

Neck circumference to thyromental distance ratio: Is a reliable predictor of difficult intubation in obese patients?

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Abstract

Introduction: The present study was carried out to evaluate the efficacy of neck circumference to thyromental distance (NC/TM) ratio to predict difficult intubation in obese patients on background of routinely practiced Modified Mallampati Classification (MMC).

Materials and Methods: Total 60 obese patients (BMI \geq 30 kg/m²) of either sex were studied in the present study. Difficult intubation was predicted by using both NC/TM ratio and modified Mallampati score. Intubation difficulties were noted using Intubation Difficulty Scale (IDS) while performing laryngoscopy and intubation.

Results: NC/TM ratio showed higher sensitivity (92.31%), higher negative predictive value (93.75%) and higher area under curve (AUC=0.73) on the ROC curve than MMC score and also found that NC/TM ratio was statistically significant independent risk factor of difficult intubation (p value <0.029, odds ratio 4.52).

Conclusion: NC/TM ratio can be considered as reliable and better bedside screening test for predicting intubation difficulties in obese patients.

Keywords: Neck circumference, Thyromental distance, Modified Mallampati classification, Obese, Intubation.

Introduction

The World Health Organization (WHO) states that a person who has a body mass index (BMI) greater than or equal to 30kg per square meter of body surface (BMI \geq 30kg.m⁻²) is an obese person.¹ The incidence of obesity has increased considerably almost worldwide and these obese patients are at a greater risk of airway-related adverse events compared with the general population. Difficult visualization of larynx in obese patients which might lead to difficult intubation is a major concern for anesthesiologists and it accounts to 17% of airway injuries and leads to significant perioperative morbidity and mortality.² 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.^{3,4}

Various anatomical measurements, tests, parameters and radiological imaging have been proposed and studied as predictors of difficult intubation. Over the years, it has become quite clear that the reliability of a single screening test to predict a difficult airway is limited.⁵ Since increased neck circumference (NC) and reduced thyromental distance (TM) both are characteristic of obese patients, combinations of these two most valuable risk factors may increase reliability and diagnostic value of a test i.e. neck circumference to thyromental distance ratio (NC/TM ratio) to predict of a difficult intubation.

Hence, the author carried out this cross-sectional observational single group study to evaluate NC/TM ratio as a predictor of difficult intubation in obese patients as

compared to Modified Mallampati Classification (MMC) which is a routinely used standard method for airway assessment with the help of specificity, sensitivity, positive and negative predictive value of each test.

Materials and Methods

Approval from Institutional Ethics Committee was taken and written informed consent was obtained from all study patients. Study was carried out on sixty obese patients with BMI \geq 30 kg/m². ASA grade I/II patients of either sex aged between 18 - 60 years, who were undergoing surgery under general anaesthesia with endotracheal intubation were included in the present study. Patients having mouth opening > 2 fingers or any airway pathology or restricted neck mobility or jaw movement were excluded from the study.

During routine preanaesthetic check-up, MMC score was noted for all the patients. Similarly, to calculate NC/TM ratio, neck circumference (NC) and thyromental distance (TM) were recorded in centimeter. MMC \geq 3 (III or IV) and for NC/TM \geq 5 were defined as difficult intubation and taken as cut off value to study outcome measures.

In the operating theater, multipara monitor was attached to patients and baseline blood pressure (Systolic BP, Diastolic BP), heart rate (HR), peripheral capillary oxygen saturation (SpO₂) and rhythm of electrocardiography (ECG) was noted for each patient. All patients were placed in the ramped position on OT table for intubation. IV access secured to start Ringer Lactate (RL). All patients were premedicated with intravenous (IV) injection of Glycopyrrolate (0.004 mg/kg), Midazolam (0.03 mg/kg) and Fentanyl (1.5mcg/kg). After preoxygenation with 100%

oxygen by face mask for 3-5 minutes, induction of anesthesia was done using injection propofol (2 mg/kg) IV. After confirming mask ventilation, injection suxamethonium (1.5 mg/kg) was given IV to achieve neuromuscular blockade. Laryngoscopy was performed with No. 3 or No. 4 Macintosh blade by an anesthesiologist, who had completed at least 2 years of postgraduate training in anaesthesia. Difficulty of intubation was graded with the help of the Intubation Difficulty Scale (IDS)⁶ while performing laryngoscopy and intubation. There are 3 groups with IDS. However, the present study has envisaged observing the relevance of preoperative airway assessment score, patients with IDS score ≥ 5 were considered belong to the difficult intubation group and patients with IDS score < 5 were put into the easy intubation group.

Outcome Measures

Predicted easy intubation: a) NC/TM ratio < 5 , b) MMC: - I, II class

Predicted difficult intubation: a) NC/TM ratio ≥ 5 , b) MMC: - class III and IV

Actual easy intubation: IDS Score < 5

Actual difficult intubation: IDS Score ≥ 5

Statistical Analysis

Qualitative data was represented in form of frequency (No. of patients) and percentage when appropriate. Quantitative data was represented in mean \pm SD. Diagnostic accuracy was calculated by using Positive Predictive Value and Negative Predictive Value, Sensitivity, Specificity. Pearson chi-square test and McNemar’s chisquare tests are used as tests of association. A probability value (p value) < 0.05 was considered statistically significant and < 0.001 was considered highly significant. All statistical calculations were done using computer programs Microsoft Excel 2010 (Microsoft Corporation, NY, and USA) and SPSS (Statistical Package for the Social Science; SPSS Inc., Chicago, IL, USA) version 21.

Statistical Terms:⁷

False Positive (FP) = An easy intubation that had been predicted to be difficult.

True Positive (TP) = A difficult intubation that had been predicted to be difficult.

False Negative (FN) = A difficult intubation that had been predicted to be easy.

True Negative (TN) = An easy intubation that had been predicted to be easy

Specificity = The percentage of correctly predicted easy intubations as a proportion of all intubations that were truly easy, i.e. $[TN / (TN + FP)]$

Sensitivity = The percentage of correctly predicted difficult intubations as a proportion of all intubations that were truly difficult, i.e. $[TP / (TP + FN)]$

Negative predictive value (NPV) = The percentage of correctly predicted easy intubations as a proportion of all predicted easy intubations, i.e. $[TN / (TN + FN)]$

Positive predictive value (PPV) = The percentage of correctly predicted difficult intubations as a proportion of all predicted difficult intubations i.e. $[TP / (TP + FP)]$

Observations and Results

Out of 60 obese study patients, 23 (38.33%) were males and 37 (61.67%) were females (Table 1). Table 2 shows distribution of study population according to Modified Mallampatti Classification and according to NC/TM ratio. Table 3 demonstrates the distribution of study population according to IDS Score which also shows that the incidence of difficult intubation in present study is 21.66% without any failure of intubation.

(Table 4) Out of 13 patients of difficult intubation, NC/ TM ratio predicted almost all patients of difficult intubation except one but MMC missed 6 cases of difficult intubation. MMC was found to be more accurate while predicting easy intubation as out of 47 patients of easy intubations, MMC predicted 31 patients as easy intubation correctly (True Negative). On the contrary, 32 patients who were predicted as difficult intubation by NC/ TM turned out to be easy (False positive value) which may be due to ramped position was given to all patients in present.

While comparing diagnostic accuracy of MMC and NC/TM ratio, NC/TM ratio had higher sensitivity (92.31%) and higher NPV (93.75%), (Table 5). On the receiver – operating characteristics (ROC) curve, NC/TM ratio has higher area under curve (AUC = 0.73) than MMC score (AUC = 0.66) as shown in Fig. 1 and 2.

The binary multivariate logistic regression (forward-Wald) analysis was carried out in each study group to determine the independent risk factors for difficult intubation and also to calculate of the power of risk factors (NC/TM ratio & MMC score) to independently influence outcome measure i.e. intubation difficulty. (Table 6) NC/ TM ratio showed higher value of odds ratio (odds ratio 4.52, P value 0.029) and statistically stronger correlation with difficult intubation than MMC (odds ratio 1.34, P value = 0.045). Hence, in present study, NC/TM ratio is of more statistical significance as independent risk factor for difficult intubation than MMC score.

Table 1: Demographic analysis of patients

Parameters	Range	Majority		Mean \pm SD
		Group	No. of Patients	
Age (Years)	20-58		19 (31.67%)	40.75 \pm 10.62
Weight (Kg)	70-170	40-49	22 (36.67%)	97.97 \pm 23.50
Height (Meter)	1.40-1.85	1.60-1.69	23 (38.33%)	1.58 \pm 0.09
BMI (kg/m ²)	30.12 – 68.10	30.00 - 34.99	23 (38.33%)	39.05 \pm 7.87

Table 2: Distribution of patients according to Modified Mallampatti Classification (MMC) and NC/TM ratio

MMC score	No. of patients	Percentage (%)
I	7	11.67%
II	31	51.66%
III	22	36.67
IV	0	0%
NC/TM ratio	No. of patients	Percentage (%)
< 5.00	16	26.67%
5.00 – 6.00	15	25.00%
6.00 – 7.00	20	33.33%
> 7	9	15.00%

Table 3: Distribution of patients in group according to IDS Score

Group	IDS score	No. of patients (%)
EI Group	<5	47 (78.34%)
DI Group	≥5	13 (21.66%)
Total	-	60 (100%)

Note = EI- Easy Intubation, DI- Difficult Intubation, IDS- Intubation Difficulty Scale score

Table 4: Distribution of patients by predicted intubation difficulty according MMC and NC/TM ratio Vs. Intubation Difficulty Scale

Predicted intubation difficulty by MMC	Total No. of patients	IDS	
		Difficult(IDS ≥ 5)	Easy(IDS < 5)
Difficult (MMC III & IV)	22 (36.67%)	6(TP)	16(FP)
Easy (MMC I & II)	38 (63.33%)	7(FN)	31(TN)
Total	60	13	47
Predicted intubation difficulty by NC/TM ratio	Total No. of patients	IDS	
		Difficult(IDS ≥ 5)	Easy(IDS < 5)
Difficult (NC/TM ≥ 5)	44 (73.33%)	12(TP)	32(FP)
Easy (NC/TM < 5)	16 (26.67%)	1(FN)	15(TN)
Total	60	13	47

Table 5: Comparison of diagnostic accuracy of MMC and NC/TM as predictors of difficult intubation

Diagnostic accuracy Against IDS	Sensitivity	Specificity	PPV	NPV	Mc Nemar’s chi-square test (p-value)	Area under ROC curve
MMC	46.15%	65.96	27.27	81.58	0.0606	0.66
NC/TM ratio	92.31	31.91	27.27	93.75	0.0001	0.73

PPV – positive predictive value, NPV – negative predictive value

Table 6: Binary multivariate logistic regression analysis

Variables	Odds ratio	P value
MMC	4.52	0.029
NC/TM ratio	1.34	0.045

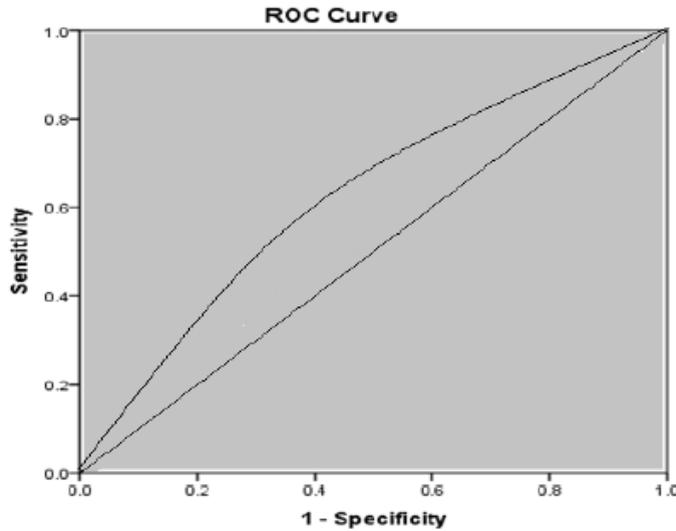


Fig. 1: Showing area under curve (AUC) on Receiver- operating characteristic (ROC) curve while comparing predicting power of MMC score to IDS score

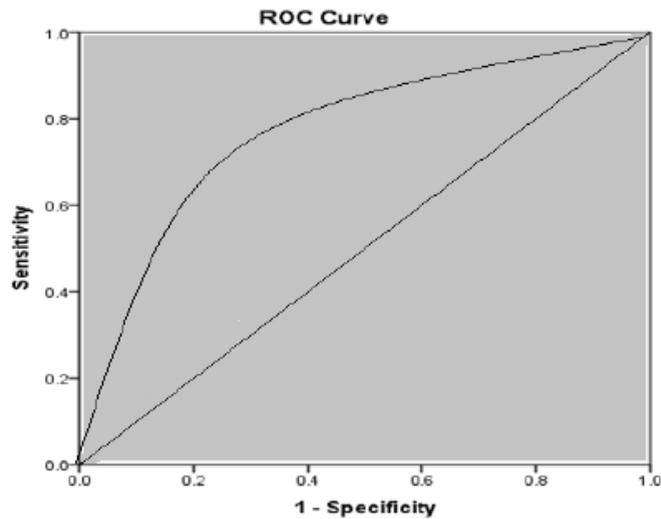


Fig. 2: Showing area under curve (AUC) on Receiver- operating characteristic (ROC) curve while comparing predicting power of NC/TM ratio to IDS scores

Discussion

Securing airway access is more difficult in obese than in non-obese due to anatomical changes resulting from excess weight. In literature, incidence of difficult intubation in obese population is found to vary from 11% to 22%.^{3,8} In present study, incidence of difficult intubation observed is 21.66% as assessed by IDS scale (higher in females than in males [$p < 0.05$]) and this was comparable with previous studies^{3,8} but studies which used lower BMI to define obesity observed lower incidence of intubation.⁸

Numerous predictors for difficult intubation like history of obstructive sleep apnoea (OSA) syndrome, high Mallampati score, male sex, increased age, short neck, large neck circumference, decreased thyromental distance and abnormal upper teeth are proposed by various authors.^{4,9,11} Juvin et al¹⁰ did not find any of these classical factors suitable for prediction of difficult intubation in obese

patients. Radiological imaging e.g. MRI, USG, CT of neck are useful for quantification soft tissue in various regions or areas of neck esp pretracheal region, at the vocal cords or at suprasternal notch and hence, can predict difficult intubation more accurately but availability, cost and time required for these investigation limit their role in day to day practice.^{3,4}

The Mallampati classification has been used for a long time for predicting difficult endotracheal intubation. The MMC, though in use for many years has limitations like higher inter-observer variability and patient’s compliance in positioning and phonation, as well as the evaluator’s assessment of the oral structure produce different results and further it cannot evaluate neck mobility in obese patients.

A meta-analysis carried out in 2017 reported that MMC had a poor diagnostic value to predict difficult intubation in obese patients.¹² Nadia et al¹³ and Kim et al¹⁴ also concluded that the modified Mallampati is not enough as a standalone or single test of a difficult laryngoscopy or

intubation in obese population. Similarly, Shailaja et al⁸ observed that MMC over predicts difficult intubation (more no. of false positive cases).

Obese patients have a large amount of neck soft tissue that can be better represented by the NC/TM ratio.¹⁴ In present study, optimal cut offs used for NC/TM ratio was ratio ≥ 5 similar to Nadia et al¹³ and Kim et al¹⁴ who used 4.99 and 5 respectively as cut off value for NC / TM ratio to predict difficult intubation in obese patients.

When comparing diagnostic accuracy of MMC and NC/TM ratio, NC/TM ratio had higher sensitivity and higher NPV than MMC which was similar to previous studies.^{5,13,14} In the present study PPV for both NC/TM ratio and MMC was same i.e. 27. 27%. PPV of our study was lower as compared to Basil et al³ and Kim et al¹⁴ studies. This can be attributed to the higher number of false positive cases as ramped position was given to all patients in our study to alien the external auditory meatus with the sternal notch. This might have eased the intubations of obese patients otherwise which would have been proved to be difficult intubation without ramped position.

In present study, specificity of NC/TM ratio and MMC were 31.91% and 65.96% respectively. Basil et al³ and Abdel et al⁵ also observed similar specificity of MMC but specificity observed for NC/TM ratio in both studies were 89.4 and 82 respectively. Also, Kim et al¹⁴ and Castro et al¹⁵ observed higher value of specificity for NC /TM ratio compared to our study which may be due to different study designs in previous studies. Moreover, specificity is of little value in our study as it predicts easy intubation. On the contrary, present study is dealing with prediction of difficult intubation.

NC /TM ratio when evaluated against MMC, neck circumference and BMI while studying patients with OSA, it became evident that NC /TM ratio had strong correlation with difficult intubation and MMC has a weaker correlation.⁵ Also, many studies observed that NC/TM ratio is a better predictor for difficult intubation as compared to other single test for obese patients.^{3,5,14,15}

There are some limitations of the study which includes- 1) Individual variations in recording Mallampati score, and while measuring neck circumference and thyromental distance, 2) All patients were not intubated with same anesthesiologist, 3) IDS score may vary with experience of anesthesiologist 4) The present study could not be blind study.

Conclusion

NC/TM ratio can be considered as reliable and better bedside screening test for predicting difficult intubation among Indian obese patients in view of various reasons such as i) NC/TM ratio provided a very high sensitivity ii) NC/TM ratio justified to be an independent risk factor of difficult intubation in obese patients, iii) Cheap, noninvasive, less time consuming, anesthetist and patient friendly. Hence, should be included in airway assessment column of Pre-anaesthetic check-up (PAC) proforma especially for obese patients.

Conflict of Interest: None.

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