Original Research Article

PREDICTIVE VALUE OF NECK CIRCUMFERENCE TO THYROMENTAL DISTANCE RATIO IN PREDICTING DIFFICULT INTUBATION IN OBESE AND NON-OBESE PATIENTS

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Abstract

Background: Anaesthesiologists manage the airway during surgical procedures, including endotracheal intubation. However, patients with airway abnormalities may also experience difficulties. Visualisation of the glottis is essential for successful intubation, and predictors such as Mallampatti's classification and group indices improve predictive accuracy. This study aimed to test the predictive value of the neck circumference-to-thyromental distance ratio in predicting difficult intubation in obese and non-obese patients. **Material & Methods:** This prospective, observational study was conducted on 200 patients aged 18–60 at Rajiv Gandhi Government General Hospital after obtaining approval from the Institutional Ethics Committee, Chennai. This study analysed the neck circumference-to-thyromental distance ratio in patients undergoing tracheal intubation, assessed airway management, loose teeth, and dentures, and compared obese and non-obese groups before induction. **Results:** The study included patients aged 18-60, mostly those aged < 40 years. Obese patients had a higher incidence of an NC/TMD ratio ≥5 than non-obese patients. Poor laryngoscopic views and difficult intubation were not significantly different between the two groups. An NC/TMD ratio of ≥5 had the highest sensitivity (76.9%) for detecting poor laryngoscopic views in obese patients, with a sensitivity of 61.5%. Non-obese patients had a sensitivity of 52.2% and a positive predictive value of 24.5%. It also had the highest sensitivity (100%) for identifying difficult intubation in obese patients, with a positive predictive value of 11.6%. **Conclusion:** The neck circumference-to-thyromental distance ratio is a reliable predictor of difficult intubation in obese and non-obese patients, with low false negatives.

INTRODUCTION

Anaesthesiologists are skilled in airway management, ensuring airway patency during surgical procedures for adequate oxygenation and maintaining normocarbia. Endotracheal intubation is a technique that ensures airway patency and reduces the risk of aspiration. This technique is performed for various reasons, including urgent (shock, pulmonary oedema), emergent (head injury, chest trauma, airway obstruction), and elective (Endo Tracheal General Anaesthesia for various surgeries).[1] Endotracheal intubation with direct laryngoscopy is typically easy for most patients, but it may be challenging for those with airway abnormalities. Preoperatively, these patients can be predicted, and appropriate airway management strategies can be developed. However, patients with seemingly normal airways who pose difficulties during laryngoscopy and intubation can experience irreversible damage to the nerve tissue and myocardium. Therefore, making preoperative plans for managing difficult airways is crucial, which can lead to improved patient outcomes.[2-4]

Visualisation of the glottis is crucial for a successful endotracheal intubation. Direct laryngoscopy can be performed by placing the patient in the sniffing position. An optimal view is achieved when tongue size is proportional to the size of the oropharynx. Adequate mouth opening and mandibular space facilitated easy insertion of the laryngoscope blade. Inadequate requirements can make intubation difficult, leading to the development of predictors.[5-7] Mallampatti's classification suggests that a tongue larger than the oropharyngeal space makes visualisation of the glottis and intubation more difficult. Other predictors include interincisor distance, thyromental distance, sternal distance, and neck circumference. However, these tests are unreliable when used alone. Group indices, such as Wilson's score, Arne's simplified score, and Benumof's 11-parameter analysis, were developed to improve predictive accuracy. A simple bedside test with good predictive value for identifying difficult intubation is needed for widespread use.[8-10]

Aim

This study aimed to test the predictive value of the neck circumference-to-thyromental distance ratio in predicting difficult intubation in obese and non-obese patients.

MATERIALS AND METHODS

This prospective, observational study was conducted on 200 patients aged 18 to 60 at Rajiv Gandhi Government General Hospital after obtaining approval from the Institutional Ethics Committee, Chennai.

Inclusion Criteria

The study included patients aged 18–60 with American Society of Anesthesiologists (ASA) classifications I, II, and III, encompassing elective and emergency surgical patients and patients with valid informed consent.

Exclusion Criteria

Patients who underwent general anaesthesia without endotracheal intubation, those with upper airway pathology or faciomaxillary trauma, those with cervical spine fractures, and patients younger than 18 years of age were excluded.

The incidence of difficult endotracheal intubation in 50 obese (BMI ≥ 27.5Kg/m2, according to the Asian obesity criteria by WHO expert consultation) and 150 non-obese patients was compared. Difficult intubation was determined using the Intubation Difficulty Scale (IDS score ≥5). The neck circumference-to-thyromental distance ratio was calculated for each case, and its ability to predict difficult tracheal intubation was analysed.

Patients who satisfied the inclusion criteria and provided consent were selected, and a preoperative airway assessment was performed using commonly used airway indices such as the modified Mallam Patti score, interincisor distance, thyromental distance, somatomental distance, neck circumference, and upper lip bite test. The neck circumference-to-thyromental distance ratio was calculated. Patients were also assessed for loose teeth, buck teeth, and dentures, which may pose difficulties in airway management. The neck circumference-to-thyromental distance ratio was calculated for all patients. Before induction, monitors (ECG, Pulse oximetry, non-invasive blood pressure, and heart rate) were connected, and baseline vital parameters were recorded. Patients in both the obese and non-obese groups underwent intravenous induction, and muscle relaxation was achieved.

After confirming the ability to mask and ventilate succinylcholine 2 mg/kg, anaesthesiologists intubated patients with at least two years of experience in anaesthesiology. For males, a McIntosh blade size of four was used. For females, a size 3 McIntosh blade was used. None of the patients in either group were desaturated during induction. All the patients in both groups were intubated without requiring alternative techniques or an emergency surgical airway. During intubation, the Cormack Lehane grading assessed the glottic view, and the intubation difficulty scale was used to grade the intubation difficulty.

RESULTS

A total of 200 patients (50 obese and 150 non-obese) were included in this study.

Patients aged 18–60 were included, and patients aged < 40 comprised most of the study population. There was no statistically significant difference in the distribution of the different age groups between the obese and non-obese groups (p =0.690). Males comprised 46.5%, and females comprised 53.5% of the study population. Obese patients had a higher incidence of NC/TMD ratio ≥5 than non-obese patients (p<0.001). [Table 1]

There was no statistically significant difference in the incidence of poor laryngoscopic views when the NC/TMD ratio was ≥5 (p=0.780). In the non-obese group, patients with NC/TMD ≥5 had a higher incidence of poor laryngoscopic view (p=0.030). There was no statistically significant difference in the incidence of difficult intubation when the NC/TMD ratio was ≥5 (p =0.122). In the non-obese group, patients with an NC/TMD ratio ≥5 had a higher incidence of difficult intubation (p=0.012). When both groups were combined, difficult intubation was more common in patients with NC/TMD ≥5 (p<0.001). [Table 2]

There was no significant difference in the incidence of a poor laryngoscopic view (CL grades III and IV) between the obese and non-obese groups (p=0.089). The incidence of difficult intubation was higher in the obese group than in the non-obese group (p=0.003). [Table 3]

In obese patients, an NC/TMD ratio of ≥5 had the highest sensitivity (76.9%) for detecting poor laryngoscopic views. The sensitivity was greater when compared to MMS III and IV, with a sensitivity of 61.5% (CL grade III and IV). The positive predictive value of NC/TMD ≥5 in detecting a poor laryngoscopic view was less (27%) than that of ULBT class III (57.1%), which had the highest positive predictive value compared to all other single indices.

In non-obese patients, the sensitivity and positive predictive value of NC/TMD ≥5 (52.2% and 24.5%, respectively) were comparable to those of MMS class III/IV in identifying poor laryngoscopic view (CL grades III and IV). These two indices have the highest sensitivity for identifying poor laryngoscopic views compared with other single indices.

The overall sensitivity (when both groups were combined) in identifying poor laryngoscopic view was highest for NC/TMD ratio ≥5 (61.1%), which was slightly higher than that of MMS class III/IV (55.5%). The overall positive and negative predictive values were comparable for the NC/TMD ratio, and MMS and ULBT class III were higher (36.6%) than those for NC/TMD ≥5 (25.5%) or MMS class III/IV (25.3%). [Table 4]

In obese patients, NC/TMD ≥5 had the highest sensitivity (100%) for identifying difficult intubation (IDS≥5). Among the single indices, the positive predictive value of NC/TMD ratio ≥5 was very poor (16.2%) when compared to the Cormack Lehane grade III/IV (38.4%), which had the highest positive predictive value (among the single indices) in predicting difficult intubation.

Among the single indices in non-obese patients, NC/TMD ≥5 and CL grades III/IV had the highest sensitivity (100%) and negative predictive value (100%) for identifying difficult intubation (IDS ≥5). The positive predictive value for identifying difficult intubation in non-obese patients was very low (6.1%) for NC/TMD ≥5 when compared to CL grades III/IV (13.4%), which had the highest PPV among the single indices. Overall (when both groups were combined), NC/TMD ≥5 had the highest sensitivity (100%) for identifying difficult intubation, even greater than the sensitivity of CL grades III/IV (88.9%). However, CL grades III/IV had the highest positive predictive value (22.2%) among the single indices. NC/TMD ≥5 had a poor positive predictive value (10.5%) for difficult intubation. [Table 5]

Table 1: Demographic data of the study population

		Obese	Non- obese
Age(years)	<30	16	48
	31-40	13	48
	41-50	13	28
	51-60	8	26
Sex	Male	11	82
	Female	39	68
NC/TMD ratio	<5	13	101
	≥5	37	49

Table 2: Comparison of easy, poor laryngoscopic view, easy and difficult intubation between groups with NC/TMD ratio

	Obese		Non-obese		P value
	NC/TMD<5	NC/TMD≥5	NC/TMD<5	NC/TMD≥5	
Easy laryngoscopic view (CL-I, II)	10	27	90	37	0.78
Poor laryngoscopic view (CL- III, IV)	3	10	11	12	0.03
Easy intubation	13	31	101	46	0.122
Difficult intubation	0	6	0	3	0.012

Table 3: The incidences of easy and poor laryngoscopic views in obese and non-obese groups

	Obese	Non-obese	P value
Easy laryngoscopic view (CL-I, II)	37	127	0.089
Poor laryngoscopic view (CL- III, IV)	13	23	
Easy intubation	44	6	0.003
Difficult intubation	147	3	

Table 4: The sensitivity, specificity, and positive and negative predictive values of various indices in detecting poor laryngoscopic view in obese, non-obese, and both groups were combined

	Sensitivity (%)	Specificity (%)	Positive predictive value (%)	Negative predictive value (%)
Obese				
MMS (III & IV)	61.5	59.4	34.8	81.5
IID≤3 cm	7.7	94.6	33.3	74.5
TMD≤6.5 cm	46.2	54.1	26.1	74.1
SMD≤12.5cm	7.7	67.6	7.7	67.6
NC>43 cm	0	97.3	0	73.5
ULBT class III	30.8	91.9	57.1	79
NC/TMD≥5	76.9	27	27	76.9
Non-Obese				
MMS (III & IV)	52.2	65.35	21.4	88.3
IID≤3 cm	13	94.5	30	85.7
TMD≤6.5 cm	26.1	70.1	13.6	84
SMD≤12.5cm	8.7	86.6	10.5	84
ULBT class III	30.4	87.4	30.4	87.4
NC/TMD≥5	52.2	70.9	24.5	89.1
Both groups are combined.				

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MMS (III & IV)	55.5	64	25.3	86.7
IID≤3 cm	11.1	94.5	30.7	82.8
TMD≤6.5 cm	33.3	66.4	17.9	81.9
SMD≤12.5cm	8.3	82.3	9.3	80.35
NC>43 cm	0	99.4	0	81.9
ULBT class III	30.5	88.4	36.6	85.3
NC/TMD≥5	61.1	60.9	25.5	87.7

Table 5: Sensitivity, specificity, positive predictive value, and negative predictive value of various indices in detecting difficult intubation view in obese, non-obese, and both groups combined

	Sensitivity (%)	Specificity (%)	Positive predictive value (%)	Negative predictive value (%)
Obese				
MMS (III & IV)	50	47.7	13	88.9
IID≤3 cm	16.7	95.5	33.3	89.4
TMD≤6.5 cm	83.3	59.1	21.7	96.3
SMD≤12.5cm	16.7	72.7	7.7	86.5
NC>43 cm	0	97.7	0	87.8
ULBT class III	33.3	88.6	28.5	90.7
NC/TMD≥5	100	29.5	16.2	100
CL grade III/IV	83.3	81.8	38.4	97.2
Non-Obese				
MMS (III & IV)	66.6	63.26	3.5	98.9
IID≤3 cm	33.3	93.9	10	98.6
TMD≤6.5 cm	33.3	70.7	2.3	98.1
SMD≤12.5cm	0	87.1	0	97.7
ULBT class III	33.3	85	4.3	98.4
NC/TMD≥5	100	68.7	6.1	100
CL grade III/IV	100	86.39	13.4	100
Both groups are combined.				
MMS (III & IV)	55.5	61.2	6.3	96.6
IID≤3 cm	22.2	94.2	15.4	96.3
TMD≤6.5 cm	66.7	68.1	9	97.7
SMD≤12.5cm	11.1	83.8	3.1	95.2
ULBT class III	33.3	85.8	10	96.4
NC>43 cm	0	99.5	0	95.5
NC/TMD≥5	100	59.7	10.5	100
CL grade III/IV	88.9	85.3	22.2	99.4

DISCUSSION

Anaesthesiologists aim to predict difficult laryngoscopy/intubation during pre-anaesthetic assessment, but no simple bedside tests accurately predict difficult intubation. Multivariate indices improve predictive value but are cumbersome and time-consuming. However, the predictive values of these multivariate indices remain inadequate. This problem is mainly due to the very low incidence of difficult intubation (1-18% in various studies). Although difficult intubation has a very low incidence, it is the major cause of anaesthesia-related morbidity and mortality.[11] When a difficult airway makes both intubation and ventilation impossible, either brain injury or death occurs due to hypoxia. Airway pathologies, such as mass lesions, retrognathia, and micrognathia, can be detected preoperatively and managed during pre-anaesthetic evaluations. However, managing patients with unanticipated difficult airways is challenging, as they often appear normal but may have difficulty during direct laryngoscopy. Despite the development of preoperative bedside tests, none accurately predicts difficult intubation.

According to the 2005 WHO expert consultation criteria, a BMI≥27.5 kg/m2 can be considered obese in the Asian population.[12] Public health action should be initiated targeting those people with BMI≥27.5 kg/m2, as people with BMI greater than this value are more susceptible to cardiovascular morbidity and mortality compared to Europeans who suffer cardiovascular morbidity and mortality only with BMI ≥30 kg/m2. Hence, we included patients with a BMI ≥27.5 kg/m2 in the obese group and those with BMI ≥27.5 kg/m2 in the obese group and those with BMI < 27.5 kg/m2 in the non-obese group.

Our study showed no statistically significant difference in poor laryngoscopy (CL grades III/IV) incidence between the obese and non-obese patients ($p=0.089$). However, difficult intubation (defined as intubation difficulty score ≥5) was comparatively higher in obese patients than in non-obese patients ($p=0.003$), proving that factors other than poor laryngoscopic view influence the incidence of difficult intubation. Hence, we used IDS to define difficult intubation (IDS score ≥5). The overall incidence of difficult intubation in our study was 4.5%, which is comparable to the incidences in many other studies.[10,13]

In our study, the incidence rates of difficult intubation in obese and non-obese patients were 12% and 2%, respectively. The incidence of a poor laryngoscopic view (CL grades III/IV) in obese and non-obese patients was 26% and 15.3%, respectively. It had been shown in some studies that obese patients were more difficult to intubate than

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lean patients.[10,13] The reasons may be due to excess fat deposition in areas surrounding the airway so that pharyngeal structures cannot be moved anteriorly during laryngoscopy, resulting in an impediment of glottic view.[14]

Our study revealed that intubation was more challenging in obese patients than in non-obese patients. However, there was no significant difference in the incidence of difficult intubation between obese and non-obese patients with Mallampati class I/II or III/IV. Of those with difficult intubation, 44% had a preoperative Mallampati class of either I or II, indicating a high false-negative prediction. Our results comply with the results of a Meta-Analysis conducted by Lee et al. on various studies on Mallampatti tests (original and modified), which concluded that Mallampatti tests had poor accuracy in predicting difficult intubation.[15]

Our study results show no statistically significant difference in the incidence of poor laryngoscopic view in obese and non-obese patients (p values respectively were 0.08 & 0.534) when Stern omental distance is ≤12.5 cm or >12.5 cm. Also, there is no statistically significant difference in the incidence of difficult intubation in both obese and non-obese (p values respectively are 0.578 & 0.505) when stern omental distance is ≤12.5 cm or >12.5 cm. Stern omental distance has poor sensitivity for identifying difficult laryngoscopy/intubation in both obese and non-obese patients. There are only a few studies on stern omental distance, and hence, its accuracy as a predictor is inconclusive.[13]

Our study results showed no statistically significant difference in the incidence of poor laryngoscopic view between obese and non-obese patients (p=0.990 and 0.710, respectively) when the thyromental distance was ≤6.5 cm or >6.5 cm. Also, there is no statistically significant difference between the incidence of difficult intubation in non-obese patients with TMD ≤6.5 cm or >6.5 cm (p=0.878). However, in the obese group, difficult intubation was more common in patients with a TMD ≤ 6.5 cm compared to those with a TMD >6.5 cm. TMD has good sensitivity in identifying difficult intubation only in the obese group and not in the non-obese group. It has poor sensitivity for identifying poor laryngoscopic views in both obese and non-obese patients.

Gonzalez et al. suggested neck circumference measured at the level of thyroid cartilage as a useful predictor of difficult intubation.[16] In our study, Neck Circumference (NC) has poor sensitivity in identifying difficult laryngoscopy and intubation in obese and non-obese groups. Kim et al. showed that the neck circumference-to-thyromental distance ratio better predicts difficult intubation than neck circumference alone.[10] Both neck circumference and NC/TMD ratio were shown to predict difficulty in obese individuals. The NC/TMD ratio reflects fat distribution in the neck better than neck circumference alone, particularly in obese patients.[11] Moreover, the distribution of fat in various topographic regions of the neck is not indicated accurately by neck circumference.[14,16] Hence, we tested the predictive value of the NC/TMD ratio in obese and non-obese patients.

In our study, 74% of obese individuals had an NC/TMD ratio of ≥5, which was 100% sensitive in identifying difficult intubation in both obese and non-obese patients. Non-obese patients had a higher incidence of difficult intubation and poor laryngoscopic view. However, there was no significant difference in the incidence of difficult intubation or laryngoscopy, indicating poor positive predictive value. A test with high false positivity results in unnecessary, costly, and time-consuming preparations for intubation and unnecessary traumatic awake intubation attempts in patients with an easy airway. False negative predictions result in inadequate preparation and failure to secure the airway and may result in hypoxic brain injury or even death. Our ratio has almost zero false-negative predictions and 100% sensitivity in identifying difficult intubations. Hence, an NC/TMD ratio of ≥5 can be considered a useful screening test in the preoperative period for identifying difficult intubation in both obese and non-obese patients. Combining this ratio with other simple bedside tests may improve the prediction accuracy of difficult intubations.

CONCLUSION

We conclude that the ratio of neck circumference to thyromental distance is a useful predictor of difficult intubation in both Obese and Non-obese patients, as this ratio has a very low false negative prediction and is highly sensitive in identifying difficult intubation in both groups.

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