Original Article

Evaluation of neck-circumference- thyromental-distance ratio as a predictor of difficult intubation: A prospective, observational study

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ABSTRACT

Background and Aims: Preoperative identification of difficult airway and subsequent planning is of utmost importance for a patient's safety. Previous studies have identified the ratio of the neck circumference (NC) to the thyromental distance (TMD); NC/TMD as a reliable predictor of difficult intubation in obese patients. But there is a lack of studies evaluating the NC/TMD in non-obese patients. Therefore, the aim of this study was to compare the NC/TMD as a predictor of difficult intubation in both obese and non-obese patients. **Methods:** A prospective, observational study was conducted after obtaining institutional ethics committee clearance and written and informed consent from each patient. One hundred adult patients undergoing elective surgeries under general anaesthesia with orotracheal intubation were included in this study. Difficulty in intubation was assessed using the Intubation Difficulty Scale. The NC/TMD was calculated and the predictive accuracy of NC/TMD and other established parameters in obese and non-obese patients were compared. **Results:** Univariate logistic regression analysis showed that gender, weight, body mass index, inter-incisor gap, Mallampati classification, NC, TMD, sternomental distance, and NC/TMD had a significant association with difficult intubation. NC/TMD has a higher sensitivity, specificity, and positive and negative predictive value with better predictability in comparison to other parameters. **Conclusion:** The NC/TMD is a reliable and better predictor of difficult intubation in both obese and non-obese patients in comparison to NC, TMD, and sternomental distance alone.

Key words: General anaesthesia, intubation, obese, airway, neck circumference, thyromental distance, Neck-circumference-to-thyromental-distance ratio

INTRODUCTION

Airway-related problem is one of the major contributors to anaesthesia-related mortality and morbidity.[1,2] Therefore, preoperative airway assessment is of utmost importance to ensure adequate patient safety. There are several predictors of difficult airway, such as neck circumference (NC), thyromental distance (TMD), sternomental distance (SMD), modified Mallampati classification, and inter-incisor gap. But a previous study found that a single parameter may not predict difficult airway accurately.[3] On the other hand, a combination of parameters like the Wilson score can improve diagnostic accuracy, but it is time-consuming and cumbersome.[4]

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.[5] Thus, a combination of these two parameters can be helpful in predicting a difficult airway. A few studies concluded that NC-TMD ratio (NC/TMD) is a reliable predictor of difficult intubation in obese patients.[5,6] But there is a lack of literature evaluating the NC/TMD in a non-obese population. Therefore, the aim of this study was to evaluate the NC/TMD as a predictor

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of difficult intubation in both obese and non-obese patients.

METHODS

This prospective, observational study was conducted at the Calcutta National Medical College and Hospital from March 2020 to August 2021 after obtaining approval from the institutional ethics committee and a written informed consent was obtained from all the patients after explaining the study protocol, for participation in the study and use of the patient data for research and educational purposes, in accordance with the Declaration of Helsinki. One hundred patients aged 18–45 years, of either gender, with American Society of Anesthesiologists (ASA) physical status I and II, and undergoing elective surgeries under general anaesthesia with orotracheal intubation were included in this study. Based on the World Health Organisation (WHO)'s *The Asia-Pacific perspective: redefining obesity and its treatment* (2000),[7] patients with a body mass index (BMI) ≥25.0 kg/m^2 were defined as obese. Patients with airway pathology, craniofacial abnormality, restricted neck or temporomandibular joint movement, morbid obesity (BMI >40 kg/m^2), edentulous patients, pregnant patients, and those requiring rapid sequence intubation were excluded from the study.

During the pre-anaesthetic check-up, body weight, NC, TMD, SMD, inter-incisor gap, modified Mallampati classification, and presence or absence of protruded upper incisor was recorded. Neck circumference was recorded at the level of cricoid cartilage in the sitting posture while keeping the head in the neutral position. The TMD was measured from the lower border of the thyroid notch to the mentum, with the head extended and the mouth closed. The NC/TMD was calculated.

In the operating room, baseline heart rate, non-invasive blood pressure, oxygen saturation, and electrocardiograph were recorded. Patients were given intravenous (IV) glycopyrrolate 0.2 mg, midazolam 0.02 mg/kg, and fentanyl 2 μg/kg. A difficult intubation cart was kept ready and the ASA difficult airway algorithm was followed.

After pre-oxygenation with 100% oxygen for three minutes, general anaesthesia was induced with propofol in titrated doses till the loss of verbal response. Neuromuscular blockade was achieved with IV vecuronium bromide 0.1 mg/kg. Mask ventilation was continued using an appropriately sized facemask.

After four minutes, laryngoscopy was performed in the sniffing position in non-obese patients and in ramped position in obese patients by a skilled anaesthesiologist who had at least five years of experience. They were not involved in preoperative airway assessment. A Macintosh laryngoscope blade of size 3 was used on female patients and another of size 4 was used on male patients.

Intubation difficulty was assessed using the Intubation Difficulty Scale (IDS). The IDS was graded as follows: N1 = number of additional intubation attempts; N2 = number of additional operators; N3 = number of alternative intubation techniques used; N4 = laryngoscopic view as defined by Cormack and Lehane[8] (grade 1: the vocal cords are completely visible; grade 2: only the arytenoids are visible; grade 3: only the epiglottis is visible; and grade 4: the epiglottis is not visible);N5 = lifting force applied during laryngoscopy (0, if inconsiderable; 1, if considerable);N6 = needed to apply external laryngeal pressure to optimise glottic exposure (0 = no external laryngeal pressure needed; 1 = external laryngeal pressure needed);N7 = position of the vocal cords at intubation (0 = abducted or not visible; 1 = adducted). The IDS score is the sum of N1 to N7. A score of 0 indicates intubation under ideal conditions. An IDS score ≥5 indicates difficult intubation.[8,9]

Patients were divided into two groups, that is, Group D and Group E, based on the IDS. Patients with IDS score ≥5 were assigned to Group D (difficult intubation) and those with IDS score <5 were assigned to Group E (easy intubation) for statistical analyses. If oxygen saturation (SpO_2) fell below 90% during the intubation, it was considered as hypoxia. The number of hypoxic events during intubation was also noted.

The primary outcome was to compare NC/TMD as a predictor of difficult intubation in obese and non-obese patients. The secondary outcome was to compare the NC/TMD with other established predictors like BMI, NC, TMD, and SMD as a predictor of difficult intubation in obese and non-obese patients.

Sample size calculation was done on the basis of previous studies that reported a 2.6% and 20.2% incidence of difficult intubation in lean and obese patients, respectively; the required sample size

was 100 to demonstrate the difference with 80% power (α=0.05 and β=0.2).[10,11]

The IBM SPSS Statistics software version 22.0 (IBM Corp., Armonk, NY, USA) was used for statistical analysis. Categorical variables were analysed using the χ^2 test or Fisher's exact test, as appropriate. Binary multivariate logistic regression analysis was performed to identify multivariate predictors for difficult airways. A receiver operating characteristic (ROC) curve was used to describe the discrimination abilities of the predictive indicators. The area under the curve (AUC) was used as the quantitative index to describe the ROC curve. The predictive values of the NC/TMD for difficult intubation was assessed and compared with other predictors.

Table 1: Binary univariate logistic regression analyses of the factors related to difficult intubation

	Group E (*n*=70)	Group D (*n*=30)	*P*
Age (years)	34.24 (7.25)	34.97 (6.69)	0.637
Gender (male-to-female ratio, *n*)	36: 34	7:23	0.012
Weight (kg)	61.66 (4.61)	67.07 (9.85)	0.004
Body mass index (kg/m^2)	23.31 (1.43)	26.75 (3.45)	<0.001
Inter-incisor gap (cm)	5.91 (0.28)	5.73 (0.39)	0.014
Protruded upper incisors (present-to- absent ratio, *n*)	4:66	1:29	0.621
Modified Mallampati classification (1:2:3, *n*)	44:26:0	8:21:1	0.001
Neck circumference (cm)	34.99 (2.17)	37.50 (1.83)	<0.001
Thyromental distance (cm)	7.55 (0.44)	6.90 (0.38)	<0.001
Sternomental distance (cm)	14.94 (0.80)	14.57 (0.86)	0.040
Neck-circumference-thyromental - distance ratio	4.63 (0.31)	5.39 (0.30)	0.001

Data represented as Mean (Standard Deviation) or number (*n*)

RESULTS

In this study, 100 patients were included [Figure 1]. Seventy patients had IDS scores <5 and thirty patients had IDS score ≥5. Binary univariate logistic regression analyses showed that gender, weight, BMI, inter-incisor gap, modified Mallampati classification, NC, TMD, SMD, and the NC/TMD had a significant association with difficult intubation in terms of IDS [Table 1].

Based on the BMI, we further divided the study population into non-obese (BMI <25 kg/m^2) and obese (BMI ≥25kg/m^2).[7] Nineteen patients in the obese group (n = 34) had difficult intubation, whereas 11 patients in the non-obese group (n = 66) had difficult intubation (P < 0.001). The ROC curve was performed for the NC/TMD, BMI, NC, TMD, and SMD. The cut-off values were determined. With this cut-off, the sensitivity, specificity, positive predictive value

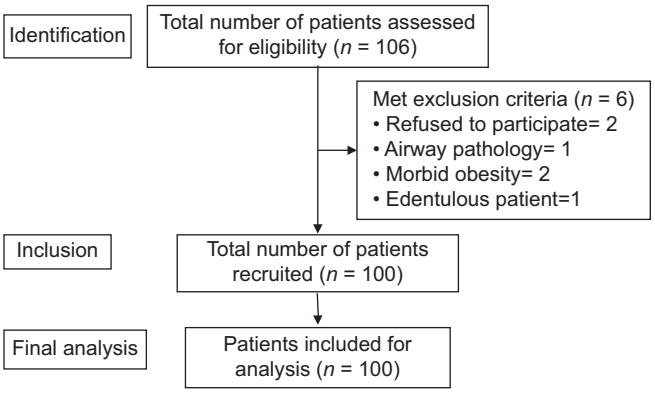

Figure 1: STROBE chart showing patient recruitment process

Table 2: Comparison of predictors of difficult intubation

Predictor	Group	Sensitivity	Specificity	PPV	NPV	AUC	*P*
NC/TMD	Non-obese patients(>4.95)	100.00	87.27	61.11	100.00	0.979	<0.001
	Obese patients (>5.05)	94.74	73.33	81.82	91.67	0.912	<0.001
BMI	Total	83.33	72.86	56.82	91.07	0.870	<0.001
Neck circumference	Non-obese patients (>35.50 cm)	90.91	61.82	32.26	97.14	0.829	0.001
	Obese patients (>35.50 cm)	84.21	60.00	72.73	75.00	0.758	0.011
Thyromental distance	Non-obese patients (<7.25 cm)	100.00	69.09	39.29	100.00	0.902	<0.001
	Obese patients (<7.25cm)	89.47	73.33	80.95	84.62	0.828	0.001
Sternomental distance	Non-obese patients (< 14.50 cm)	81.82	80.00	45.00	95.65	0.783	0.003
	Obese patients (<15.50cm)	78.95	26.67	57.69	50.00	0.516	0.876

(PPV=Positive predictive value; NPV=Negative predictive value; AUC=Area under the curve; NC/TMD=Neck-circumference-to-thyromental-distance ratio; BMI=Body mass index)

(PPV), and negative predictive value (NPV) of different predictors of difficult intubation were calculated [Table 2].

The NC/TMD showed the highest sensitivity, PPV, and NPV as a predictor of difficult intubation in obese patients in comparison to BMI, NC, TMD, and SMD. In non-obese patients, both the NC/TMD and TMD showed 100% sensitivity and NPV. But, the NC/TMD showed highest specificity and PPV as a predictor of difficult intubation in non-obese patients compared to other predictors like BMI, NC, TMD, and SMD. The cut-off values for NC/TMD were determined as 4.950 and 5.050 for non-obese and obese patients, respectively. The AUC in ROC curves of the NC/TMD was found to be maximum compared to BMI, NC, TMD, and SMD for both the obese and non-obese population (0.912 and 0.979, respectively) [Figures 2 and 3].

DISCUSSION

In this study, gender, body weight, BMI, inter-incisor gap, modified Mallampati classification, NC, TMD, SMD, and the NC/TMD were significantly associated with difficult intubation. The incidence of difficult intubation was significantly higher in female patients compared to male patients.

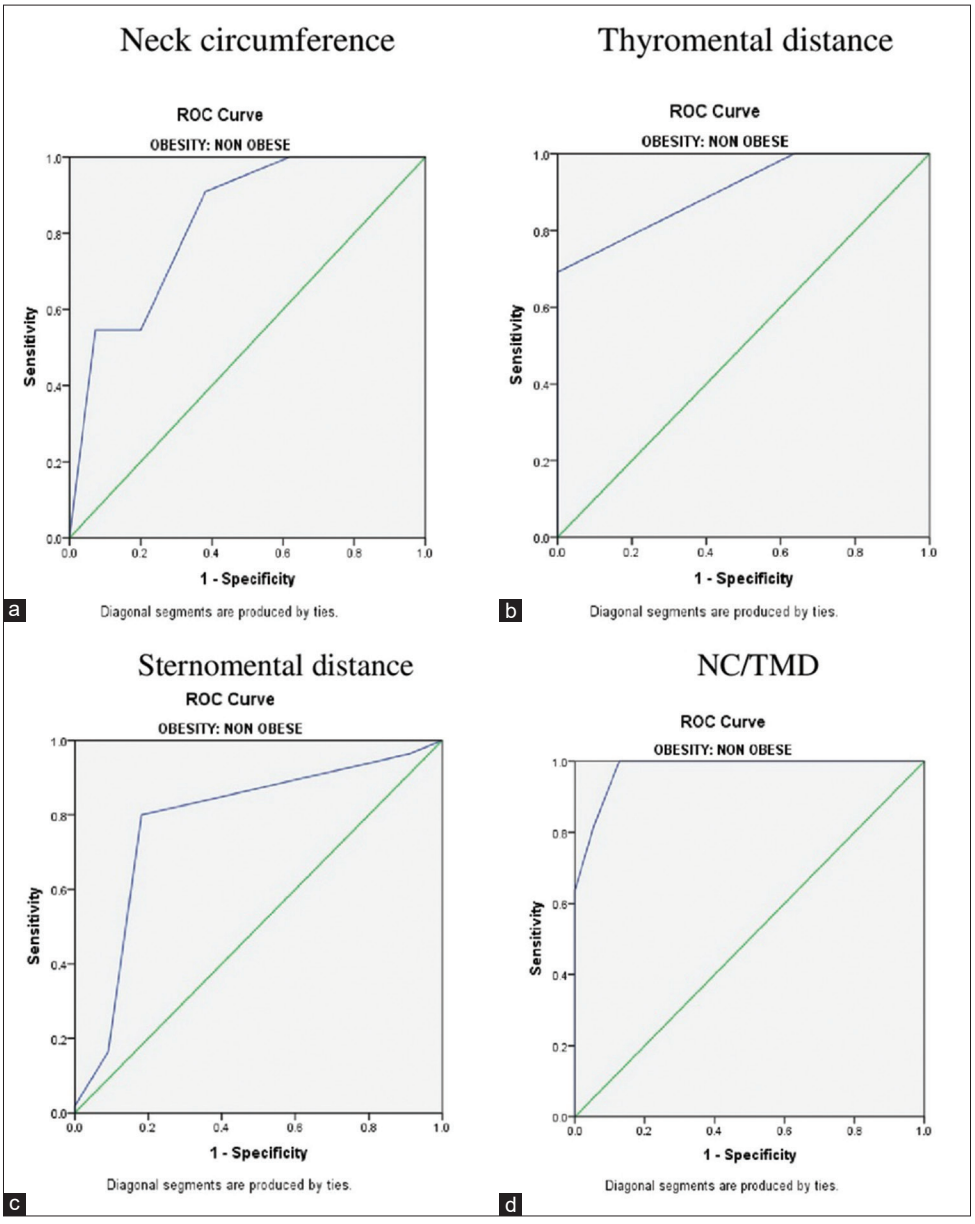

Figure 2: The receiver operating characteristic curves for neck circumference (a); thyromental distance (b); sternomental distance (c); and neck-circumference-to-thyromental-distance ratio (d) for difficult intubation in the non-obese population

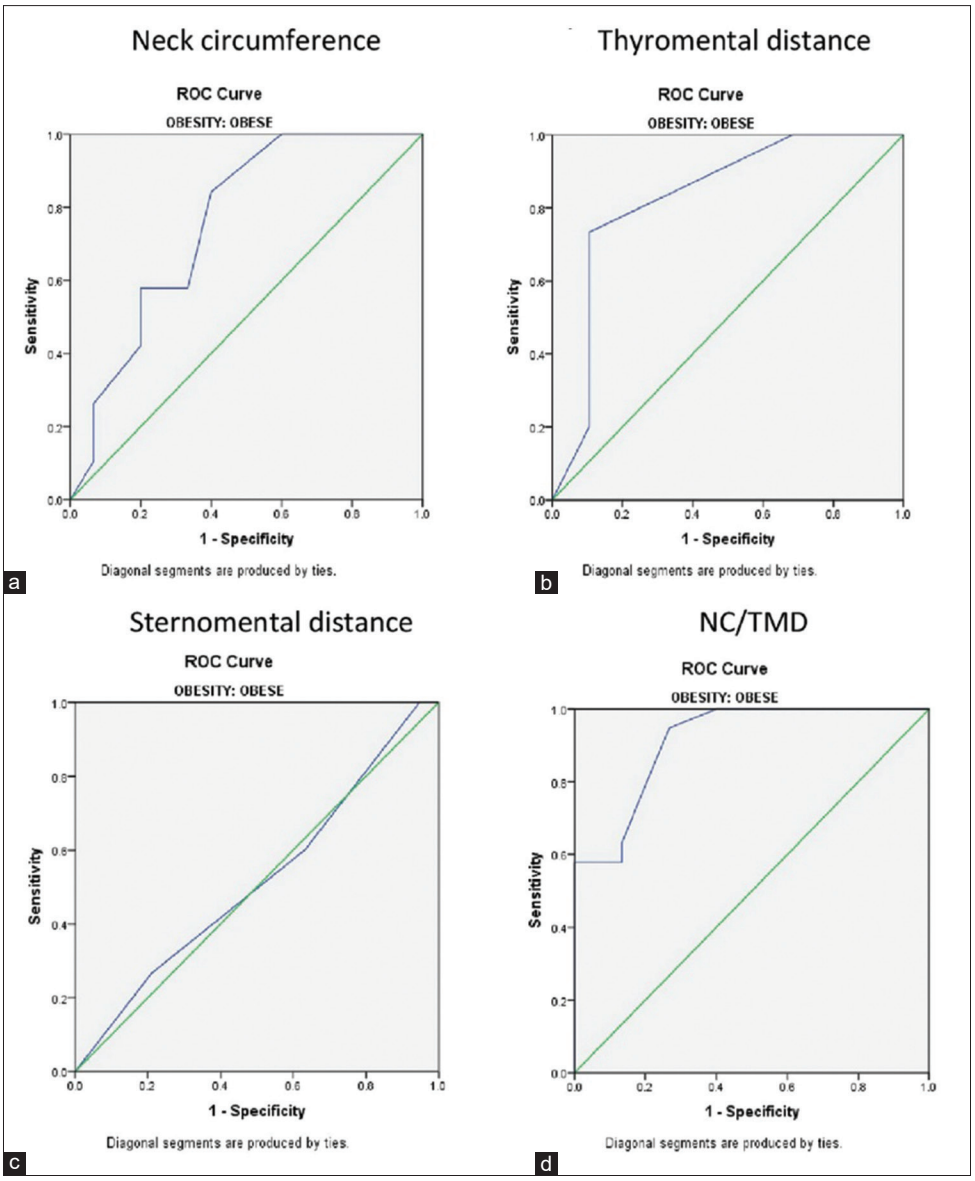

Figure 3: The receiver operating characteristic curves for neck circumference (a); thyromental distance (b); sternomental distance (c); and neck-circumference-to-thyromental-distance ratio (d) for difficult intubation in the obese population. NC/TMD: Neck-circumference-to-thyromental-distance ratio

Patients with higher weight and BMI showed a higher incidence of difficult intubation in comparison to those with lower body weight and BMI. A study conducted by Yadav *et al*.[12] also demonstrated that difficulty of intubation was associated with increased body weight and BMI of the patients. But many other studies concluded that BMI alone does not have any predictive value for difficult laryngoscopy and intubation.[13]

In our study, inter-incisor gap was reduced in the difficult intubation group in comparison to the easy intubation group ($P = 0.014$). A similar result was also found in a previous study.[12]

We have found that the incidence of difficult intubation was less in patients having lower Mallampati grade in comparison to those having a higher grade. Modified Mallampati classification has certain disadvantages like interobserver variability and dependence on the patient's compliance. A study conducted by Lee[3] found that the classification had poor prognostic value to predict difficult intubation. Various studies also reported that it cannot be used as a standalone test for predicting difficult intubation or laryngoscopy[6,14,15] and should be used in combination with other predictors to increase diagnostic accuracy.[15] There is also risk of overprediction of difficult intubation using this parameter.[16] In obese patients, limited

jaw movement due to the mass effect may reduce the predictive value of the Mallampati score in them.[6]

The measurement of NC/TMD is easy, simple, and less time-consuming. In obese patients, the NC/TMD showed the highest sensitivity (94.74%), specificity (73.33%), PPV (81.82%), NPV (91.67%), and AUC (0.912) in comparison to other predictors of difficult intubation like BMI, NC, TMD, and SMD. A previous study on obese patients observed similar sensitivity and NPV.[17] Kim *et al*.[6] also observed high sensitivity and NPV similar to our study in obese patients, but they found a higher specificity. In obese patients, the presence of excess soft tissue in the neck can be indicated by high NC/TMD. It is also representative of a short neck.

In non-obese patients, NC/TMD had the highest sensitivity (100%), specificity (87.27%), NPV (100%), and AUC (0.979). Previous studies on non-obese patients found similar specificity and NPV but low sensitivity.[15] A previous study observed that the amount of pre-tracheal soft tissue is an important predictor of difficult intubation.[18] A larger amount of pre-tracheal soft tissue may be present in a relatively non-obese patient, which may be reflected by higher NC/TMD in such a patient.

Patients in the difficult intubation group had a significantly higher NC compared to those belonging to the easy intubation group. NC was found to have a high sensitivity and NPV and low specificity and PPV in both obese and non-obese patients. Previous studies conducted by Gonzalez *et al*.[19] and Manayaliul *et al*.[5] observed similar sensitivity and NPV of neck circumference, as in our study, but reported a higher specificity. NC alone may not clearly reflect the amount of soft tissue present in different areas of the neck.[20] Conversely, the distribution of fat in various regions of the neck can be reflected better by the NC/TMD than NC alone.[6,21]

Reduced TMD indicates shortness of the neck.[6] As a predictor of difficult intubation, TMD showed 100% sensitivity and NPV in non-obese patients in this study. But its specificity (69.09%) and PPV (39.29%) were found to be low in non-obese patients. Moreover, it showed lower sensitivity (89.47%) and NPV (84.62%) in obese patients compared to non-obese patients. Rose *et al*.[15] observed sensitivity and NPV similar to our study. The disadvantage of TMD is that it may be influenced by the patient's size and racial difference.[15,22]

In obese patients, SMD cannot be considered as a good predictor of difficult intubation. It had a low specificity (26.67%), PPV (57.69%), NPV (50%) and a low AUC (0.516). In non-obese patients, it showed a high sensitivity (81.82%), specificity (80%), NPV (95.65%) and a low PPV (45%). A previous study found a similar specificity and NPV, but sensitivity was lower in the non-obese population.[6]

There were certain limitations in this study like subjective variability in the determination of the IDS score and relatively small sample size in the difficult intubation group. Further studies may be conducted to evaluate the NC/TMD in morbidly obese patients and in obstetric patients as a predictor of the difficult airway.

CONCLUSION

The NC/TMD is a reliable and better predictor of difficult intubation with high sensitivity, specificity, and positive and negative predictive values in obese and non-obese patients in comparison to NC, TMD, and SMD alone.

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Conflicts of interest
There are no conflicts of interest.

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