RESEARCH PAPER

A Prospective Observational Study on the Importance of Neck Circumference to Thyromental Distance Ratio (NC/TM Distance Ratio) As a Predictor of Difficult Intubation in Obese Patients Coming for Elective Surgery Under General Anaesthesia

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ABSTRACT

Backgrounds and objectives: We conducted this study to ascertain the role of Neck circumference/Thyromental distance ratio as a predictor of difficult airway among obese patients undergoing endotracheal intubation for surgery. We also compared different predictors of Difficult intubation like Neck circumference, thyromental distance, Mallampati score with Neck circumference/Thyromental distance ratio.

Material and Methods: Following the approval by Internal ethical committee review board of the Adichunchanagiri Institute of Medical Sciences, Mandya, preoperative assessments using study proforma were conducted on 250 obese patients (BMI ≥30 kg/m^2) between December 2022 and June 2024, with the patients' informed consent. Using the study proforma, the NC/TM distance ratio was computed. The anaesthetist performing the intubation completed an intraoperative assessment of each obese patient's Intubation Difficulty Score (IDS score). Based on the IDS score, the complete study population was split into groups for easy and difficult intubations. An IDS score of five or higher was deemed to indicate a difficult intubation. Through the use of univariate and multivariate logistic regression analysis, the study evaluated the statistical significance of the NC/TMD ratio in predicting difficult intubation and comparisons with the Mallampati score, neck circumference alone and Thyromental distance alone was done.

Results: Increased weight, increased neck circumference, decreased thyromental distance and NC/TMD ratio ≥ 5 were found to be statistically significant variables that were associated with a difficult intubation ($p \leq 0.05$) in a binary univariate logistic regression analysis of the predictors of difficult intubation. Only the neck circumference [p=0.043, odd ratio 2.36(1.029-5.455)] and the NC/TMD ratio [p <0.001, (odd ratio 17.75(7.573-41.617)] were shown to be independent predictors of difficult intubation in the binary multivariate logistic regression analysis. In contrast to neck circumference, the NC/TMD ratio demonstrated a bigger AUC on a ROC curve, higher specificity, a higher PPV and higher NPV. In obese patients, the rate of difficult intubation was 18.4%.

Interpretation and Conclusion: We concluded from the study that NC/TM ratio can be considered as reliable bedside screening test for prediction of difficult intubation in obese patients.

Keywords: *Thyromental distance ratio, neck circumference, obese*

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INTRODUCTION

Obesity is a medical disorder characterised by excessive body fat accumulation that poses a significant risk to one's health. People whose body mass index (BMI) is 30 kg or higher per square metre of body surface are classified as obese by the World Health Organisation (WHO).[1]

The prevalence of obesity has significantly increased practically everywhere, and compared to the general population, obese people are more likely to experience unfavourable events related to their airways. Anaesthesiologists are concerned about obese patients' difficult laryngeal visualisation since it can result in

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difficult intubation and account for 17% of airway injuries, which can cause significant perioperative morbidity and mortality**.** In obese patients, the airway becomes narrowed by fat deposition around the neck, making mask ventilation and intubation challenging. Moreover, it is challenging to achieve regulated ventilation due to fat deposition in the upper body and abdomen.[2,3]

Preoperative airway examination is therefore crucial to ensuring sufficient patient safety. Several factors, including neck circumference (NC), sternomental distance (SMD), thyromental distance (TMD), modified Mallampati classification, and inter incisor gap, are associated with difficult airway. However, one parameter may not be sufficient to predict problematic airway with accuracy, according to a prior study**.**On the other hand, although time-consuming and laborious, a combination of criteria such as the Wilson score can increase diagnostic accuracy.

NC has been found to have high sensitivity and TMD to have high specificity in predicting difficult intubation preoperatively, and they are easy to measure. Thus, a combination of these two parameters can be helpful in predicting a difficult airway.

Our goal in this dissertation is to investigate the neck circumference to thyromental distance ratio as a preoperative predictor of difficult intubation that requires no special tools, takes little time to conduct, and does not cause the patient discomfort with better statistical significance compared to other indices.

AIMS AND OBJECTIVES

AIM OF THE STUDY

To evaluate the significance of the neck circumference to thyromental distance ratio (NC/TMD ratio) in predicting difficult intubation in obese individuals coming for elective surgery under general anaesthesia.

OBJECTIVES OF THE STUDY

PRIMARY OBJECTIVE - To evaluate the relationship between the ratio of neck circumference to thyromental distance (NC/TMD ratio) and intubation difficulty score (IDS) in obese patients coming for elective surgery under general anaesthesia.

SECONDARY OBJECTIVES-

1. To determine if the neck circumference/thyromental distance ratio (NC/TMD ratio) is a more accurate predictor of intubation difficulty in obese patients than thyromental distance, neck circumference, and Mallampati score alone.
2. To find out the incidence of difficult intubation among obese individuals coming for elective surgery under general anaesthesia.

MATERIALS AND METHODS

SOURCE OF DATA:

Adult patients of both sexes aged between 18-80 years with physical status ASA 1 and ASA 2 coming for elective surgery under general anaesthesia in Adichunchanagiri Institute of Medical Sciences, BG Nagra, Karnataka.

STUDY DURATION: 18 MONTHS (December 2022 to June 2024)

STUDY DESIGN: A PROSPECTIVE OBSERVATIONAL STUDY

SAMPLE SIZE ESTIMATION:

As per study done on difficult intubation among obese patients **Kim et al**.,[24] and following details of NC/TM distance ratio were taken into consideration to calculate sample size

Cut off values for NC/TM distance ratio	Kim et al [24]
Sensitivity	90
Specificity	83
P value	<0.001
Confidence interval	95

So as to achieve a 95% CI of true sensitivity (true positive) with a allowable error between 0.05 and 0.1 and to achieve precision of 10 % for specificity (true negative), it was decided to keep a sample size of **250** obese patients with tracheal intubation for the current study.

SELECTION OF STUDY PARTICIPANTS:

INCLUSION CRITERIA:

1. Age greater than 18 years.
2. ASA class I, II.
3. Patients of both genders.
4. Body mass index **≥ 30 kg/m2**(Obese patients)
5. Patients undergoing surgery with tracheal intubation.

EXCLUSION CRITERIA:

1. Patient Refusal.
2. Patients with upper airway pathology such as facial and maxillary fractures or any thyroid or neck related pathologies
3. Cervical spine injury.
4. Obstetric patients.
5. Patients with OSA history.

METHODOLOGY

Data collection was done in two steps.

Preoperative assessment

Intra operative assessment

Preoperative assessment consists of proforma with emphasis on:

Demography of patient (Age, gender, sex, height, weight,)

Body mass index: [Formula: Weight/(Height)^2, (kg/m$^{2)}$]

Airway assessment variables include:

Neck circumference (cm) – measured at the level of the cricoid cartilage with a measuring tape.

Thyromental distance (cm) - Using a measuring tape, the distance between the thyroid notch and the mentum when the neck is completely extended is measured.

The ratio of neck circumference to thyromental distance. (NC/TM distance ratio)

Mallampati classification without phonation [47,48] Class 1 – soft palate, fauces, uvula and pillars visible Class 2 – soft palate, fauces, and uvula visible

Class 3 – soft palate and base of uvula visible Class 4 – soft palate not visible.

Intra Operative Assessment:
The anaesthetist determined the difficulty of intubation by recording the Intubation Difficulty Score (validated IDS score)[7] following intubation. The seven elements that make up the intubation difficulty score range from N1 to N7. The overall IDS score is the sum of N1 through N7. A score of five or more will be categorised as difficult intubation, whereas a score of less than five would be classified as easy intubation.

PROTOCOLS FOR INTUBATION:
In the operating room, ASA standard monitors (ECG leads with monitor, Pulse oximetry Capnography-ETCo2 monitor, Nihon Kohden monitor) were connected to the patient and baseline values was recorded , Additional monitors were utilised if necessary, or according to the anesthetist's authority assigned to the case.

Intravenous Access Preferably with 18G Wide Bore Cannula Secured
Patients received premedication with intravenous (IV) glycopyrrolate at a dose of 0.2 mg, midazolam at 0.02 mg/kg, and fentanyl at 2 μg/kg. In preparation for potential difficulties, a difficult intubation cart was prepared, and the ASA difficult airway algorithm was adhered to.

Propofol was used to induce general anaesthesia in titrated doses until vocal response was lost following three minutes of 100% oxygen pre-oxygenation. IV vecuronium bromide 0.1 mg/kg was used to produce neuromuscular blockade. A facemask of the proper size was used to maintain mask ventilation.

The laryngoscope, equipped with a Macintosh blade size 3 for women and size 4 for men, was inserted into the right side of the patient's mouth. The tongue is swept to the left, and the tip of the blade is advanced until a fold of tissue or cartilage is visible at the 12 o'clock position. An endotracheal tube of size 7 or 7.5 mm was used for female patients, while sizes 8 or 8.5 mm were used for male patients.

The standard head position was a pillow under the head with neck extended.

Extra points were awarded for any position shift from the standard position. (For instance, stacking, ramping, or altering the standard position).

Any additional method used in addition to the conventional direct laryngoscopy will receive extra points. (For instance, video assisted intubation, fibre optic intubation, Bougie use, and glide scope use.)

Anaesthetists with at least three years of expertise in anaesthesia and airway management performed the first intubation attempt.

GUIDELINES TO FILL UP INTUBATION DIFFICULTY SCORE SHEET

N1	Number of additional intubation attempts is indicated by N1 **0 = first attempt** **1 = for each supplementary attempts.**
N2	Number of additional persons directly attempting intubation (Not assisting intubation) is indicated by N2 **0 = one operator** **1 = for each supplementary operators**
N3	Number of alternative techniques used is indicated by N3 **0 = for standard technique** **1 = for each alternate techniques** Standard technique means pillow under the head and Macintosh size 3 for woman and size 4 for men. Alternative technique includes

	Change in patient positioning(Ramping /Stacking) Change of instruments (Blade, ET tube , Addition of stylette, Bougie) Change in approach (Nasotracheal /orotracheal) Use of other instruments (Fibre optic, Glidescope, Video assisted, intubation through a laryngeal mask)
N4	Laryngoscopy view as defined by **Cormack and Lehane** is indicated by N4 **GRADE 1**: Full exposure of Glottis= N4 = **0** **GRADE 2**: Anterior commissure not visualized = N4 =**1 GRADE 3**: Only Epiglottis visualized = N4 =**2** **GRADE 4**: No glottis structure visualized = N4 = **3**
N5	The lifting force applied during laryngoscopy is indicated by N5 **0 = if little effort is necessary** **1 = if subjectively increased lifting force is necessary.** (This notion is based on the operator's impression that an abnormal amount of force was used compared with routine practice)
N6	Need to apply external laryngeal pressure for optimized glottis exposure is indicated by N6
N7	Position of vocal cords at intubation is indicated by N7 **0 = if abducted or not visible** **1 = if adducted (impediment to tube passage)**

RESULTS

Between December 2022 and June 2024, a total of 269 obese patients were evaluated for our study. Of these, 250 patients underwent endotracheal intubation and were subsequently recruited for the study with informed consent. Patients who underwent laryngeal mask airway surgery or who declined to participate in the study were excluded.

Two groups were created out of the 250 obese individuals who underwent tracheal intubation: the Easy intubation group (IDS < 5) and the Difficult intubation group (IDS > 5). The numbers of patients in the easy and difficult intubation categories were 46 and 204, respectively. The following are the results.

RESULTS OF DEMOGRAPHIC DATA

The baseline data comparing age, gender, weight, height, ASA status, and BMI between the easy and difficult intubation groups are presented in the table below. **The easy intubation group, defined as having an IDS score of less than 5, is referred to as group 1, while the difficult intubation group, with an IDS score of 5 or greater, is referred to as group 2.**

Table 4: Demographic data of the study population.

FACTORS	Total Obese patients n=250	Group 1 (Easy intubation) n= 204	Group 2 (Difficult intubation) n=46
Male	99 (39.6%)	80 (39.2%)	19(41.3%)
Female	151 (60.4%)	124 (60.8%)	27(58.7%)
Age (Mean ± Standard deviation)	45.93 ± (12.95)	45.37 ± (13.12)	48.41 ± (12.00
Weight (Mean ± Standard deviation) in Kg	81.39 ± (10.57)	80.66 ± (10.42)	84.63 ± (10.76)
Height (Mean ± Standard deviation) In cm	157.89 ± (9.57)	157.53 ± (9.59)	159.46 ± (9.40)
BMI (Mean ± Standard deviation) In kg/m^2	32.64 ± (3.19)	32.49 ± (3.07)	33.31 ± (3.62)
ASA 1	115(46%)	96(47.1%)	19 (41.3%)
ASA 2	135 (54%)	108(52.9%)	27 (58.7%)

Males made up 41.3% of patients in Group 2 (difficult intubation group) and 39.2% of patients in Group 1 (easy intubation group). Patients in groups 1 and 2 had mean ages of 45.37 and 48.41 years, respectively. Group 1 had a mean weight of 80.66 kg, whereas Group had a mean weight of 84.63 kg. Patients in Groups 1 and 2 had respective mean heights of 157.89 and

157.53 cm. The mean BMI for groups 1 and 2 was 32.64 kg/m2 and 32.49 kg/m2, respectively.

47.1% of patients in group 1 were classified as ASA grade 1, and the remaining patients as ASA 2. Group 2 consisted of 41.3% ASA grade 1 patients and the remaining patients belonged to ASA class 2.

RESULTS OF PRIMARY OBJECTIVE:

The primary objective was to evaluate the significance of the NC/TM distance ratio in predicting difficult intubation in individuals who are obese. For both the easy and difficult intubation groups, a binary univariate logistic regression model was used to identify the important risk factors. (This test is intended to distinguish between factors that significantly and non-significantly affect the outcome).

Age, height, weight, gender, BMI, ASA classification, Mallampati score, neck circumference, thyromental distance, and NC/TMD ratio were the variables that were compared.

The variables that were statistically significant and linked to a difficult intubation (IDS≥5) were weight, neck circumference, thyromental distance, and NC/TMD ratio, as seen in Table 3. The significance of NC/TM ratio to predict difficult intubation is highlighted in table 5 and 6 respectively.

Table 5: Univariate logistic regression analysis of variables related to difficult intubation (IDS≥5)

VARIABLES	Group 1 (Easy intubation) n= 204	Group 2 (Difficult intubation) n=46	P
Age	45.37 ± 13.12	48.41 ± 12.00	0.150
Gender (Male:Female ratio, n)	80:124	19:27	0.794
Height in cms	157.53 ± 9.59	159.46 ± 9.40	0.219
Weight in kgs	80.66 ± 10.42	84.63 ± 10.76	0.021*
Body mass index In kg/m^2	32.49 ± 3.07	33.31 ± 3.62	0.116
MP score 3 and 4	68	26	0.564
NC ≥ 41 cm in males and ≥ 35 cm in females	36.73 (3.49)	38.48 (3.10)	<0.01**
TMD ≤ 7 cm in males and ≤ 6.5 cm in females	8.68 (1.02)	7.51 (107)	<0.01**
NC/TMD ≥5	**4.27 (0.52)**	**5.19 (0.62)**	**<0.01****

Significant if p ≤0.05, **Highly significant if p ≤ 0.01

We used binary multivariate logistic regression analysis to determine the independent risk factors for intubation difficulty in each group and to obtain more precise results. This test looks for the ability of each risk factor—neck circumference, thyromental distance, and NC/TMD ratio—to independently affect the result (in this case, its difficult intubation), as indicated by the table below.

Table 6 : Multivariate logistic regression analysis to determine the independent predictors of difficult intubation (forward-Wald analysis)

Variable	beta	SE	Z	Odds ratio	95% CI		p
					Lower	Upper	
NC ≥ 41 cm in males and ≥ 35 cm in females	0.863	0.426	2.027	2.36	1.029	5.455	0.043*
TMD ≤ 7 cm in males and ≤ 6.5 cm in females	1.222	1.074	1.138	3.39	0.413	27.867	0.255
NC/TMD ≥5	**2.877**	**0.435**	**6.618**	**17.75**	**7.573**	**41.617**	**<0.001****
Constant	-3.232	0.406	7.957	0.039	0.0178	0.0875	<0.001

**** Significant if P value ≤ 0.05. ** Highly significant if P value ≤ 0.01.***

RESULTS OF SECONDARY OBJECTIVES:

Comparing the NC/TMD ratio with other preoperative predictors of DI was the first secondary objective. The sensitivity, specificity, NPV, PPV, and ROC curve analysis of predictors of DI are displayed in the following table.

Table 7 : Comparison of the predictors of DI (in percentage)

Test	Sensitivity	Specificity	PPV	NPV	Area under curve of ROC
NC ≥ 41 cm in males and ≥ 35 cm in females	67.4 %	64.2 %	29.8 %	89.7 %	0.649
TMD ≤ 7 cm in males and ≤ 6.5 cm in females	32.6 %	93.6 %	53.6 %	86.0 %	0.790
NC/TMD ≥5	**76.1 %**	**88.2 %**	**59.3 %**	**94.2 %**	**0.860**
MP score 3 and 4	56.5 %	66.7 %	27.7 %	87.2 %	0.633

DISCUSSION

This study was conducted on obese patients in order to determine the importance of the NC/TMD ratio as a predictor of difficult intubation, compare it with other established predictors, and determine the incidence of difficult intubation in this population. The analysis and discussion of the data are shown here.

DEMOGRAPHIC DATA:

A review of the demographic data showed that women (59.5%) were more likely than men to experience problematic intubation. Compared to patients with lower body weight, those with higher weights had a statistically significant ($p < 0.021$) higher incidence of difficult intubation. A research by **Yadav et al.,**[49] also showed that patients' higher body weight and BMI were linked to intubation difficulty. However, in our research, we discovered that BMI did not significantly predict the likelihood of difficult intubations.

According to the literature review, five studies—**Pradeep et al**[46]., **Qureshi et al** [45]., **Liaskou C et al.,**[32] **Ankalwar et al.,**[50] and **Abdel et al**.,[36]—were conducted to determine the significance of the NC/TMD ratio.The statistical significance of the NC/TMD ratio is shown in the accompanying table, which compares the author's current work with the previously stated studies.

Table 8 : Comparison of present study and other studies with reference to NC/TMD ratio

	Current Study	Pradeep et al 46	Qureshi et al 45	Liaskou C et al[32]	Ankalwar et al [50]	Abdel et al 36
Year	**2024**	2023	2022	2021	2019	2014
Sample size	**250**	100	130	1134	60	50
Study population	**Obese patients**	Obese (O) and Non-	Obese patients	Non obese patients	Obese patients	Obese with OSA
Sensitivity (%)	**76.1**	100(O) 94.74(N)	83.87	52.9	92.31	100
Specificity (%)	**88.2**	87.27(O) 73.33(N)	91.92	78.7	31.91	82
PPV (%)	**59.3**	61.11(O) 81.82(N)	76.47	22.6	27.27	
NPV (%)	**94.2**	100(O) 91.67(N)	94.79	93.4	93.75	
Area under ROC curve	**0.860**	0.979(O) 0.912(N)		0.69	0.73	0.95
P value	**<0.001**	<0.001		0.01	<0.001	0.004
Odds ratio	**17.75**			2	1.34	26.73

The NC/TMD ratio was shown to be statistically significant ($p < 0.05$) in all studies. Additionally, we discovered that the NC/TMD ratio [p value <0.001, odds ratio 17.75 (7.57-41.61)] was an independent risk factor for DI that correlated with findings from other research.

However, compared to **Qureshi et al.,**[46] **Pradeep et al.,**[47] **Ankalwar et al.,**[51] **and Abdel et al.**[36]**,** our study found a lower value of sensitivity and a greater value compared to **Liaskou et al.,**[32] (study not done on obese patients).Our study's specificity was on par with studies conducted by **Pradeep et al.,** [47] **Qureshi et al.,**[46] **Liaskou et al.,**[32] **and**

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Abdel et al [36].In addition, the positive predictive value was similar to the study done by Pradeep et al. NPV, AUC, and odds ratio all compared favourably to prior studies.

In our pre anaesthesia clinic, the modified Mallampati test, thyromental distance, and neck circumference are the most often and regularly used preoperative difficult intubation predictors. But according to the previously mentioned literature study, none of the aforementioned metrics guaranteed the high sensitivity, specificity, and PPV that are essential components of a screening test. Only the neck circumference (p=0.043) and the NC/TMD ratio (p= <0.001) were found to be independent risk factors for difficult intubation as shown in the Table 6 analysis. When compared to neck circumference alone, the NC/TMD ratio demonstrated superior specificity (88.2 vs 64.2), PPV (59.3 vs. 29.8), and AUC (0.860 vs. 0.649). Thyromental distance was not a stand-alone risk factor for DI, however it was linked to difficult intubation. NPV of Mallampati score was comparable to NPV of other predictors of DI but showed no statistical significance in predicting DI in obese patients.

Therefore, as measurements of neck circumference and NC/TMD ratio can independently predict difficult intubation among obese patients, our study strongly suggests using these characteristics as a predictor of difficult airway.

Our study correlated with the findings of **Gonzalez et al.,**[25] and **Brodsky et al.,**[42] who concluded that increased neck circumference is a good sensitive indicator of DI with good NPV but poor specificity.

The rate of difficult intubation ranged from 11% to 22%, according to the literature review. There aren't many published Indian or Asian studies on this topic. Every intubation performed during our study was carried out by an anaesthesiologist with at least three years of clinical experience. According to our research, 18.4 % of obese people had DI. The comparison of previous research with the current study about the incidence of DI in obese patients is displayed in the following table.

Table 9: Incidence of difficult intubation among obese patients.

Study done among obese patients	Incidence of difficult intubation among obese patients (Expressed as percentage)
Current study	18.4
Kim et al	13.8
Juvin et al	15.5
Shiga et al	15.8
Shailaja et al.,	20.0
Castro et al	20.75
Basil et al	20.8

CONCLUSION

The results of a binary univariate logistic regression analysis were used to identify the factors that were linked with difficult intubation in obese individuals. These factors included increased weight, increased neck circumference, decreased thyromental distance, and NC/TMD ratio. ($p < 0.05$). The results of binary multivariate logistic regression analysis indicated that the only independent risk factors for difficult intubation were larger neck circumference (p=0.043) and NC/TMD ratio (p <0.001).

When compared to neck circumference alone, the NC/TMD ratio demonstrated superior specificity (88.2 vs 64.2), PPV (59.3 vs. 29.8), and AUC (0.860 vs. 0.649). The NC/TMD ratio may be a more accurate preoperative predictor of difficult intubation in obese patients. The incidence of intubation difficulty among obese patients was as high as 18.4%.

The study came to the following conclusions, given the following factors, the NC/TMD ratio may be a more effective bedside screening tool for identifying difficult airways in obese individuals. (1) The NC/TMD ratio was found to be an independent risk factor for difficult intubation in the obese Indian population in the current study, which is consistent with research on the western and Indian population. (2) In comparison to other predictors, it offered superior sensitivity, specificity, PPV. (3) Tool for bedside screening. (4) Inexpensive, painless, and time efficient. The study also suggests that the modified Mallampati test and decreased thyromental distance be avoided as stand-alone indicators of intubation difficulty in obese patients, and that increased neck circumference be used as a guide to detect difficult intubations.

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