The Importance of Evaluation of Neck Circumference to Thyromental Distance Ratio as a Predictor of Difficult Intubation

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ABSTRACT

Background: Pre-operative airway assessment for predicting difficult intubation is of utmost importance for anaesthesiologists to ensure adequate oxygenation and ventilation which is a priority.

Aims & Objectives: To evaluate the effectiveness of neck circumference (NC) to thyromental distance (TMD) ratio (NC/TMD) as a predictor of difficult intubation and its correlation with established predictors namely Mallampatti grading (MPC grading), Modified Cormack Lehane's Score (MCLS grading).

Methods: 140 patients of age between 18 to 60 years with ASA I, II were selected. Pre-operative, MPC grading and NC to TMD ratio was measured. Intra-operatively, MCLS grading, time taken for intubation, number of attempts taken for intubation, any additional use of equipment required and grading ease of intubation were noted. Correlation was done between them.

Results: Out of 140 patients, NC/TMD ratio of >5 was found in 20 patients in which 19 patients required an adjuvant during intubation. NC/TMD ratio had significantly higher sensitivity (75.20) and specificity (99.02) as compared to sensitivity (56.31) and specificity (92.38) of MPC grading. ROC curve for NC/TMD ratio had higher area under curve (AUC = 0.74) than Mallampatti grading (AUC = 0.66).

Conclusion: As compared to MPC grading, NC/TMD has emerged out as a better predictor of difficult intubation.

Introduction

Airway management in patients planned for general anaesthesia is of utmost importance for an anaesthesiologist since ages. An anaesthesiologist needs to be well-versed, quick and expert enough to secure the airway and ensure the adequacy of oxygenation and ventilation to avoid disastrous complications including hypoxia, cardiopulmonary arrest, brain injury, and even death.

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.

As per the ASA guidelines [1], difficult endotracheal intubation is defined as "more than three attempts or more than ten minutes proper for insertion of a tracheal tube with conventional laryngoscopy".

However, in 2000, Benumof et al. [2], reported that one-third of deaths were attributable solely to anaesthesia related to maintaining a patent airway, and feel that this definition is not sufficient enough because an optimal/best attempt at laryngoscopy may be achieved on the first attempt, within 30 seconds, and reveal a grade IV view.

In recent years, a lot of studies have been done taking into account patients' external factors for predicting

difficult intubation like mouth opening, neck motion, thyromental distance, overbite, mobility of submandibular soft tissue structures, prognathic ability and obesity prior to surgery.

In the present scenario, Mallampati grading is the most common airway parameter we use for the assessment of the airway.

NC/TMD ratio has been recommended as a new parameter to assess and predict difficult intubation. Kim et al. [3] in their study mentioned that NC/TMD ratio of more than 5 reliably predicts difficult intubation.

Therefore, we in the present study, have evaluated whether neck circumference to thyromental distance ratio can be a reliable predictor of difficult intubation in patients under general anaesthesia.

Methods

A prospective observational study was conducted over a period of October 2020 and September 2022 in a tertiary care hospital. After approval from the institutional ethical committee BVDUMC/IEC/68 and registration with clinical trial registry (CTRI/2022/06/043318), patients aged between 18 and 60 years, belonging to ASA I and II requiring general anaesthesia were included in the study. Patients were explained about the study and written informed consent was obtained. Patient refusal to participate in the study, plan of general anaesthesia without tracheal intubation, having multiple facial trauma, oral or nasal cavity masses, midline neck swellings. joint pathology like ankylosing spondylitis, rheumatoid arthritis, cervical fusion, were excluded from the study.

The sample size was calculated based on the standard deviation from previous study. Considering power at 80%, and confidence interval at 95%, a sample size was calculated as 140 [3].

Pre-operatively, neck circumference (measured at the level of the cricoid cartilage), thyromental distance (measured between the thyroid notch and symphysis-menti keeping the neck in full extension) in centimeters (cm) were measured and ratio (NC/TMD) was calculated. Additionally, Mallampati grading was also recorded.

The standard protocol of General Anaesthesia was followed. Patients were intubated under the effect of muscle relaxant Inj. Atracurium with cuffed portex ETT of appropriate size by trained anaesthesiologists (after 1 year of training).

Intra-operatively, during laryngoscopy, MCLS grading, time taken for intubation (in seconds), number of attempts, additional use of adjuvants was recorded. The ease of intubation was graded as follows [4]:

a)   Grade I: no extrinsic manipulation of the larynx is required

b)   Grade II: external manipulation of the larynx is necessary to intubate

c)   Grade III: intubation possible only when aided by a stylet

d)   Grade IV: failed intubation.

The patients were divided into those having NC/TMD ratio of <5 and ≥5. Both the groups were compared with respect to difficulty in intubation as per the intubation parameters.

General anaesthesia was maintained with 50% Oxygen:50% Air, 0.2-2% Sevoflurane, and intermittent doses of Inj, Atracurium with controlled ventilation.

Statistical Analysis

Qualitative data was represented in form of frequency (No. of patients) and percentage when appropriate. Quantitative data were represented in mean ± SD. Pearson correlation test and correlation coefficient tests were used as tests of association. A probability value (P-value) < 0.05 was considered statistically significant and < 0.001 was considered highly significant. Sensitivity, Specificity, Positive Predictive Value (PPV), and Negative Predictive Value (NPV) were used to calculate diagnostic accuracy. A Receiver-operator curve was done to evaluate the performance. All statistical calculations were done using Statistical Package for Social Sciences (SPSS) software (version 25.0) used to analyze the data.

Results

After analysis, demographic characteristics (age, gender, weight, height and BMI) as shown in (Table 1). Out of 140 patients, 65 patients were male and 75 patients were female. A minimum weight was 38kg and maximum was108kgs with an average of around 65kg. Minimum height of 141cm and a maximum height of 182cm with an average of 161.3cm among the study population. A mean BMI of 25.06kg/m² with a minimum BMI of 17 kg/m² to maximum 45 kg/m². 18 patients were found to have Mallampati grading of >II (III and IV).

As per (Table 2), both NC/TMD ratio and MP grading had significant p-value when correlated with intra-operative intubating parameters i.e., MCLS grading, time taken for intubation (in seconds), number of attempts, additional use of adjuvants. However, as compared to MPC grading, NC/TMD ratio showed a higher correlation (higher value of correlation coefficient) for each of the parameters studied.

As per (Table 3), correlation of NC/TMD ratio of <5 and ≥5 was done with intubation difficulty as per the intubating parameters. The NC/TMD ratio of ≥5 correlated well with difficulty of intubation and the association was statistically significant.

While comparing diagnostic accuracy of NC/TMD ratio and Mallampati grading, NC/TM ratio had higher sensitivity (75.2%) and higher NPV (84.17%), (Table 4). On the receiver–operating characteristics (ROC) curve, NC/TMD ratio has the higher area under curve (AUC = 0.74) than Mallampati score (AUC = 0.66), suggesting better diagnostic accuracy for the prediction of difficult intubation as shown in (Figure 1 and 2).

Table 1- Demographic characteristics of the study population (general and according to Mallampati grading)

	N	Minimum	Maximum	Mean + SD
		Descriptive Statistics		
Age (in years)	140	18	60	37.84 + 10.91
Gend-er	Males = 65 Females = 75			
Weig-ht (in kg)	140	38	108	64.91 + 14.27
Height (in cm)	140	141	182	161.31 + 8.32
BMI (kg/m²)	140	17	45	25.06 + 4.76

Mallampati Grading	Patients	Percentage (%)
I	50	36
II	72	51
III	17	12
IV	1	1

Table 2- A correlation study of NC/TMD ratio and MP grading with intubating parameters

		Modified Cormack Lehane's Score (MCLS) (N = 140)	Grading Ease of Intubation (N = 140)	Time taken for Intubation (In seconds) (N = 140)	Number of Attempts taken for Intubation (N = 140)
NC/TMD ratio	Pearson Correlation	0.305	0.286	0.301	0.317
	P-value	<0.001	0.001	<0.001	<0.001
Mallampati Grading	Correlation Coefficient	0.280	0.254	0.280	0.271
	P-value	0.001	0.002	0.001	0.001

Table 3- Comparative study between NC/TM ratio of <5 and >5 with intubating parameters

NC/TMD Ratio		Modified Cormack Lehane's score	Time taken for Intubation (in seconds)	Number of attempts taken for intubation	Grading ease of Intubation
	Correlation	-0.014	-0.030	-0.166	-0.065
<5	P value	0.882	0.746	0.071	0.481
	N	120	120	120	120
	Correlation	0.401	0.458	0.524	0.522
≥5	P value	0.048	0.044	0.034	0.035
	N	20	20	20	20

Table 4- Diagnostic accuracy of the predictive factors by using Sensitivity, Specificity, Positive likelihood ratio (PLR), Negative likelihood ratio (NLR), Positive predictive value (PPV), and Negative predictive value (NPV)

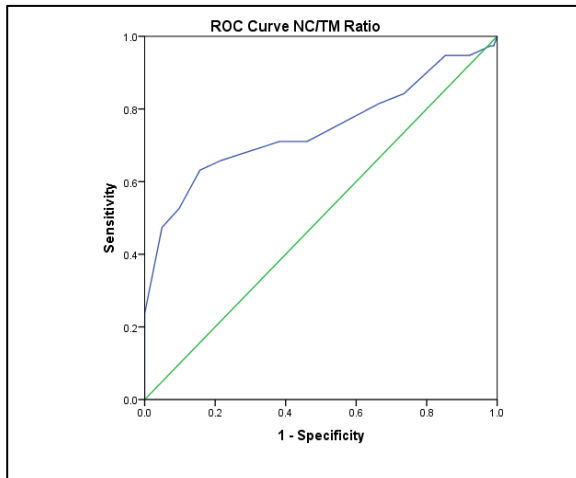|	Mallampati Grading	Modified Cormack Lehane's Score	NC/TMD Ratio
Sensitivity (%)	56.31	89.47	75.20
Specificity (%)	92.38	75.49	99.02
PLR (%)	3.45	3.65	51.00
NLR (%)	1.08	0.14	1.12
PPV (%)	75.64	57.63	95.25
NPV (%)	77.60	95.06	84.17
Accuracy	74.83	79.29	85.71

Figure 1- Area Under Curve (AUC) on Receiver-operating characteristic (ROC) curve while comparing predicting power of NC/TMD Ratio with MCLS grading
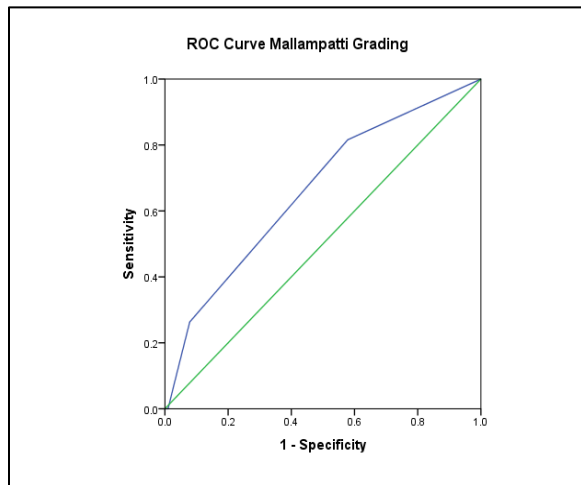

Figure 2- Area Under Curve (AUC) on Receiver-operating characteristic (ROC) curve while comparing predicting power of Mallampati grading with MCLS grading

Discussion

For an anaesthesiologist, identifying the patients in whom laryngoscopy and intubation may be difficult, is still a challenge despite the advancements in airway management. Several studies have been conducted over the years to identify predictors of difficult laryngoscopy and intubation. Even though few studies have shown promising results with various parameters, none of them is 100% reliable for the prediction of difficult intubation.

A lot of studies were done in the past taking multiple individual factors to predict difficult intubation. Mamta Harjai et al. [5] tried to establish the clinical relevance of the Mallampati Grading, as compared to new parameters

including the inter-incisor gap (IIG), the ratio of height to thyro-mental distance (RHTMD), and NC/TMD and concluded observed that the MP grading has the highest sensitivity of 86.7% to predict difficult laryngoscopy, they arrived at the conclusion that, when compared to relatively new indicators, MP grading still has a high predictive value.

However, in the meta-analysis done by Shiga et al. [6] a combination of parameters proved to have more accuracy than individual parameters alone.

In the present scenario, the Mallampati classification is the most common parameter used by anaesthesiologists for predicting difficult airway and intubation. Though it is reliable and has been in use for many years, it has it's own set of 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 producing different results.

In our study, 140 patients were selected irrespective of obesity ranging from a minimum BMI of 17 kg/m² to a maximum of 45 kg/m². Previous studies done by Kim et al. [3] and Paul et al. [7] were done on obese patients. However, studies done by Shiga et al. [6] and Juvin et al. [8] have shown that BMI alone does not offer any predictive value for difficult intubation.

It is further strengthened by studies done by Hekiert et al. [9] and Kim et al. [3] that Mallampati grading has relatively poor diagnostic value, and is not enough as a single test for the prediction of difficult laryngoscopy and intubation. Shailaja et al. [10] had also concluded that Mallampati grading over-predicts difficult intubation (a greater number of false positive cases).

In our study, the optimal cut off used for NC/TMD ratio was ≥ 5 similar to that used by Kim et al. [3] to predict difficult intubation in obese patients.

Previous studies done by Kim et al. [3] and Basil Paul et al. [7] to evaluate the efficacy of NC/TMD were compared with Intubation Difficult Score (IDS), inspired from the study conducted by Frederic Adnet et al. [11] However, in our study, the efficacy of NC/TMD was compared with MCLS grading, attempts required for intubation, time taken for intubation and grades of ease of intubation.

A correlation was done in our study between NC/TMD ratio of <5 and ≥5 with intubating parameters, where securing the airway was found to be more difficult when NC/TMD ratio was ≥5 and the correlation was statistically significant (p-value <0.05). The ratio of ≥5 can be attributed to short stature and higher BMI. Our study findings are consistent with the studies done by Kim et al. [3] and Basil Paul et al. [7]

While comparing the diagnostic accuracy of Mallampati grading and NC/TMD ratio, NC/TMD ratio had higher sensitivity and higher NPV than Mallampati grading which was similar to previous studies.   The sensitivity of NC/TMD ratio and Mallampati grading

were 75.20 and 56.31, respectively. However, the sensitivity value of NC/TMD ratio in our study has come lower when compared to the study done by Kim et al. [3] (88%)

Also in our study, the positive predictive value (PPV) of NC/TMD ratio was relatively higher (95.25%) than Mallampati grading (75.64%) which is similar to the values of a previous study done by Basil Paul et al, [7] with a specificity of NC/TMD ratio and Mallampatti grading (66%), respectively.

Diagnostic accuracy of the NC/TMD ratio and Mallampati grading was obtained by Receiver Operating (ROC) curve. NC/TMD ratio was found to have a higher area under curve (AUC = 0.73) than Mallampati Grading (AUC = 0.66). Thus, the sensitivity of NC/TMD was better than the Mallampati grading. The AUC for NC/TMD ratio and Mallampati grading in the study done by Basil Paul et al. [7] was found to be 0.85 and 0.65, respectively. Similarly, study done by Kim et al. in their study [3] observed the AUC for NC/TMD ratio and Mallampati grading as 0.86 and 0.74, respectively. Our findings are consistent with the above-mentioned studies proving better performance of NC/TMD ratio as a predictor of difficult intubation. However, both Kim et al. [3] and Basil Paul [7] et al. [6] in their studies, have compared NC/TMD ratio and Mallampati grading with Intubation Difficulty Score (IDS) while in our study, we have evaluated both the above parameters with respect to MCLS grading, time taken for intubation (in seconds), number of attempts, additional use of adjuvants. Hence, it can be considered a better indicator of difficult intubation.

Our study shows that NC/TMD ratio, with a relatively large area under the curve on ROC and higher sensitivity and specificity at cut- off ≥ 5, is a better airway assessment tool for predicting difficult intubation compared to Mallampati grading.

However, there are certain limitations in our study. In order to study the incidence of difficult intubation, a larger study population will be required to calculate the exact incidence of difficult intubation. Also, the parameters studied, namely MPC grading, measurement of neck circumference and thyromental distance are bound to have subjective variations. To overcome this same observer has taken the measurements in all the patients.

Conclusion

From our study, we conclude that NC/TMD ratio can be considered as a better predictor of difficult intubation, when compared to Mallampati grading.

From our study we recommend including NC/TMD ratio as a component of routine preoperative assessment of airway, as it does not require any special equipment, is simple and non-invasive.

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