A Study To Evaluate Neck Circumference To Thyromental Distance Ratio To Predict Difficult Intubation In Patients Scheduled For Elective Surgeries Under General Anaesthesia

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Keywords:	ABSTRACT
Modified Mallampati grading (MMG), Difficult intubation (DI), Neck circumference (NC), Thyromental Distance (TMD), Body mass index (BMI)	**Background:** A comprehensive airway assessment requires an understanding of the anatomical features of the neck and upper airway. Accurately predicting a potentially difficult airway is a multifactorial challenge, dependent on patient-related factors, clinical context, and the anesthesiologist's proficiency. Failure to anticipate a difficult airway remains a common cause of anesthesia-related complications. **The objective:** To evaluate the relationship between the neck circumference to thyromental distance ratio (NC/TMD) and the incidence of difficult intubation in adult patients scheduled for elective surgeries under general anesthesia. **Methods.** This study included 100 patients undergoing elective surgeries under general anesthesia with endotracheal intubation of ASA grades I and II. Patients were examined preoperatively and intraoperatively. Data collection using the patient proforma which includes the demographic data, body mass index (BMI), ratio of NC/TMD, thyromental distance (TMD), and Modified Mallampati Test (MMT). Statistical software (SPSS 20.0) was used for statistical analyses of the data. **Results**: The current study examines the efficacy of the neck circumference/ thyromental distance ratio (NC/TM distance ratio) in comparison to the Mallampati score and neck circumference as more reliable indicators for predicting difficult intubation. **Conclusion:** The NC/TMD ratio is a simple, effective, and non-invasive predictor of difficult intubation. It demonstrates superior sensitivity and specificity compared to MMG and NC alone. Routine incorporation of this measurement in preoperative airway assessment could improve anesthesia outcomes.

Introduction

The occurrence of a challenging laryngoscopy is approximately the same (around 10%) across non-obese individuals and obese individuals. However, there have been an increasing number of studies indicating challenges in performing intubation in obese patients [10]. This is attributed to difficult visualization of larynx in obese patients which might lead to difficult intubation. DI is a major concern for anesthesiologists and it accounts to 17% of airway injuries and leads to significant perioperative morbidity and mortality. Radiological imaging like ultrasonography, magnetic resonance imaging and computed tomography scans also have shown the presence of excess soft tissue in various areas of neck like the pharynx, retro pharynx, suprasternal notch, at the level of cords and lateral neck region of obese patients [2]. Several clinical indicators can raise the risk of a challenging airway in obese people. Some of these characteristics include an enlarged airway management in patients planned for general anaesthesia is of utmost importance for an anesthesiologist since ages.

Prediction of difficult intubation is one of the most challenging tasks for any anaesthesiologist and it is affected by not only the patient factors but the clinical settings, risk assessment, clinical judgement and skills of an anesthesiologist as well [13]. The difficult endotracheal intubation as per the ASA guidelines is defined as "more than three attempts or more than ten minutes proper for insertion of a tracheal tube with conventional laryngoscopy" [8].

The hypothesis is that the ratio of Neck circumference to thyromental distance (NC/TMD ratio) of more than or equal to five will predict a difficult intubation and will have a better statistical and clinical significance as compared to other standard indices of airway assessment among patients. Therefore, in this study, our goal was to investigate a preoperative indicator of challenging intubation named the ratio of neck circumference to thyromental distance.

This indicator does not require any specialized equipment, can be performed quickly, is not uncomfortable for the patient, and is noninvasive. The current study examines the efficacy of the neck circumference/ thyromental distance ratio (NC/TM distance ratio) in comparison to the Mallampati score and neck circumference as accurate indicators for predicting difficult intubation.

Aim of the study
To assess the validity of neck circumference to thyromental distance ratio (NC/TMD) as an important parameter to predict difficult intubation amongst adult patients undergoing elective surgery under general anaesthesia.

Method
The clinical study was conducted at People's College of Medical Sciences & Research Centre, Bhopal, India in the span of six months.

Permission of the Ethics Committee: This work was approved by Institutional Ethical Committee Code: IEC-2022/66.

100 patients were studied after approval by institutional ethical committee (IEC-2022/66) and written informed consent. Age more than 18 and less than 65 years, ASA class I and II, patients scheduled for elective surgery under general anaesthesia with endotracheal intubation were included.

Exclusion criteria: Patients less than 18 years and more than 65 years of age, Patients scheduled for general anaesthesia without endotracheal intubation such as mask ventilation, use of laryngeal mask airways, sedation, monitored anesthetic care were excluded. Patients coming for surgery under regional anaesthesia. Patients with upper airway pathologies, thyroid gland dysfunction, facial and maxillary fractures. Obstetric patients and cervical spine fractures were excluded along with patient refusal to participate in the study.

Pre operative assessment: It consisted of proforma with emphasis on a) Demography of patient b) Body mass index c) Airway assessment variables include 1. Neck circumference ((Measured at the level of cricoid cartilage) 2. Thyromental distance (The distance between thyroid cartilage and mentum with neck fully extended) 3. The ratio of neck circumference to thyromental distance (NC/TM distance ratio) 4. Mallampati classification without phonation.

Intra operative assessment: Difficulty of intubation was assessed by anesthetist by filing up intubation difficulty score (validated IDS score) [17 Adnet] after intubation. Intubation difficulty score consists of seven variables from N1 to N7. The sum of N1 to N7 gives total IDS score. Any score of greater than or equal to five was considered to be difficult intubation and score less than five considered to be easy intubation.
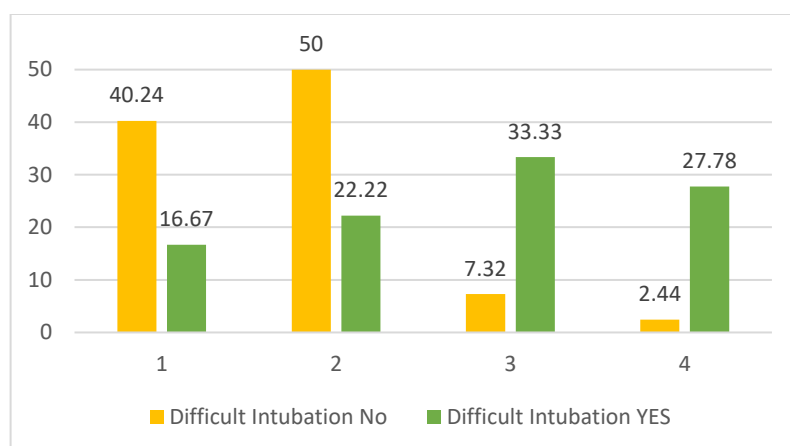
Statistical Analysis
The results are presented as numbers (percentage). The Chi-square test was used. Statistical analysis was performed using SPSS software, and statistical significance was set at $p < 0.05$.

Results
The distribution illustrates a clear trend in table 1: as the Mallampati grading increases, the proportion of difficult intubation cases also rises, particularly noticeable in Grades 3 and 4, where the rates significantly exceed those of Grades 1 and 2. The statistical significance of this trend was evaluated using Pearson's Chi-square test, resulting in a Chi2 value of 26.67 and a P-value of less than 0.0001. This highly significant P-value indicates a strong association between higher Mallampati grades and an increased incidence of difficult intubation.

Table 1. Mallampati Grading among participants (n=100)

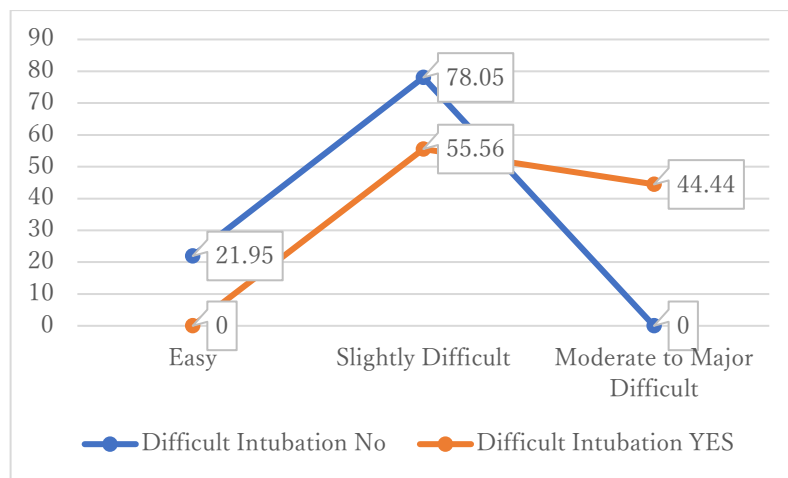| MPC	Difficult Intubation		
	NO	YES	Total
1	33	3	36
	40.24	16.67	36.00
2	41	4	45
	50.00	22.22	45.00
3	6	6	12
	7.32	33.33	12.00
4	2	5	7
	2.44	27.78	7.00
Total	82	18	100
Pearson Chi2 = 26.67; P-value < 0.0001			

Fig 1. Mallampati Grading among participants (n=100)

Table 2 categorizes the ease of intubation according to the Intubation Difficulty Scale (IDS) and its correlation with the occurrence of difficult intubation among 100 participants.

Table 2: Eaze of Intubation according to IDS Scale (n=100)

IDS	Difficult Intubation		
	No	YES	Total
Easy	18	0	18
	21.95	0.00	18.00
Slightly Difficult	64	10	74
	78.05	55.56	74.00
Moderate to Major Difficult	0	8	8
	0.00	44.44	8.00
Total	82	18	100
Pearson Chi2 = 41.40; p-value < 0.0001			

Fig 2: Eaze of Intubation according to IDS Scale (n=100)

Table 3 provides an analysis of various body parameters and their correlation with difficult intubation among participants, summarized as follows:

▪ BMI (Body Mass Index): The mean BMI for participants without difficult intubation was 25.2 (SD = 2.67), while for those with difficult intubation, it was 28.00 (SD = 2.40). The difference is statistically significant (P-value = 0.0001), indicating higher BMI is associated with an increased incidence of difficult intubation.

▪ Obesity: 7.2% of participants without difficult intubation were classified as obese, compared to 22.2% of those with difficult intubation. The difference approached statistical significance (P-value = 0.059), suggesting a trend toward higher obesity rates in those experiencing difficult intubation.

▪ Neck Circumference: The mean neck circumference for participants without difficult intubation was 34.96 cm (SD = 5.44), and for those with difficult intubation, it was significantly higher at 40.46 cm (SD = 5.68) (P-value = 0.0002).

Table 3. Body Parameters.

Parameter Mean (SD)	Difficult Intubation		P-value
	No	YES	
BMI	25.2 (2.67)	28.00 (2.40)	0.0001
Obese	6 (7.2%)	4 (22.2%)	0.059
NC	34.96 (5.44)	40.46(5.68)	0.0002
TMD	7.31 (0.877)	6.07 (0.892)	0.029
NC/TMD	4.78 (0.466)	5.71 (0.183)	< 0.0001

Thyromental Distance: There was a significant difference in thyromental distance between those without (mean = 7.31 cm, SD = 0.877) and with difficult intubation (mean = 6.07 cm, SD = 0.892) (P-value = 0.02994). Neck Circumference-to-Thyromental Distance Ratio: Participants without difficult intubation had a lower mean ratio of 4.78 (SD = 0.466) compared to those with difficult intubation, who had a significantly higher mean ratio of 5.71 (SD = 0.183) (P-value < 0.001). The 95% confidence intervals for these means did not overlap, further highlighting the significant difference. The analysis indicates that certain body parameters, particularly BMI, neck circumference, and the neck circumference-to-thyromental distance ratio, are significantly associated with an increased risk of difficult intubation. These findings underscore the importance of considering these

parameters in the preoperative assessment to identify patients at risk for difficult intubation and prepare appropriate airway management strategies.

Table 4 presents the results of a logistic regression analysis investigating the association of various factors with the likelihood of difficult intubation, expressed as odds ratios (ORs), P-values, and 95% confidence intervals (CIs).

Table 4. Logistic regression for difficult intubation

Variable	Odds ratio	P-value	95% CI	
NC/TMD	9.47	<0.0001	3.30	25.86
BMI	0.85	0.426	0.58	1.25
Age	0.963	0.324	0.89	1.03
Male	0.909	0.917	0.15	5.49
Female	1.0	-	-	-

Neck Circumference-to-Thyromental Distance Ratio: The analysis showed a significant association, with an OR of 9.47 (95% CI: 3.30-25.86, P-value < 0.0001), indicating that each unit increase in the ratio increases the odds of difficult intubation by approximately 9.47 times.

▪ BMI (Body Mass Index): BMI was not significantly associated with difficult intubation, with an OR of 0.85 (95% CI: 0.58-1.25, P-value = 0.426). This suggests that, within this study, BMI alone does not significantly influence the likelihood of difficult intubation.

▪ Age: Age also showed no significant association with difficult intubation, evidenced by an OR of 0.963 (95% CI: 0.89-1.03, P-value = 0.324), indicating that the likelihood of difficult intubation does not significantly decrease or increase with age in this sample.

▪ Gender: Male participants had an OR of 0.909 (95% CI: 0.15-5.49, P-value = 0.917) compared to female participants, indicating no significant gender difference in the odds of experiencing difficult intubation. Female participants are the reference category (OR = 1.0). The results from the logistic regression analysis underscore the importance of the neck circumference-to-thyromental distance ratio as a significant predictor of difficult intubation. In contrast, BMI, age, and gender were not statistically significant predictors in this model. This analysis provides valuable insights into factors that may warrant consideration during preoperative airway assessments to identify patients at higher risk for difficult intubation.

Discussion

The existing data are inconclusive and there is a divergence of perspectives on the challenge of tracheal intubation. Various endeavors have been made to provide precise predictors for difficulty laryngoscopy or difficult intubation. The present study was undertaken to assess the validity of neck circumference to thyromental distance ratio (NC/TMD) as an important parameter to predict difficult intubation amongst adult patients undergoing elective surgery under general anaesthesia.

A total of 100 patients who were scheduled for elective surgery were evaluated for the presence of difficult intubation in the study. The group consisted of individuals from varied demographic backgrounds and with varying physical attributes, enabling a thorough investigation of factors that predict and the occurrence rate of difficult intubation. Patients had a preoperative assessment, which included the evaluation of the Mallampati score, measurement of thyromental distance, and assessment of neck mobility. Anesthesia was delivered according to established protocols, and the level of difficulty in intubation was assessed using the Intubation Difficulty Scale (IDS). The findings indicated that 18% of patients encountered challenging intubation, specifically defined as having an IDS score of 5 or higher. The reported incidence by Fotopoulou G et al[7] (20%), Voyagis GS et al[24] (20.2%), Castro D et al[4] (20.75%). In contrast, other authors such as Shiga T et al[21] (15.8%), Juvin P et al. [12] (15.5%), Gonzalez H et al. [9] (14.3%), Kim W.H. et al. [13] (13.8%), and

Shailaja S et al. [22] (11%) reported a lower incidence. Therefore, the literature study indicates that the occurrence of problematic intubation ranged from 11% to 22%.

The present study found a highly significant p-value (p<0.0001) indicating a strong association between higher Mallampati grades and an increased incidence of difficult intubation. The distribution of patients according Mallampati grade score illustrates a clear trend: as the Mallampati grading increases, the proportion of difficult intubation cases also rises, particularly noticeable in Grades 3 and 4, where the rates significantly exceed those of Grades 1 and 2. Our results are in concordance with other studies reported in the literature. The Mallampati score has become a standard part of a comprehensive airway evaluation, although its predictive value for difficult intubation has proven to be low. The Mallampati score is based upon visualization of anatomical oropharyngeal structures and relates them to intubation difficulty.[20] One of the adjustments made to the Mallampati scoring system is the one by Samsoon and Young, which adds a fourth class to the descriptions of oropharyngeal exposures.[20] Some drawbacks of the modified Mallampati classification include interobserver variability and reliance on patient compliance. According to research by Lee A. et al. [14], the categorization was not very good at predicting difficult intubations. Additionally, other authors have found that, in order to improve diagnostic accuracy, it should be used in conjunction with other predictors rather than being used alone as a test to predict difficult intubation or laryngoscopy.[16,18]

The Intubation Difficulty Scale (IDS) was developed by Adnet F et al.[1] It has seven objective features that are utilized for the assessment of intubation. IDS has been employed as a verified measure of difficulty to characterize challenging intubation. The present study utilized the Adnet F Intubation Difficulty Scale score to determine the frequency of intubation difficulty in individuals undergoing elective surgery under general anesthesia.

Koh W. et al. [14] found the Cormack-Lehane grade was most sensitive for predicting difficult intubation compared with other parameters of IDS and their findings indicated a correlation between Cormack-Lehane grade 3 or 4 and the likelihood of encountering challenges during intubation. These findings suggest that even though the actual incidence of difficult intubation (5.8%) was lower in patients with a Cormack-Lehane grade of 3 or 4 (16.2%), anesthesiologists should always be prepared for difficult intubation when encountering patients with a high Cormack Lehane grade.

The present study found a clear delineation between the perceived difficulty of intubation and the actual incidence of difficult intubation, especially highlighted by the 100% incidence rate in the "Moderate to Major Difficult" category with a statistical significance (p= 0.0000) difference. This highly significant p-value strongly indicates a significant association between the IDS category and the occurrence of difficult intubation. All 18 cases classified as "Easy" experienced no difficult intubation, indicating a 0% incidence of difficulty in this category. Of the 74 cases deemed "Slightly Difficult," 10 were identified as difficult intubations, accounting for 55.56% of all difficult intubation cases. In the "Moderate to Major Difficult" category, all 8 cases were considered difficult intubations, comprising 44.44% of the difficult cases. The present study analyzed various body parameters and their correlation with difficult intubation among participant. The mean BMI for participants without difficult intubation was 25.2 (SD = 2.67), while for those with difficult intubation, it was 28.00 (SD = 2.40). The difference is statistically significant (P-value = 0.0001), indicating higher BMI is associated with an increased incidence of difficult intubation. The mean neck circumference for participants without difficult intubation was 34.96 cm (SD = 5.44), and for those with difficult intubation, it was significantly higher at 40.46 cm (SD = 5.68) (P-value = 0.0002). There was a significant difference in thyromental distance between those without (mean = 7.31 cm, SD = 0.877) and with difficult intubation (mean = 6.07 cm, SD = 0.892) (P-value = 0.02994). Participants without difficult intubation had a lower mean ratio of 4.78 (SD = 0.466) compared to those with difficult intubation, who had a significantly higher mean ratio of 5.71 (SD = 0.183) (P-value < 0.001). The 95% confidence intervals for these means did not overlap, further highlighting the significant difference. Comparing our study with various studies, a study conducted by Ittichaikulthol W et al[11] with a substantial sample size that the combination of MMT (Mallampati Modified Test) and TMD (Thyromental Distance) were reliable indicators of a challenging laryngoscopy procedure in the Thai population. Nevertheless, they employed a TMD value of <6cm which differs from the <6.5cms parameter utilized in the present investigation.[11] Another study by Magalhães E et al[17] that evaluated Chinese women who were pregnant and those who were not pregnant and discovered that the combination of predicting factors might enhance the accuracy. A study conducted by Díaz-Gómez JL et al. in the United States found that

the utilization of up to ten measurements significantly enhanced the predictability of a challenging intubation by improving the aggregate set of factors [6].

The results from the logistic regression analysis underscore the importance of the neck circumference-to-thyromental distance ratio as a significant predictor of difficult intubation. In contrast, BMI, age, and gender were not statistically significant predictors in this model. This analysis provides valuable insights into factors that may warrant consideration during preoperative airway assessments to identify patients at higher risk for difficult intubation.

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