

Comparison of Neck Circumference to Thyromental Distance as A Predictor of Difficulty Visualizing The Larynx in Elective Surgery Patients At Haji Adam Malik General Hospital

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ABSTRACT

Background: Airway management is the responsibility of anesthesiologists, but clinical assessment documentation is often incomplete. Difficult laryngoscopy and intubation occur in 1% to 15% of cases. Intubation is considered difficult if it takes more than ten minutes for a trained anesthesiologist to achieve successful endotracheal intubation. In Indonesia, difficult laryngeal visualization occurs in 10.1% of Malay patients. Common predictors include Mallampati classification, thyromental distance (TMD), obstructive sleep apnea (OSA), male gender, and age.

Objective: This study aims to compare neck circumference (NC) to TMD as a predictor of difficulty visualizing the larynx.

Methods: This diagnostic study aimed to evaluate the sensitivity and specificity of NC and TMD as predictors of difficult laryngeal visualization in patients undergoing elective surgery at Haji Adam Malik General Hospital, Medan. The sample consisted of 85 patients, aged 18 years or older, with ASA classifications of 1-2, who were undergoing general anesthesia. Exclusion criteria included limited mouth opening, acute burns, airway tumors, or anatomical abnormalities.

Result: The mean age of participants was 54.97 ± 14.41 years, with a mean body mass index (BMI) of 26.63 ± 3.12 kg/m², and an average NC/TMD ratio of 6.37 ± 0.87 . Patients with an NC/TMD ratio > 5 had difficult intubation in 87.5% of cases, while those with an NC/TMD ratio < 5 had easy intubation in 94.6% of cases. Fisher's Exact test showed a significant association ($p < 0.001$). The NC/TMD ratio had a sensitivity of 95.45%, specificity of 85.36%, positive predictive value (PPV) of 87.5%, negative predictive value (NPV) of 94%, and an area under the curve (AUC) of 90%.

Conclusion: The NC/TMD ratio is a significant and accurate predictor of difficult intubation, supporting its use as a simple, non-invasive preoperative tool.

Keywords: difficult intubation; difficult laryngeal visualization; NC/TMD ratio; sensitivity; specificit

INTRODUCTION

One of an anesthesiologist's most important responsibilities is airway management. Even in patients whose airways appear to be normal, they must be able to determine the risk of difficult tracheal intubation. Thankfully, the prevalence of problematic intubation is low, ranging from 1.5% to 13%. Inadequate management of problematic airways results in the highest rates of morbidity and mortality, accounting for 30% of all deaths due to anesthesia. Poor visibility is the main reason for challenging intubation, and there are wide variations in the difficulty of seeing the larynx during laryngoscopy and intubation.¹

If a skilled anesthesiologist needs more than three tries or more than ten minutes to successfully perform endotracheal intubation, it is deemed challenging. It has been reported that 1.5% to 8% of patients scheduled for elective surgery under general anesthesia had difficulties with intubation.²

The results of Tantri et al. (2016) showed that 10.1% of Malays in Indonesia had trouble visualizing their larynx. Compared to other races, the Malays have distinct craniofacial characteristics. Race differences can be shown using the cephalic index, which is calculated by multiplying the ratio of head width to length by 100. Between 75 and 80 is the average cephalic index in the UK, Scandinavia, and several Mediterranean regions. The cephalic index is less than 75 in Africa and higher than 80 and 85 in Western and Central Europe, respectively. The cephalic index ranges from 75 to 80 in China, Korea, and Japan, while it exceeds 80 in Indonesia.

Furthermore, the Malay mandible differs from that of other races in terms of size and shape. The predictors for difficult intubation may also differ depending on racial disparities in craniofacial characteristics. The diagnostic value of this test may be different if applied to Malay individuals. Difficult tracheal intubation is also more common in females, due to fat accumulation at the back of the neck, which may impede intubation.²

Numerous studies have tried to use basic bedside physical examinations to predict problematic intubations. Commonly used tools for this purpose include the Wilson score, thyromental distance, sternomental distance, and Mallampati score; however, none of these have demonstrated good diagnostic accuracy, especially in obese patients. Research suggests that an elevated neck circumference (NC) is frequently associated with difficult intubation, particularly in obese individuals, and efforts are ongoing to find accurate predictors for difficult intubation or laryngoscopy.³

Even though a lot of research has been done to find predictors of difficult intubation, none of them have been entirely successful up to this point. Studies differ in how accurate these screening tests are at diagnosing conditions. There have been numerous attempts to create trustworthy predictors of challenging laryngoscopy and difficult intubation, but none have shown a high level of diagnostic accuracy. Mallampati classification, thyromental distance measurement, obstructive sleep apnea (OSA), male gender, and advancing age are among the most widely accepted and advised predictors.

Mouth openness less than 4 cm, TMD less than 6 cm, Mallampati class III or above, neck size and mobility less than 35°, and mandibular difficulties are risk factors linked to intubation difficulty. Neck circumference and thyromental distance are two of the most easily measured markers of difficult intubation; neck circumference has been demonstrated to have high sensitivity and high specificity in predicting preoperative intubation difficulties. Consequently, a combination of these two factors could be useful in anticipating a challenging airway.⁴

Celik et al (2021) and Ahmed et al (2014) concluded that the NC-TMD (Neck Circumference/Thyromental Distance) ratio is a reliable predictor of difficult intubation in obese patients. The research assessing NC/TMD in non-obese groups is still lacking, nevertheless.^{7,10,4} Therefore, researchers are interested in knowing how the ratio of neck circumference to thyromental distance predicts laryngeal visualization difficulty.⁴

Hypoxic brain injury might result in challenging laryngoscopy and intubation. Anoxic brain damage and maybe death could occur if oxygenation is not maintained for even a few minutes. Serious perioperative problems are still mostly caused by difficulties with airway control.⁵

The thyromental height test (TMHT), a useful addition to airway diagnostic criteria, has been brought to light by recent research. We compared TMHT with other measures, such as the modified Mallampati score, thyromental distance, neck circumference, neck extension, and inter-incisor gap, to assess its usefulness as a straightforward bedside test for predicting problematic

airways. Comparing the Thyromental Height Test to various alternative airway evaluation techniques, we evaluated its sensitivity, specificity, positive predictive value, negative predictive value, and overall diagnostic accuracy.⁵

Mouth openness less than 4 cm, TMD less than 6 cm, Mallampati class III or above, neck size and mobility less than 35°, and mandibular difficulties are risk factors for problematic intubation. Neck circumference has demonstrated high sensitivity, and thyromental distance has demonstrated good specificity in predicting preoperative intubation difficulty, and both are easily measurable. Therefore, combining these two factors could aid in anticipating a challenging airway.⁶

METHOD

This study is a diagnostic test study to assess the sensitivity and specificity of neck circumference and thyromental distance as predictors of laryngeal visualization difficulty in elective surgery patients at Haji Adam Malik General Hospital, Medan. The study was conducted at Haji Adam Malik Hospital, Medan, starting after ethical clearance approval and lasting until March 2024. The study subjects were taken from patients who would undergo elective surgery at Haji Adam Malik General Hospital, with the application of inclusion and exclusion criteria. Inclusion criteria include: patient undergoing surgery with general anesthesia, patient aged >18 years, and patient with an ASA score of 1-2. Exclusion criteria include: a patient with a limited mouth opening of less than 3 cm. Patients who have acute burns in the facial and neck area with inhalation trauma, airway tumors, patients with limited neck movement, risk of bleeding due to laryngoscopy, potential difficult

ventilation, airway trauma, upper respiratory tract infections, or anatomical abnormalities. The method of selecting research subjects used consecutive sampling, which was based on primary data from the measurement of neck circumference and thyromental distance, as well as secondary data in the form of demographic and clinical characteristics obtained from patient medical records. The measurement was taken during the preoperative visit, which is 1 day before the surgery. Determination of difficult intubation in patients was done by assessing the Cormack-Lehane score from the direct laryngoscopy results.

RESULTS

After analysis in this study, the basic characteristics of the participants included age, gender, height, weight, body weight, NC, TMD, and the NC/TMD ratio. The average age of the participants was 54.97 ± 14.41 years, with 33 males (38.8%) and 52 females (61.2%). The most common ethnic group was the Malay, accounting for 26 individuals (30.6%). The mean height was 162.22 ± 5.55 cm, body weight was 70.28 ± 11.39 kg, and the average BMI of the sample was 26.63 ± 3.12 . The

mean NC was 34.29 ± 4.7 cm, while the average TMD was 5.4 ± 0.78 cm, and the average NC/TMD ratio was 6.37 ± 0.87 . (Table 1)

Body mass index (BMI) with normoweight obtained easy intubation of 28 (100%), with no difficult intubation, based on overweight, found easy intubation of 13 (28.9%) with difficult intubation 32 (71.1%), while obesity found difficult intubation of 12 (100%). (Table 2)

The NC/TMD assessment obtained the NC/TMD ratio value > 5 with difficult intubation for as many as 42 (87.5%) patients and easy intubation for 6 patients (12.5%), while the NC/TMD ratio value < 5 obtained difficult intubation for 2 patients (5.4%) with easy intubation for 35 patients (94.6%). Based on the results of the Fisher Exact test analysis, it is known that NC/TMD with difficulty visualizing the larynx has a significant relationship ($p < 0.001$). (Table 3)

It is known that NC/TMD has sensitivity (95.45%), specificity (85.36%) has PPV (87.5%), NPV (94%), and an area under the curve (AUC) of 90%. (Table 4)

Table 1. Sample characteristics

Characteristics	Total (n=85)	p-value
Age (Years)*	54.97 ± 14.41	0.800
Gender		
- Male	33 (38.8)	
- Female	52 (61.2)	
Tribes		
- Aceh	4(4.7)	
- Batak	24 (28.2)	
- Java	13 (15.3)	
- Malay	26 (30.6)	
- Minang	9 (10.6)	
- Tianghoa	9 (10.6)	
Body Height**	162.22cm ± 5.55	0.670
Body Weight*	70.28kg ± 11.39	0.789
BMI*	26.63kg/m ² ± 3.12	0.740
TMD*	5.4cm ± 0.78	0.460
NC*	34.29cm ± 4.7	0.890
NC/TMD*	6.37 ± 0.87	0.430

*Mean±SD, BMI: Body mass index, TMD: Thyromental distance, NC: Neck circumference

Table 2. Body mass characteristics of difficult intubation

Characteristics	Easy intubation	Difficult intubation
BMI		
Normo Weight	28 (100%)	0
Over Weight	13 (28.9%)	32 (71.1%)
Obesity	0	12 (100%)

*BMI: Body mass index

Table 3. NC/TMD characteristics on the incidence of difficult intubation

Characteristics	Difficult intubation	Easy intubation	P-value
NC/TMD			
> 5	42 (87.5 %)	6 (12.5%)	0.001
< 5	2 (5.4 %)	35 (94.6%)	

Table 4. NC/TMD Diagnostic Test Results

Karakteristik	Sensitivitas (%)	Spesifisitas (%)	PPV (%)	NPV (%)	AUC(%)
NC / TMD	95.45	85.36	87.5	94	90

*PPV: Positive predictive value, NPV: Negative predictive value, AUC: Area under the curve

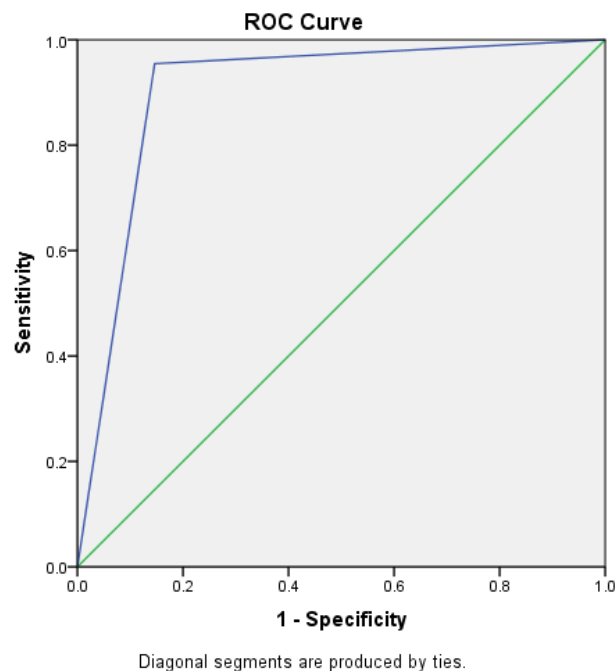


Figure 1. AUC graph

DISCUSSION

An extremely complex anatomical tract, the upper airway necessitates preparation and anticipation for challenging airway care. It's crucial to identify any potentially problematic airways. In the practice of anesthesia, unexpectedly difficult tracheal intubations are a major cause of morbidity and fatality. Hypoxic brain injury can even result after a challenging laryngoscopy and intubation. Anoxic brain damage and death can occur if oxygenation is not maintained for longer than a few minutes. Airway management issues continue to be a leading source of severe perioperative complications. Approximately 30 - 40% of deaths in anesthesia are due to the inability to manage a difficult airway.⁵

A history of obstructive sleep apnea (OSA), a high Mallampati score, a short neck, a big neck circumference, a shortened thyromental distance, atypical upper teeth, and obesity are some of the

characteristics that can make intubation challenging. This study discovered that among patients with an average BMI of $26.63 \pm 3.12 \text{ kg/m}^2$, 32 (71.1%) were overweight, and 12 (100%) were obese. These patients were also at risk for difficult intubation. According to other studies, between 11% and 82% of obese persons experience problematic intubation. Because of the structural abnormalities brought on by extra weight, it is more difficult to ensure airway passage in obese individuals than in non-obese patients.⁵

However, it is still challenging to identify patients who have laryngoscopy and intubation issues, even with advancements in airway care. In order to improve management, patient preparation, equipment selection, and technique application, numerous studies have been carried out throughout the years to identify predictors of laryngoscopy and intubation difficulties. There is no single parameter that can be

used as a 100% benchmark in predicting such difficulties, even though numerous studies have assessed straightforward, inexpensive tests like the modified Mallampati score, thyromental distance, hyomental distance, sternomental distance, thyrosternal distance, neck circumference, neck extension, distance between incisors, upper lip bite test (ULBT), and thyromental height test.⁷

This study examines the parameters of neck circumference (NC) and thyromental distance (TMD) ratio as predictors of difficulty in laryngeal visualization. The results showed that an NC/TMD ratio > 5 tended to lead to difficulty in intubation (87.5%), while an NC/TMD ratio < 5 more often facilitated intubation (94.6%). Based on Fisher's Exact test analysis, it was found that the NC/TMD ratio was significantly associated with difficulty in laryngeal visualization ($p < 0.001$). This finding is in line with Shamim A's study in 2024 involving 140 samples in India, which showed that securing the airway was more difficult when the NC/TMD ratio was ≥ 5 , with a significant statistical correlation ($p = 0.04$; $p < 0.05$).⁷

This study showed that the NC/TMD ratio had a sensitivity of 95.45%, specificity of 85.36%, positive predictive value (PPV) of 87.5%, negative predictive value (NPV) of 94%, and an AUC of 90. Another study in India in 2024 that evaluated the diagnostic accuracy of the NC/TMD ratio found a sensitivity of 75.20%, specificity of 66%, PPV of 95.25%, and a higher AUC of 85. Another study conducted in 2023 on 330 adult patients, which compared several tests to evaluate difficult intubation, found the NC/TMD ratio had a sensitivity of 82.9%, specificity of 65.4%, PPV of 25.37%, NPV of 96.42%, and AUC of 77. A 2018

Indian study of 60 obese patients concluded that the NC/TMD ratio was a better predictor, especially in obese patients with a lot of soft tissue in the neck, with a sensitivity of 92.31%, specificity of 65.96%, and a strong correlation with intubation difficulty ($p = 0.001$).⁷

The sensitivity of the NC/TMD ratio reached 99%, with a specificity of 66.5%, a positive predictive value of 22.4%, and a negative predictive value of 99.2%, according to a 2022 study on 217 patients at Cipto Mangunkusumo Hospital that compared the ratio of neck circumference to thyromental distance with the Mallampati score and thyromental distance as a predictor of laryngeal visualization difficulty in patients undergoing elective surgery. These results suggest that because the NC/TMD ratio accounts for the optimal TMD ratio and shows fatty tissue in the neck region, it is a more accurate predictor of laryngeal visualization difficulty. In addition, the NC/TMD ratio also considers the movement of the neck joints and the proportion of the tongue to the surrounding tissue, which is more comprehensive than using only the Mallampati and TMD score parameters.⁸

In addition to predicting ease of tongue displacement during direct laryngoscopy, the thyromental distance assessment is utilized to evaluate mandibular space and tissue compliance. Short thyromental distance is common in patients with micrognathia (extremely small mandible) or retrognathia (mandible positioned more posteriorly than other facial structures). While the patient is sitting straight, the neck circumference is measured using a flexible ruler at the level of the thyroid cartilage along the upper edge of the seventh cervical vertebra. A neck

circumference of more than 40 cm is frequently linked to challenges during endotracheal intubation, laryngoscopy, and mask breathing. The amount of soft tissue above the trachea is a better indicator of airway difficulty than neck circumference, which may not provide a clear image of the distribution of soft tissue throughout the neck. Big body bulk and fluid retention are frequently linked to a big neck circumference. A novel measure that more accurately depicts the distribution of soft tissues in the neck is the ratio of neck circumference to thyromental distance.⁸

Shamim Ahmed et al., 2024. This study found a relationship between intubation settings and the NC/TMD ratio of less than or equal to five. A statistically significant (p -value <0.05) correlation was established between the difficulty of securing the airway and an NC/TMD ratio of ≥ 5 , which is linked to characteristics like shorter stature and greater BMI. In comparison to the Mallampati grading system, the study shows that the NC/TMD ratio is a more effective airway assessment tool for predicting difficult intubation, with a comparatively larger area under the ROC curve and greater sensitivity and specificity at a threshold of ≥ 5 .⁹

In contrast to a study carried out in Iran that compared five methods for visualizing laryngoscopic difficulties—neck circumference (NC), NC/TMD ratio, ratio of height to thyromental distance (RHTMD), upper lip bite test (ULBT), and Mallampati test (MMT)—the study found that the NC/TMD ratio had a lower sensitivity of 57.95% and a specificity of 76.37% compared to the ratio of height to thyromental distance (RHTMD) and Mallampati test (MMT). This study concludes that RHTMD and ULBT are simple pre-operative tests

with better accuracy compared to the NC/TMD ratio, TMD, NC, and MMT in predicting airway difficulty.^{8,10,11}

According to a 2024 study done in India, the NC/TMD ratio has a sizable area under the ROC curve, and when the ratio is ≥ 5 , the sensitivity and specificity are increased. These results suggest that the NC/TMD ratio might be utilized to forecast intubation difficulty and evaluate the airway. Because the NC/TMD ratio is easy to use, non-invasive, and doesn't require specialized equipment, it is advised to incorporate it into routine pre-operative airway assessments.^{8,11}

Identifying patients with difficult laryngoscopy and intubation remains a challenge despite advances in airway management. Several studies have been conducted over the years to identify predictors of difficult laryngoscopy and intubation for better management, patient preparation, and selection of optimal equipment and appropriate techniques.^{12,13,15}

The limitation of this research is study focuses on the NC/TMD ratio; it does not extensively discuss or control for other risk factors such as vascular conditions, neck function impairments, or the operator's experience, which may influence the level of intubation difficulty. The study used an observational diagnostic design, which has limitations in controlling variables and may contain observational bias.

CONCLUSION

In this study, we conclude that an NC/TMD ratio >5 was mostly associated with difficult intubation (87.5%), while an NC/TMD ratio <5 was mostly associated with easy intubation (94.6%). There was a significant association between the NC/TMD ratio and difficulty of laryngeal visualization ($p<0.001$). Patient characteristics showed that most were female (52 people, 61.2%), with the Malay ethnicity as the largest group (26 people, 30.6%). The average height of the patients was 162.22 ± 5.55 cm, weight 70.28 ± 11.39 kg, and BMI 26.63 ± 3.12 . The mean thyromental distance (TMD) was 5.4 ± 0.78 cm, neck circumference (NC) was 34.29 ± 4.7 cm, and the NC/TMD ratio was 6.37 ± 0.87 . The NC/TMD ratio showed a sensitivity of 95.45%, specificity of 85.36%, PPV of 87.5%, NPV of 94%, and AUC of 90, making it a good predictor of laryngeal visualization difficulty.

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