

# Validity of Preoperative Assessment of Neck Circumference to Thyromental Height Ratio as a Reliable Predictor of Difficult Laryngoscopy in Obese Adult Patients Undergoing Elective Surgery Under General Anaesthesia

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## Abstract

**Background:** Difficult laryngoscopy is a major challenge in anaesthetic practice, especially in obese patients, when airway anatomy can change. Traditional airway evaluation measures, such as Mallampati scores, have limited predictive capabilities. Recently, the neck circumference-to-thyromental height (NC/TMH) ratio has been proposed as a potential anthropometric indicator of challenging laryngoscopy. The proposed study focused on evaluating the accuracy of the NC/TMH ratio as a predictor of challenging laryngoscopy in obese adult patients undergoing elective surgery under general anaesthesia. **Material and Methods:** This was a prospective observational study involving 60 obese adult patients with body mass index 30 kg/m<sup>2</sup> and above, aged between 18 and 65 years old, who had been planned to undergo elective surgeries under general anaesthesia. Airway examination performed before surgery included measurement of neck circumference (NC) and thyromental height (TMH), after which the NC/TMH ratio was estimated for each patient. The Mallampati classification was done. The Intubation Difficulty Scale (IDS) was used to characterize intubation as being easy (IDS <5) or difficult (IDS >5) during the laryngoscopy. Statistical analysis involved comparisons between groups and receiver operating characteristic (ROC) curve analysis to assess predictive accuracy. **Results:** Of the 60 patients, 45 (75%) had an easy intubation, and 15 (25) had a difficult intubation. The neck circumference (38.85 ± 0.92 cm) and thyromental height (7.45 ± 0.58 cm) of the patients were significantly lower in the easy intubation group (37.42 ± 1.05 cm and 8.21 ± 0.68 cm, respectively) than in the difficult intubation group (p = 0.001). The NC/TMH ratio of the difficult intubation group (5.22 ± 0.28) was considerably higher than that of the ease intubation group (4.56 ± 0.31; p < 0.001). The ROC analysis revealed good predictive ability of the NC/TMH ratio (AUC = 0.898), with an optimal cut-off of 4.85, sensitivity of 94.29, and specificity of 71.11. By comparison, the Mallampati score was poor at predicting (AUC = 0.208). **Conclusion:** The NC/TMH ratio appears to be a simple, reliable, and extremely sensitive predictor of difficult laryngoscopy in obese patients. It demonstrated superior predictive accuracy compared with the Mallampati classification. Incorporating the NC/TMH ratio into routine preoperative airway assessment may improve identification of patients at risk for difficult intubation.

**Keywords:** Difficult laryngoscopy, Neck circumference, Thyromental height, NC/TMH ratio, Obesity, Airway assessment, General anaesthesia.

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## INTRODUCTION

Obesity, characterized by an excessive accumulation of body fat, has become a significant global health concern. The World Health Organization (WHO) defines obesity as having a body mass index (BMI) of 30 kg/m<sup>2</sup> or higher.<sup>[1]</sup> In Asian populations, this definition has been adapted to account for differences in body fat distribution, with individuals having a BMI of 25 kg/m<sup>2</sup> or higher being considered at risk for obesity-related health complications, including difficulties in airway management during anaesthesia.<sup>[2]</sup> Obesity is strongly associated with an increased risk of difficult airway management, including challenging intubation, which poses a major concern for anaesthesiologists.<sup>[3]</sup> Difficult laryngoscopy, defined as inadequate visualization of the larynx during endotracheal intubation, is a significant cause of anaesthesia-related complications. It accounts for

approximately 17% of airway injuries, leading to increased perioperative morbidity and mortality. Imaging techniques, such as magnetic resonance imaging (MRI) and ultrasonography, have been used to assess soft-tissue volume at various levels of the neck, including the pharynx, retropharynx, and suprasternal notch, which can contribute to airway difficulty in obese patients.

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Studies have demonstrated that ultrasonographic measurement of pre-tracheal soft tissue can predict difficult laryngoscopy, with some suggesting it is the most reliable measure for distinguishing between easy and difficult intubation cases.<sup>[4]</sup> However, these techniques require specialized equipment, take time, and may not be feasible in all clinical settings.

A critical challenge in airway management is the accurate preoperative identification of patients at risk for difficult intubation, especially in the obese population. Various tests, such as the Modified Mallampati test (MMT), sternal height (SMD), thyromental height (TMH), and upper lip bite test (ULBT), have been used to predict difficult intubation.<sup>[5]</sup> While these tests are useful, they are not without limitations, particularly in obese individuals, where factors such as increased neck tissue and altered airway anatomy complicate predictions. However, no single test has demonstrated sufficient sensitivity and specificity to predict difficult airway management across all patient populations reliably. A combination of these tests may improve prediction accuracy, but the optimal approach remains unclear.<sup>[6]</sup> Research has also examined the relationship between neck circumference (NC) and other anatomical measures, such as thyromental height (TM), a key indicator of potential difficult intubation. Studies have shown that an increased neck circumference and decreased thyromental height are both predictive of difficult intubation in obese patients.<sup>[7]</sup> However, these individual measures often lack the sensitivity and specificity required for reliable clinical decision-making. The combination of these two measures, neck circumference and thyromental height, may increase the predictive accuracy for difficult laryngoscopy. The neck circumference-to-thyromental height (NC/TM) ratio has been proposed as a novel predictor of difficult intubation, offering a potentially more reliable and clinically useful tool for airway assessment.<sup>[8]</sup> The NC/TM ratio has the potential to be a simple, non-invasive, and cost-effective predictor that does not require specialised equipment or extensive time to perform, making it an attractive option for widespread clinical use. The goal of this study is to evaluate the validity of the preoperative neck circumference-to-thyromental height (NC/TM) ratio as a reliable predictor of difficult laryngoscopy in obese adult patients undergoing elective surgery under general anaesthesia. By identifying reliable preoperative predictors of difficult laryngoscopy, the study aims to improve patient safety and reduce the risk of complications associated with difficult intubation in obese patients.

## MATERIALS AND METHODS

The prospective observational study was conducted in the Department of Anaesthesiology, Kakatiya Medical College and MGM Hospital, Warangal, Telangana. Institutional Ethical Approval was obtained for the study. Written consent was obtained from all the participants of the study after explaining the nature of the study in the vernacular language.

### Inclusion Criteria

1. Age 18 years or less than 65 years

2. ASA class I and II
3. Patients who are scheduled for surgery under general anaesthesia with endotracheal intubation
4. Patients who fulfil the criteria and agree to participate in the study
5. Body mass index (BMI) of > 30
6. Signed the informed consent

### Exclusion criteria

1. Emergency anaesthesia
2. Patients scheduled for anaesthesia without endotracheal intubation, such as mask ventilation, use of laryngeal mask airways, sedation, or monitored anaesthetic care.
3. Patients undergoing surgeries under regional anaesthesia
4. Patients with airway pathologies, tumours, and facial and maxillary fractures
5. Obstetric patients and cervical spine fractures

Based on the inclusion and exclusion criteria in this study, a total of n=60 cases were identified and included in the synthesis of the study's results. The sampling method was convenience sampling, and successive cases that met the inclusion and exclusion criteria were included.

Parameters recorded: All patients were evaluated using a pre-validated pro forma that included Demographics. The records included the names, ages, sexes, and residential addresses of the study participants. Measurements were taken for height, weight, and BMI in Kg/m<sup>2</sup>. Factors related to thyroscopy: We measured neck circumference and thyromental height.

Used the Modified Mallampati Classification

**Preoperative Preparation:** In the operating theater, we closely monitored all patients with a multipara monitor. This tracked baseline parameters such as systolic and diastolic blood pressure, heart rate, peripheral capillary oxygen saturation, and electrocardiographic rhythm. We then positioned each patient on the operating table. This helps align the airway for intubation. We established access to start administering Ringer's Lactate, a crystalloid solution for fluid resuscitation.

**Premedication:** All patients received premedication to optimise conditions for anaesthesia and intubation. We gave the following drugs intravenously: Glycopyrrolate (0.004 mg/kg) to reduce secretions, Midazolam (0.03 mg/kg) for anxiolysis and sedation, and Fentanyl (1.5 mcg/kg) for analgesia. These medications ensured the patient's comfort and reduced the risk of complications during the procedure.

**Induction of Anaesthesia:** After premedication, patients underwent pre-oxygenation with 100% oxygen delivered via a face mask for 3-5 minutes. This step increased oxygen reserves before anaesthesia induction. We then induced anaesthesia with an injection of Propofol (2 mg/kg), a rapid-acting anaesthetic agent. After confirming mask ventilation, we achieved neuromuscular blockade by administering Suxamethonium (1.5 mg/kg) intravenously. This agent facilitates muscle relaxation, allowing for intubation and laryngoscopy.

**Laryngoscopy and Intubation:** We performed laryngoscopy using a No. 3 or No. 4 Macintosh blade commonly used for routine intubation. An experienced anaesthesiologist with at least 2 years of postgraduate training in anaesthesia performed the procedure. We assessed intubation difficulty using the Intubation Difficulty Scale (IDS), a validated tool that grades intubation ease or difficulty based on laryngoscopic manoeuvres. We

divided patients into two groups based on their IDS scores: those with an IDS score  $\geq 5$  had intubation, while those with an IDS score  $< 5$  had easy intubation.

**Preoperative Airway Assessment:** Before anaesthesia induction, we conducted an airway assessment to predict the likelihood of difficult intubation. We used two parameters:

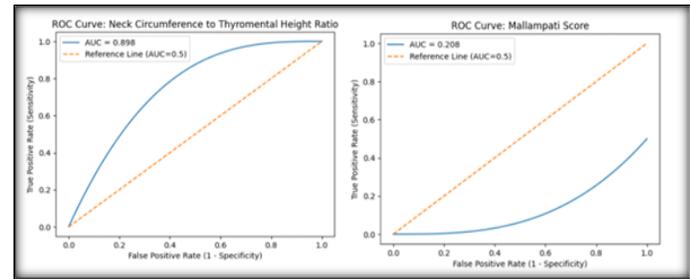
1. Neck circumference to thyromental height (NC/TM ratio): A ratio of  $\geq 5$  indicated potential difficult intubation.
2. Modified Mallampati Classification (MMC): Class III and IV were predictive of difficult intubation, while Class I and II were associated with easier intubation.

**Outcome Measures:** The study compared predicted and actual difficulties using preoperative airway assessment parameters. Predicted Easy: Patients with an NC/TM ratio  $< 5$  and a Mallampati Classification of I or II were predicted as easy. Predicted Difficult: Patients with an NC/TM ratio  $\geq 5$  and a Mallampati Classification of III or IV were predicted to face difficulty. Actual Easy: Patients who had an IDS score  $< 5$  were classified as easy. Difficult: Patients with an IDS score  $\geq 5$  were classified as difficult. Monitoring of vital signs like blood pressure, heart rate, peripheral capillary oxygen saturation, and electrocardiography. We then established access and administered Ringer's Lactate. Premedication consisted of Glycopyrrolate, Midazolam, and Fentanyl, followed by anaesthesia induction with Propofol and neuromuscular blockade using Suxamethonium.

**Laryngoscopy:** An anaesthesiologist conducted laryngoscopy using a No. 3 or No. 4 Macintosh blade. We evaluated intubation difficulty using the Intubation Difficulty Scale (IDS). The preoperative airway assessment included calculating the neck circumference-to-height ratio (NC/TMH) and the Modified Mallampati Classification. A ratio  $\geq 5$  and MMC classes III and IV indicated difficulty in intubation. We compared predicted and actual intubation difficulties to assess the evaluation's accuracy.

**Statistical analysis:** All available data were segregated, refined, and uploaded to an MS Excel spreadsheet, and analysed using SPSS version 25 in Windows. The continuous variables were presented as means, standard deviations, frequencies, and percentages. The Pearson correlation coefficient was calculated for the categorical variables. The ROC was calculated using Positive Predictive Value, Negative Predictive Value, Sensitivity, and Specificity. A probability value (p-value)  $< 0.05$  was considered significant.

**RESULTS**



The demographic characteristics of the cohort are presented in [Table 1]. A critical analysis of the table shows that most participants were aged 41-50 years (31.7%) and 31-40 years (30.0%), indicating that most subjects were middle-aged adults. The average age was  $44.27 \pm 11.77$  years, indicating a wide range of age groups. In terms of gender breakdown, the largest portion of the study population (81.7%) was females, with males (18.3%) of cases. Physical status showed that 63.3% of patients were in ASA I and 36.7% in ASA II, indicating that the majority of participants were in good health, with a few having mild systemic disease. The comorbidities were more prevalent, with the most prevalent being hypertension (20%), diabetes mellitus (13.3%), and hyperthyroidism (10%). Such results are in line with the clinical history of obese surgical patients.

**Table 1: Demographic Profile of Study Cohort**

Demographic Parameter	Category	Frequency (n)	Percentage (%)
Age Group (Years)	18-20	3	5.0
	21-30	3	5.0
	31-40	18	30.0
	41-50	19	31.7
	51-60	11	18.3
	61-65	6	10.0
	Mean $\pm$ SD	44.27 $\pm$ 11.77 years	
Gender	Male	11	18.3
	Female	49	81.7
ASA Physical Status	I	38	63.3
	II	22	36.7
Co-morbidities	Hypertension	12	20.0
	Diabetes Mellitus	8	13.3
	Hyperthyroidism	6	10.0

[Table 2] summarizes the anthropometric features of the cohort. The mean height was  $151.27 \pm 5.66$  cm, and the average body weight was  $81.07 \pm 6.76$  Kgs. The mean body mass index (BMI) was  $35.54 \pm 3.71$  kg/m<sup>2</sup>, indicating that the study population was mainly obese. The mean circumference of the neck (NC) was  $37.782$  cm  $\pm$  1.19 cm, and the average thyromental height (TMH) was  $8.02$  cm  $\pm$

$0.75$  cm. The calculated mean NC/TMH ratio was  $4.75 \pm 0.47$ , and this was the main predictor variable considered in this study. These findings indicate that obese patients are relatively more likely to exhibit large neck circumferences and small thyromental heights, which could be one of the causes of airway management challenges.

**Table 2: Anthropometric Measurements of Study Participants**

Anthropometric Variable	Mean	Standard Deviation (SD)
Height (cm)	151.27	5.662
Weight (kg)	81.07	6.757
Body Mass Index (BMI) (kg/m <sup>2</sup> )	35.54	3.709
Neck Circumference (NC) (cm)	37.78	1.192
Thyromental Height (TMH) (cm)	8.02	0.748
NC/TMH Ratio	4.75	0.473

The preoperative airway assessment parameters are shown in [Table 3]. Analysis of the table showed that, according to the Mallampati classification, the most frequent category was Class III (31.7%), followed by Class I (28.3%), Class II (26.7%), and Class IV (13.3%). A higher Mallampati grade indicated a potentially difficult airway. The intubation

difficulty scale was used to determine intubation difficulty. The analysis reveals that 75% of patients had easy intubation (IDS < 5). The remaining 25% with (IDS > 5) were having difficult intubation. This showed that about one-fourth of the obese patients were having difficulty with laryngoscopy.

**Table 3: Preoperative Airway Assessment Parameters**

Airway Parameter	Category	Frequency (n)	Percentage (%)
Mallampati Score	Class	17	28.3
	Class II	16	26.7
	Class III	19	31.7
	Class IV	8	13.3
Intubation Difficulty Scale (IDS)	Easy (IDS < 5)	45	75.0
	Difficult (IDS > 5)	15	25.0

[Table 4] compares the NC/TMH ratio between the easy and difficult intubation groups. The mean neck circumference was greater in the difficult intubation group than in the easy intubation group ( $38.85 \pm 0.92$  cm vs  $37.42 \pm 1.05$  cm), and the difference was statistically significant. Similarly, the mean thyromental height was found to be significantly lower in the difficult intubation group compared to the easy

intubation group ( $7.45 \pm 0.58$  cm vs  $8.21 \pm 0.68$  cm), and the p-values were found to be significant. The NC/TMH ratio was markedly higher in the difficult intubation group compared to the easy intubation group ( $5.22 \pm 0.28$  vs  $4.56 \pm 0.31$ ). The difference was statistically significant. These findings indicate that an increased NC/TMH ratio is strongly associated with difficult laryngoscopy.

**Table 4: Comparison of NC/TMH Ratio Between Easy and Difficult Intubation Groups**

Parameter	Easy Intubation (n=45)		Difficult Intubation (n=15)		p-value
Neck Circumference (NC) (cm)	37.42	1.05	38.85	0.92	<0.001
Thyromental Height (TMH) (cm)	8.21	0.68	7.45	0.58	<0.001
NC/TMH Ratio	4.56	0.31	5.22	0.28	<0.001

[Table 5] presents the predictive validity of the NC/TMH ratio and Mallampati Score. The predictive performance of the NC/TMH ratio and Mallampati score, assessed using ROC curve analysis, showed that the area under the ROC curve (AUC) for the NC/TMH ratio was 0.898, indicating excellent predictive accuracy for difficult intubation. Whereas the Mallampati score showed a much lower AUC of 0.208, suggesting poor predictive ability in this cohort.

Using an optimal cut-off value of 4.85, the NC/TMH ratio demonstrated high sensitivity (94.29%) and good specificity (71.11%). The positive predictive value was 88.39%, and the negative predictive value was 84.21%, yielding an overall diagnostic accuracy of 87.33%. In comparison, the Mallampati score had significantly lower sensitivity, specificity, and diagnostic accuracy (46.67%), indicating inferior predictive performance.

**Table 5: Predictive Validity of NC/TMH Ratio and Mallampati Score for Difficult Intubation**

ROC Curve Variable	NC/TMH Ratio	Mallampati Score
Area Under Curve (AUC)	0.898	0.208
Standard Error	0.028	0.042
95% Confidence Interval	0.83.3 - 0.95.3	012.6 – 0.291
p-value	<0.001	<0.001
Sensitivity (%)	94.29	53.26
Specificity (%)	71.11	52.46
Positive Predictive Value (PPV) (%)	88.39	24.11
Negative Predictive Value (NPV) (%)	84.21	84.21
Accuracy (%)	87.33	46.67
Cut-off Value	4.85	Class $\geq$ III

\*Optimal cut-off value derived from ROC analysis.

## DISCUSSION

Airway prediction is a crucial aspect of anaesthetic practice to prevent airway-related complications. Obesity is a known risk factor in the management of difficult airways due to increased soft-tissue deposition in the upper airway and altered airway anatomy. Hence, it is important to find valid and convenient preoperative predictors of difficult airway, especially among obese patients under general anaesthesia. The current study tested the validity of the neck circumference-to-thyromental height (NC/TMH) ratio as a predictor of difficult laryngoscopy and compared its predictive value with that of the widely relied on Mallampati classification. The results of this study showed that difficult intubation was experienced in 25% of patients. It is comparable to other studies where a difficult airway is reported to be more common among obese individuals than people in the general population. Obesity increases pharyngeal soft-tissue mass and reduces upper airway space, making laryngoscopy and intubation more challenging.<sup>[9,10]</sup> Past studies have also confirmed that anthropometric measurements of upper airway anatomy can be more predictive of challenging laryngoscopy than traditional bedside examinations.<sup>[11]</sup> Findings of this study indicated that the neck circumference was large and the thyromental height was low in patients with difficult intubation, resulting in a high NC/TMH ratio. This observation indicates that a greater neck circumference, an indicator of greater soft-tissue mass around the airway, and a lower thyromental height, a measure of a smaller mandibular space, contribute to difficulty with laryngoscopy. Previous studies have also concluded that neck circumference is a significant predictor of challenging intubation, particularly in the obese population.<sup>[12,13]</sup> The NC/TMH ratio showed strong predictive performance, with an Area under the ROC curve (AUC) of 0.898, Sensitivity of 94.29%, and Specificity of 71.11% at a cut-off value of 4.85. The results of our study were consistent with those of Kim et al., who initially found that the NC/TMH ratio is a useful predictor of difficult laryngoscopy and demonstrated high sensitivity and specificity when used as a measurement.<sup>[14]</sup> The NC/TMH ratio combines two significant airway dimensions, that is, neck circumference and thyromental height, and thus represents airway anatomy more holistically than either of the two parameters. Conversely, the Mallampati classification did not show good predictive performance in this study, as the AUC was low and the sensitivity and specificity were moderate. Although the Mallampati score is a popular bedside airway assessment tool, some studies have shown that it has low predictive value when used alone.<sup>[15,16]</sup> Patient cooperation and observer variability, as well as failure to account for neck and mandibular anatomical features, can reduce its reliability. The second major finding in this research is that the NC/TMH ratio had a high negative predictive value, indicating that patients with a low ratio are unlikely to have a challenging laryngoscopy. This feature is clinically useful because it enables anaesthesiologists to be confident in low-risk patients and to prepare more advanced airway management plans for patients with higher ratios.

Furthermore, the results of the present study are consistent with current evidence, which suggests that anthropometric measurements, including neck and mandibular parameters, are more effective at predicting difficult laryngoscopy, especially in obese patients. The NC/TMH ratio is easy to calculate, non-invasive, and does not require complex equipment, making it an appropriate choice for preoperative airway assessment. This study, however, is limited, just like any other study. The size of the sample used was modest and restricted to the obese patients who were undergoing elective surgery. Further research to support the NC/TMH ratio as a universal predictor of difficult airway would involve larger, multicenter studies across different populations. Despite these constraints, the current results indicate the utility of the NC/TMH ratio as a practical screening tool for preoperative airway assessment.

## CONCLUSION

The results of the present study showed that the NC/TMH ratio is a more reliable and superior predictor of difficult laryngoscopy in obese patients than the traditional Mallampati classification. A higher NC/TMH ratio, particularly values above 4.85, was strongly associated with difficult intubation. Therefore, the NC/TMH ratio can serve as a simple, non-invasive, and practical preoperative airway assessment tool in obese patients undergoing general anaesthesia.

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## Conflicts of interest

There are no conflicts of interest.

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