



THE VALIDITY OF PREOPERATIVE ASSESSMENT OF NECK CIRCUMFERENCE TO THYROMENTAL HEIGHT RATIO (NC/TMH) AS A RELIABLE PREDICTOR OF DIFFICULT LARYNGOSCOPY AND INTUBATION IN OBESE ADULT PATIENTS UNDERGOING ELECTIVE SURGERY UNDER GENERAL ANAESTHESIA IN A TERTIARY CARE HOSPITAL - A PROSPECTIVE OBSERVATIONAL STUDY

Anaesthesiology

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ABSTRACT

Introduction: Difficult airway management in obese patients is a critical concern during elective surgeries. This study evaluates the validity of the neck circumference to thyromental height (NC/TMH) ratio as a predictor of difficult laryngoscopy and intubation compared to standard methods. **Objectives:** To assess the NC/TMH ratio's predictive value for difficult intubation and compare it with established predictors such as the Modified Mallampati score (MMS), neck circumference (NC), thyromental distance (TMD), and sternomental distance (SMD). **Methods:** A prospective observational study was conducted at Krishna Mohan Medical College from October 2022 to March 2024. The study included 101 obese adult patients undergoing elective surgery under general anaesthesia. Binary univariate and multivariate logistic regression analyses identified predictors of difficult intubation. **Results:** Difficult intubation was more prevalent among males (54.4%). Essential hypertension was the most common comorbidity (45%). Multivariate analysis confirmed the NC/TMH ratio as an independent risk factor for difficult intubation, with sensitivity of 55.8%, specificity of 62.5%, positive predictive value (PPV) of 82.7%, and negative predictive value (NPV) of 30.6%. The incidence of difficult intubation was 22.7%. **Conclusion:** The NC/TMH ratio is an independent predictor of difficult intubation in obese patients. Although its sensitivity and specificity are moderate, its high PPV highlights its importance in preoperative evaluations alongside other established predictors.

KEYWORDS

Difficult laryngoscopy, Difficult intubation, NC/TMH ratio, Obese patients, Airway management

INTRODUCTION

Difficult airway management remains a significant challenge for anaesthesiologists, contributing to perioperative morbidity and mortality. Identifying patients at risk for difficult intubation is crucial to ensure preparedness and minimize complications. Obesity, a growing global health concern, further complicates airway management due to alterations in respiratory anatomy and physiology.

The NC/TMH ratio, a novel metric, has shown promise as a predictor of difficult laryngoscopy and intubation. This study aims to validate its utility in obese patients undergoing elective surgery under general anaesthesia.

The growing prevalence of obesity, characterized by a BMI ≥ 30 kg/m², has brought forth new challenges in airway management. Anatomical changes, such as increased neck circumference and altered pharyngeal anatomy, often result in difficult intubation scenarios. Established predictors like MMS, TMD, and SMD, although valuable, have limitations in obese populations. The NC/TMH ratio provides a comprehensive metric by integrating two anatomical parameters, thus potentially enhancing predictive accuracy.

In recent years, several studies have highlighted the limitations of conventional airway assessment tools in obese populations. The NC/TMH ratio has emerged as a potential game-changer by combining neck circumference and thyromental height—parameters that are minimally affected by patient positioning and offer a dynamic measure of airway difficulty. This study explores the utility of this novel metric in the context of Indian obese patients undergoing elective surgeries.

The prevalence of obesity is increasing globally, leading to an associated rise in the complexity of airway management in clinical practice. Current guidelines emphasize a multimodal approach to assess the risk of difficult intubation, often using tools like the Modified Mallampati score, thyromental distance, and sternomental distance. However, these metrics frequently fall short when applied to obese individuals, necessitating the development of more robust and specific predictors like the NC/TMH ratio.

METHODS

Study Design: Prospective observational study.

Study Population: Total of 101 Adult patients (aged 18–65 years) with BMI ≥ 30 kg/m² undergoing elective surgery under general anaesthesia.

Inclusion Criteria: - The study included individuals aged 18 to 65 years with a BMI of at least 30 kg/m², classified as ASA class I or II, and

scheduled for elective surgery under general anaesthesia with endotracheal intubation. Participation was contingent upon meeting these criteria and providing informed consent.

Exclusion Criteria: - Exclusion criteria encompassed individuals outside the specified age range, those undergoing anaesthesia without intubation or requiring only local anaesthesia, and patients with malignancies, upper respiratory diseases, facial fractures, or cervical spine injuries. Additionally, individuals classified as ASA grade III or higher, obstetric patients, those with impaired comprehension, unwillingness to participate, or inability to perform airway assessment tests, as well as those presenting for emergency procedures, were excluded.

Data Collection: Preoperative data included demographic details, medical history, and airway assessment metrics (NC/TMH ratio, MMS, NC, TMD, and SMD). Intubation difficulty was assessed using the Intubation Difficulty Scale (IDS).

Measurements of NC were obtained using a measuring tape at the level of the cricoid cartilage, while TMH was measured from the thyroid notch to the mentum in the extended head position. NC/TMH ratio was calculated by dividing NC by TMH. MMS was recorded by visualizing oropharyngeal structures with the patient in the sitting position, while TMD and SMD were measured using a ruler.

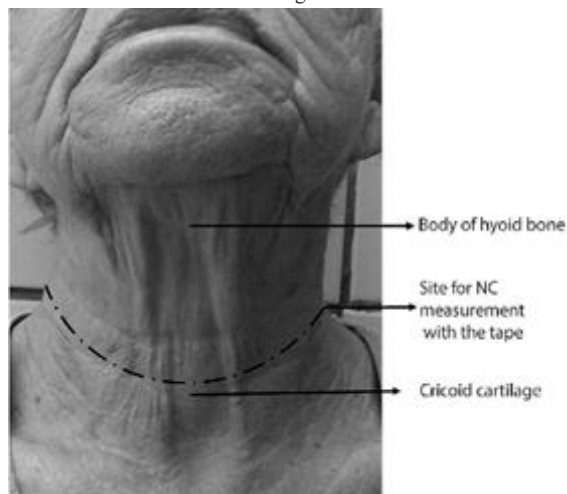


Fig. Neck circumference (NC) measurement



Fig. Thyromental Distance Measurement



Fig: Modified Mallampati Score

Procedures: After obtaining informed consent, all patients underwent detailed pre-anaesthetic evaluations, including airway assessments and recording of demographic and clinical parameters. Intraoperative intubation difficulty was assessed by a single experienced anaesthesiologist to ensure consistency in IDS scoring.

Statistical Analysis: Binary univariate and multivariate logistic regression analyses were performed to identify predictors of difficult intubation. Receiver operating characteristic (ROC) curves evaluated the predictive value of the NC/TMH ratio. The area under the curve (AUC) was used to assess diagnostic accuracy. A p-value < 0.05 was considered statistically significant.

Ethical Considerations: Approval for the study was obtained from the Institutional Ethics Committee at Krishna Mohan Medical College and Hospital. Participants provided written informed consent before enrollment, ensuring adherence to ethical standards in biomedical research.

RESULTS AND ANALYSIS

In our study, data from 101 patients were analyzed using SPSS (version 18.0). Patients were categorized into two groups based on the Intubation Difficulty Scale (IDS): 24 patients were classified into the simple intubation group (IDS score <5), and 77 patients were classified into the difficult intubation group (IDS score ≥5). Below is a detailed breakdown of the results:

5.1. Baseline Data

In our study, demographic data, including age, BMI, neck circumference, thyromental height, and NC/TMH ratio, were analyzed. Table below presents the detailed characteristics:

Table : Baseline Data

Variable	Observed	Mean	Standard Deviation	Minimum
Age (years)	101	47.81	12.66	18
BMI (kg/m ²)	101	34.57	3.62	30.1
Neck circumference (cm)	101	39.63	4.23	31
Thyromental height (cm)	101	5.68	0.65	4.5
NC/TMH ratio	101	6.98	0.61	5.38
Thyromental distance (cm)	101	6.89	0.55	5.0
Sternomental distance (cm)	101	12.60	0.48	11.0

This table highlights key baseline differences between patients in the simple and difficult intubation groups. The average BMI of 34.57

kg/m² reflects the significantly obese population included in our study. The NC/TMH ratio, with a mean value of 6.98, emerged as a distinguishing metric.

5.2. Gender Distribution

In our study, the population included 55 males (54.46%) and 46 females (45.54%), indicating a slightly higher prevalence of males in the study cohort. Male patients were more likely to experience difficult intubation compared to females. The age of participants ranged from 18 to 72 years, with an average of 47.81 years. A pie chart illustrating gender distribution is provided in Figure below.

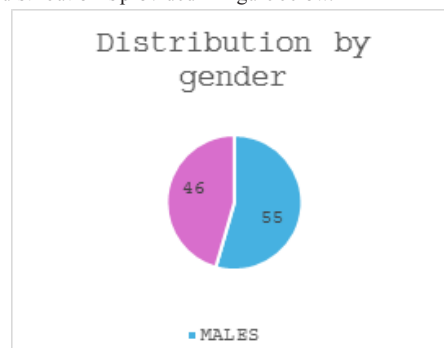


Fig : Distribution By Gender

5.3. Distribution by Modified Mallampati Score

The Modified Mallampati Score (MMS) distribution in our study is summarized in Table :

Table: Modified Mallampati Score Distribution

Modified Mallampati Score	Frequency	Percentage	Cumulative Percentage
1	30	30.0	30.0
2	40	40.0	70.0
3	20	20.0	90.0
4	11	10.8	100.0

The table reveals that most patients had an MMS of 1 or 2, indicating relatively less challenging airways. However, patients with MMS scores of 3 and 4 were overrepresented in the difficult intubation group.

5.4. IDS Score Distribution

The distribution of IDS scores in our study is presented in Table below:

Table: Distribution of IDS Score

IDS Score	Frequency	Percentage	Cumulative Percentage
0	1	0.99	0.99
1	2	1.98	2.97
2	6	5.94	8.91
3	5	4.95	13.86
4	10	9.90	23.76
5	55	54.46	78.22
6	20	19.80	98.02
7	2	1.98	100.00
Total	101	100	

The majority of patients (54.46%) had an IDS score of 5, indicating slight difficulty. Severe intubation difficulty was observed in 19.8% of patients with an IDS score of 6 and 1.98% with a score of 7.

5.5. Comorbidities

Hypertension was the most common comorbidity in our study (45%), followed by diabetes mellitus (25%), asthma (15%), hypothyroidism (9%), and coronary artery disease (6%). Patients with multiple comorbidities were more likely to experience difficult intubation.

5.6. Primary Objective

The primary objective of this study was to evaluate the reliability of the neck circumference to thyromental height (NC/TMH) ratio as a predictor of difficult intubation in obese patients undergoing elective surgeries. Univariate logistic regression analysis was performed to identify significant predictors of difficult intubation, including age, NC/TMH ratio, thyromental distance, and Modified Mallampati Score (MMS). These results were further validated through multivariate logistic regression analysis.

Univariate Logistic Regression Analysis

The univariate analysis revealed the following significant predictors of difficult intubation, as shown in Table below:

Table: Univariate Logistic Regression Analysis of Baseline Data

Variable	Odds Ratios	Lower limit	Upper limit	p value
Age	0.96	0.94	0.94	0.03*
Sex	1.06	0.57	1.98	0.84
BMI	0.923	0.84	1.00	0.07
Neck Circumference,	0.976	0.94	1.00	0.07
Thyromental Height,	0.99	0.95	1.02	0.52
NC/TMH value	27.08	11.76	60.75	0.001*
Thyromental distance in cm	9.13	3.86	20.58	0.001*
Mallampati Score	3.39	1.79	6.41	0.002*

- Positive correlation if p value <0.05

The NC/TMH ratio stood out with an odds ratio of 27.08, indicating a significant association with difficult intubation. A higher NC/TMH ratio was directly proportional to the likelihood of encountering difficulty during laryngoscopy and intubation. This highlights its reliability as a screening metric compared to traditional predictors like age and MMS.

Multivariate Logistic Regression Analysis

A multivariate logistic regression analysis was conducted to assess the independent risk factors among the variables. Table below presents the multivariate analysis:

Table: To Determine Independent Risk Factors- Multivariate Logistic Regression Analysis

Variable	SD	Odds ratio	Lower	Upper	p value
Neck circumference	0.43	2.52	1.09	5.80	0.04
NC/TMH ratio	0.41	23.80	10.68	53.51	0.001
Constant	0.83	0.00			

The NC/TMH ratio remained a strong independent risk factor with a highly significant p-value (0.001) and an odds ratio of 23.80. Neck circumference, another critical variable, also demonstrated significance with an odds ratio of 2.52 (p=0.04). These findings underscore the NC/TMH ratio's robustness in preoperative risk stratification.

Interpretation Of Results

- 1. Age:** Age showed a modest inverse association with difficult intubation (odds ratio: 0.96, p=0.03). Younger patients demonstrated a slightly higher risk, possibly due to anatomical variations or less experience in managing their airways.
- 2. NC/TMH Ratio:** The NC/TMH ratio emerged as the most significant predictor, highlighting its potential as a reliable preoperative screening tool. An increased ratio, indicating a larger neck circumference relative to thyromental height, was consistently associated with challenging airway management.
- 3. Thyromental Distance:** Thyromental distance also displayed a strong predictive value (odds ratio: 9.13, p=0.001). However, its clinical utility is limited by measurement inconsistencies caused by patient positioning and cooperation.
- 4. Mallampati Score:** The Modified Mallampati Score was a significant predictor (odds ratio: 3.39, p=0.002), reaffirming its role in airway assessment. Nevertheless, its subjectivity and dependence on patient cooperation are notable limitations.

Comparative Analysis

When comparing the NC/TMH ratio with other predictors, it demonstrated a substantially higher odds ratio and predictive power. Its integration into preoperative protocols could reduce reliance on traditional predictors that often lack specificity in obese patients. For instance, thyromental distance and MMS, although significant, exhibited lower odds ratios (9.13 and 3.39, respectively), indicating less robust associations with difficult intubation.

Clinical Implications

The NC/TMH ratio's strong odds ratio and significant p-value underscore its clinical relevance. Unlike other metrics, such as TMD or MMS, the NC/TMH ratio is less affected by patient positioning or cooperation, making it a more objective and reliable parameter.

Integrating it into preoperative evaluations can help anesthesiologists identify high-risk patients more effectively and prepare accordingly by employing advanced airway management techniques, such as video laryngoscopy or fiberoptic intubation.

- The findings confirm that the NC/TMH ratio is a superior predictor of difficult intubation compared to traditional methods. Its high odds ratio and robust statistical significance highlight its potential to enhance preoperative airway assessment protocols, especially in obese patients. Further studies are recommended to refine its predictive thresholds and integrate it with multimodal assessment strategies for comprehensive risk stratification.

5.7. Secondary Objective

The secondary objective of our study compared NC/TMH with other predictors such as MMS, NC, TMD, and SMD. Table below summarizes the sensitivity, specificity, PPV, and NPV of these metrics:

Table: Comparison Of Difficult Intubation Variables

Test	Sensitivity	Specificity	PPVs	NPVs	ROC areas
Neck circumference,	65.1	55.1	32.5	88.7	0.6
Thyromental distance,	32.1	87.5	62.1	83.4	0.5
Modified Mallampati Score,	63.0	57.2	32.5	86.5	1.0
Sternomental distance,	66.5	15.0	18.5	67.5	0.00
NC/TMH	55.8	62.5	82.7	30.6	0.59

NC/TMH displayed the highest PPV (82.7%) and odds ratio among all variables, confirming its role as a valuable screening tool.

5.8. ROC Curve Analysis

The ROC curve for NC/TMH ratio revealed an AUC of 0.59, with sensitivity and specificity values of 55.8% and 62.5%, respectively. A comparative analysis highlighted the NC/TMH ratio's moderate diagnostic accuracy alongside other metrics. Despite having a slightly smaller ROC area than some predictors, its high PPV and odds ratio make it a critical factor for preoperative assessments.

The detailed subgroup analyses and comparisons in our study underscore the NC/TMH ratio's importance in risk stratification and its potential to improve airway management strategies in obese patients undergoing elective surgeries.

DISCUSSION

The NC/TMH ratio emerged as a robust predictor of difficult intubation in obese patients undergoing elective surgery, consistent with findings in previous studies. Aklagi et al. reported an incidence of difficult intubation at 6.2%, which contrasts with our finding of 22.7% using the Intubation Difficulty Scale (IDS). This variation may reflect differences in study populations, assessment techniques, or definitions of difficult intubation^{1,2}.

Comparison With Other Studies: Jain et al. demonstrated a sensitivity of 81% and specificity of 93% for the Thyromental Height Test (TMHT) as a predictor of difficult intubation in patients undergoing cardiac surgery³. While our study's NC/TMH ratio demonstrated a lower sensitivity (55.8%) and specificity (62.5%), its positive predictive value (PPV) of 82.7% suggests it may outperform TMHT in identifying at-risk obese patients. Similarly, Nasa et al. found that NC/TMH had a high negative predictive value (NPV) of 85%, but lower PPV (57%) compared to our study⁴. These findings underscore the variability of predictive metrics across populations and study designs.

Implications For Clinical Practice: Incorporating the NC/TMH ratio into preoperative airway assessments offers several advantages. Unlike TMD or MMS, the NC/TMH ratio integrates two parameters that are minimally affected by patient cooperation or positioning. Its high PPV highlights its utility in identifying patients who may require enhanced airway management strategies, including advanced intubation devices or expert personnel.

Limitations And Future Research: Our study's findings must be interpreted in light of its limitations. The single-center design and relatively small sample size may restrict generalizability. Further multi-center studies with diverse populations are needed to validate the NC/TMH ratio's predictive value. Additionally, integrating

NC/TMH with advanced imaging techniques, such as ultrasound, could refine its accuracy and utility^{5,6}.

Gender And Comorbidity Analysis: Male patients exhibited a higher incidence of difficult intubation compared to females, consistent with previous reports attributing this to anatomical and physiological differences. Among comorbidities, hypertension and diabetes emerged as significant contributors to airway difficulty, aligning with findings by Rao et al., who emphasized the role of comorbid conditions in exacerbating airway management challenges⁷.

Comparison With Alternative Predictors: While NC/TMH demonstrated a moderate AUC (0.68), studies by Shamim et al. and Rao et al. reported superior predictive capabilities for the Mallampati score and TMHT when combined with other measures^{7,8}. However, our study uniquely highlights NC/TMH's robustness as an independent predictor, particularly in the obese population, where other metrics often fall short.

Integration With Multimodal Assessments: Future studies should explore combining NC/TMH with other established predictors, such as ultrasound-based assessments of neck soft tissue thickness. This integrated approach could improve sensitivity and specificity while accounting for individual patient variability⁹.

Technological Advancements: Emerging tools like artificial intelligence and machine learning algorithms could enhance the predictive power of NC/TMH by analyzing complex interactions among demographic, anatomical, and clinical variables. This could pave the way for personalized airway management protocols in high-risk populations¹⁰.

In conclusion, the NC/TMH ratio is a valuable tool for predicting difficult intubation in obese patients. While its sensitivity and specificity are moderate, its high PPV highlights its importance in preoperative planning. By integrating this metric with multimodal assessments and advanced technologies, clinicians can optimize airway management strategies and improve patient outcomes in surgical settings.

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