrasound, as an independent predictor for difficult intubation in adults[10]. However, another study[7] found no significant difference in tongue volume between patients with easy and difficult laryngoscopy. This discrepancy might be explained by the fact that tongue volume does not directly reflect tongue thickness, as it is also influenced by tongue width.

Univariate analysis with area under the ROC curve showed that using a tongue thickness greater than 58 mm as a predictor yielded a sensitivity of 0.73 and a specificity of 0.63 for predicting difficult laryngoscopy. This sensitivity was higher than other clinical predictors in a previous study[3], such as the modified Mallampati test (47.3%), inter-incisor gap (31.5%), upper lip bite tests (28.9%), and thyromental distance (10.5%). However, our sensitivity and specificity were similar to those reported in a previous study in adults[10], which identified a tongue thickness greater than 61 mm as a predictor, with a sensitivity of 0.75 and specificity of 0.72. These findings may indicate that tongue thickness demonstrates high sensitivity for predicting difficult laryngoscopy in both obese and general adult populations. Moreover, our study showed that combining parameters—tongue thickness >58 mm in the closed-mouth position, age ≥45 years, and inter-incisor gap <45 mm—improved sensitivity to 0.87 and specificity to 0.67.

In our study, no statistically significant correlation was found between difficult laryngoscopy and either BMI or the modified Mallampati score. This finding is consistent with previous studies[14,15], which reported that a high BMI was a weak but significant predictor of difficult or failed intubation[14], and that the modified Mallampati score had poor sensitivity (0.35) for predicting difficult laryngoscopy[15].

Table 2 Univariate analysis comparison of preoperative characteristics between patients with easy laryngoscopy and difficult laryngoscopy

Variables	Easy laryngoscopy	Difficult laryngoscopy	Test	p-value
[a]Gender			Fisher's exact test	1
Male	13 (18.6)	2 (13.3)		
Female	57 (81.4)	13 (86.7)		
[c]Age group (years)			Chi-square (1 df)=3.28	0.07
<45	44 (62.9)	5 (33.3)		
≥45	26 (37.1)	10 (66.7)		
[b]Body mass index (kg/m^2)	35.2 (31.3,41.7)	37.4 (33.2,44.8)	Rank-sum test	0.384
[c] Modified Mallampati score			Fisher's exact test	0.094
I	16 (22.9)	0 (0)		
II	36 (51.4)	9 (60)		
III	18 (25.7)	6 (40)		
IV	0 (0)	0 (0)		
[b]Thyromental distance (mm)	120 (110.5,130)	120 (118,132.5)	Rank-sum test	0.939
[a]Sternomental distance (mm)	162.7 (14.7)	163.3 (16.3)	t-test (83 df)=0.13	0.897
[b]Inter-incisor gap (mm)			Chi square (1 df)=1.41	0.235
<45	32 (45.7)	10 (66.7)		
≥45	38 (54.3)	5 (33.3)		
[b]Neck circumference (mm)	410 (380,430)	410 (380,420)	Rank sum test	0.733
[c]Upper-lip bite test			Fisher's exact test	0.417
I	10 (14.3)	3 (20)		
II	55 (78.6)	10 (66.7)		
III	5 (7.1)	2 (13.3)		
[b]Tongue thickness (mm)				
Closed-mouth position			Chi-square (1 df)=5.19	0.023
≤58	44 (62.9)	4 (26.7)		
>58	26 (37.1)	11 (73.3)		
Open-mouth position				
≤61	36 (51.4)	6 (40)	Chi-square (1 df)=0.27	0.604
>61	34 (48.6)	9 (60)		

[a]=Data are presented as mean (Standard Deviation), [b]=Data are presented as median (interquartile range), [c]=Data are presented as number (percentage)

Table 3 Multivariate logistic regression analysis of variables

Factors	Odds ratio	95% CI	p-value
Tongue thickness in closed-mouth position >58 mm	4.65	2.1-40.33	0.001
Age group ≥45 years old	5.82	1.45-23.37	0.008
Inter-incisor gap <45 mm	4.69	1.14-19.26	0.022

CI=confidence interval

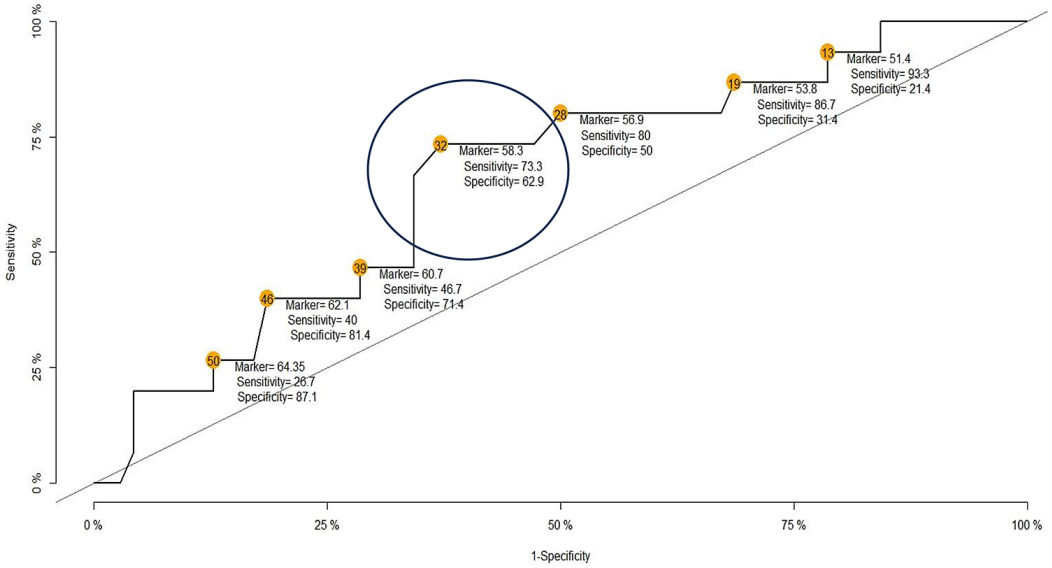
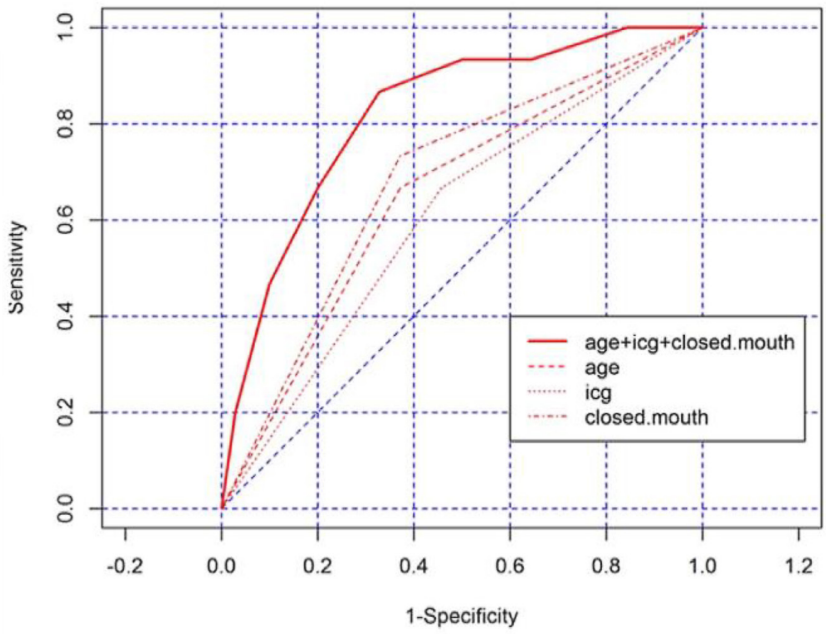


Figure 3 Receiver operating characteristic plot analysis of optimal cut point of tongue thickness in the closed-mouth position



ICG=inter-incisor gap

Figure 4 Receiver operating characteristic curve analysis of the three predictors and the area under the curve (AUC) values to predict difficult laryngoscopy

Therefore, using BMI or the modified Mallampati score alone might be inadequate for predicting difficult laryngoscopy. In addition, we found that thyromental distance also showed no statistically significant correlation with either easy or difficult laryngoscopy. This result was similar to a previous study[6], which showed that thyromental distance <6 cm was not correlated with difficult laryngoscopy in 50 morbidly obese patients.

In this study, the incidence of difficult laryngoscopy in obese patients was 17.65%, which was comparable to that reported in a previous study[16], where 15.4% of obese patients had a Cormack–Lehane grade of 3 or 4.

In this study, tongue thickness was measured in both the open-mouth and closed-mouth positions. A statistically significant association with difficult laryngoscopy was observed only in the closed-mouth position, which is the resting position of the tongue. At present, the majority of investigators use the closed-mouth position for such assessments[10,17-19]. Accordingly, when considered alongside the existing evidence, our findings suggest that measurements obtained in the open-mouth, tongue-protruded position may have limited utility for evaluating tongue thickness in the context of predicting difficult laryngoscopy.

There are limitations in this study. First, only obese patients of a single racial group were included, which may limit the generalizability of the findings to obese populations of other racial backgrounds. Second, we did not perform a validity assessment of the measurement method. Specifically, tongue thickness measured by ultrasonography was not compared with measurements obtained using magnetic resonance imaging or computed tomography due to constraints in study conditions.

For future studies, as our results were based on descriptive sensitivity and specificity, employing a gold-standard test for comparison would be beneficial. In addition, combining standard preoperative airway assessments with tongue thickness and other ultrasound-derived parameters to predict difficult laryngoscopy or tracheal intubation may further enhance the accuracy of airway prediction.

Conclusion

Tongue thickness greater than 58 mm, measured by ultrasound, can predict difficult laryngoscopy in obese Thai patients. Moreover, a combination of age group and inter-incisor gap increased the accuracy.

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Conflict of interest

The authors declare that there is no conflict of interest.

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