



COMPARISON OF FIVE EXTERNAL PARAMETERS IN ASSESSING THE AIRWAY: A PROSPECTIVE COMPARATIVE STUDY

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ABSTRACT

Aim & Objective: This study aims to determine the single predictor, which is more sensitive, specific and has higher positive predictive value in predicting difficult airway.

Material and Methods: A total of 90 patients who are scheduled to undergo elective surgery under general anesthesia are selected. Pre-operative airway examination was performed using MMP, TMD, and Neck circumference, NC/TMD to predict difficult intubation. After induction of the general anesthesia laryngoscopy was performed, view on laryngoscopy was graded using the classification of Cormack and Lehane. A note was also made of whether or not intubation was difficult that is if the view at laryngoscopy was grade III or IV even in patients who were predicted to have easy intubation using multiple screening tests. If difficulty was experienced in tracheal intubation, backward, upward and rightward pressure on thyroid cartilage, BURP was applied as it improved visualization of glottis on direct laryngoscopy. Endotracheal intubation was considered truly difficult (observed difficult), if any of the following were positive. 1. Cormack and Lehane grade III and IV, 2. Three attempts at tracheal intubation or duration longer than ten minutes, 3. If special maneuvers were used to facilitate tracheal intubation which in our study fiber-optic intubation. 4. Failure to intubate. Rest of the patients were considered to have truly easy. [Observed easy] endotracheal intubation.

Results: By comparing all five parameters, TMD to NC ratio has the highest accuracy (90%) with 89.3% of sensitivity and 90.3% of specificity.

Conclusion: The study indicated that NC/TMD as simple preoperative bedside tests have a higher level of accuracy compared to TMD, NC, MMP, and BMI in predicting a difficult airway.

Keywords: Positive Predictive Value, General Anesthesia, Laryngoscopy, Thyroid Cartilage, Endotracheal Intubation, Glottis, BMI.

INTRODUCTION

Management of the airway during induction of anaesthesia is the primary and unique responsibility of the anesthesiologist. From the time of introduction of endotracheal intubation, several problems have occurred due to failed intubation. An unusual and unanticipated situation is one of "Cannot ventilate and cannot intubate".

Closed claims analysis has found that vast majority (85%) of airway related events involve brain damage and one third of mortality was attributable solely to anaesthesia. This was related to inability to maintain a patent airway in these cases¹.

Many studies have tried to develop some bedside tests that are easy to perform and don't consume the time and special equipment, but all these tests have their limitations, and no single one is complete². Therefore, comparison of these methods is inevitable to find the best one. We compared some tests that are among wellknown tests or the tests that recently have taken attentions in studies. There are hypotheses suggesting that intubation in obese patients with short and thick necks and patients with small thyromental distance (TMD) are more difficult. Neck circumference (NC), NC/TMD ratio



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have been presented with regard to this concept and have been assessed in several studies⁹⁻¹¹.

The Mallampati classification or Mallampati test (MMT) is a simple test to predict difficult tracheal intubation from anatomy of the oropharynx. All these parameters are relatively quick bedside tests, and there is no need to special equipment and skills. It is not clear, which method is better than others for prediction of difficult laryngoscopy. Therefore, we conducted this study to compare the predictive value of NC, NC/TMD, TMD, BMI and MMT for difficult laryngoscopy assessed by CL grading. The objective of this study is to determine the single predictor, which is more sensitive, specific and has higher positive predictive value.

MATERIALS AND METHODS

The study was conducted after obtaining clearance from Institutional Ethics committee of Saveetha medical college & hospital, Chennai. Data was collected from January 2019 to June 2019 among the patients admitted to various surgical specialties of Saveetha medical college Hospital.

Study Design: A prospective comparative study

Sample Size: 90 patients

Sample size was calculated using the following formula. $TP+FN = z^2 \times \frac{SN(1-SN)}{W^2} \times N$ (sN) = TP+FN/P (TP=true positive, FN=false negative, SN-sensitivity, Z-confidence interval normal distribution value i.e for 95%, z= 1.96, P-prevalence of disease in the test population, W-accuracy-0.005, N-sample size) Substituting the values we arrived at the sample size of 90.

Sampling Technique: Convenience sampling

Patient Selection Inclusion Criteria: Patients who are scheduled to undergo surgery under general anesthesia. Patients posted for elective surgical procedures in different surgical specialties. Age group of 18-65 years inclusive of both sexes.

Exclusion Criteria: Facial fractures, restricted mouth opening, Neck swellings, and cervical spine injuries.

In all the patients selected for the study a detailed history and general examination was performed. Preoperative airway examination was performed using multiple screening tests to predict difficult airway. The following screening tests were used in present study.

- Recording of patient's - Height in cm, Weight in kilogram and BMI
- Modified Mallampatti Test [MMT] similar to that used by Samssoon and Young which is performed in a seated patient who opens his mouth as wide as he can and protrudes the tongue as far as possible, while the observer looks from the patient eye level and inspects the pharyngeal structures with a pen torch. It is important when performing this test that the patient does not phonate since this can alter what is seen. The view is then graded as: Grade

I : Soft palate, fauces, uvula and pillars seen, Grade II: Soft palate, fauces and uvula seen, Grade III : Soft palate and base of uvula seen and Grade IV: soft palate not visible.

- Thyromental distance [TMD \geq]: The distance between the prominence of the thyroid cartilage and the bony point of the chin with the head fully extended on the neck was measured and the results were graded into three levels. TMD > 6.5cms, TMD 6.0-6.5cms, TMD < 6 cms
- Neck circumference: A neck circumference measured at the level of cricoid cartilage \geq 35.5 cm in men and \geq 32 cm in women should be considered the cutoff point for predicting difficult intubation.
- NC/TMD: NC/TMD ratio of >5.0 was the cut off point for predicting Difficult tracheal intubation

Checklist: Anesthesia machine and circuits were checked and following equipment was kept ready.

- Endotracheal tubes - cuffed Portex and red rubber tubes of appropriate size and one size lower than required.
- Macintosh laryngoscope - with medium and large sized blade,
- Airway: oral and nasopharyngeal airway,
- Laryngeal mask airway of appropriate size,
- Suction apparatus,
- Monitors - Multipara monitor with ECG, NIBP, SPO₂, and
- Temperature. A fiber - optic bronchoscope and video laryngoscope was kept available in the OT as a backup if laryngoscopy failed.

All the patients were pre-oxygenated with 100% O₂ for 3 minutes and induced with IV propofol 2mg/kg body weight. Either succinylcholine 1 mg/kg or atracurium 0.5 mg/ kg was given to facilitate intubation in most cases. Laryngoscopy was performed using Macintosh blade. The best view obtained on laryngoscopy was noted. View on laryngoscopy was graded using the classification of Cormack and Lehane.

Grade I: Whole of the vocal cords visible. Grade II: Only posterior commissure is visible. Grade III: Only epiglottis is visible. Grade IV: None of the above is visible

A note was also made of whether or not intubation was Difficult that is if the view at laryngoscopy was grade III or IV even in patients who were predicted to have easy intubation using multiple screening tests. If difficulty was experienced in tracheal intubation, backward, upward and rightward pressure on thyroid cartilage, BURP was applied as it improved visualization of glottis on direct laryngoscopy.

Endotracheal intubation was considered truly difficult (observed difficult), if any of the following were positive. 1. Cormack and Lehane grade III and IV. 2. Three attempts at tracheal intubation or duration longer than ten minutes 3. If special maneuvers were used to facilitate tracheal intubation which in our study was fiber-optic intubation. 4. Failure to intubate. Rest of the patients were

considered to have truly easy. [Observed easy] endotracheal intubation.

The main goal of the study was to find out which test has the most discriminating power to be clinically useful. Receiver operating characteristic (ROC) analyses were performed using the software SPSS version 25. The area under ROC curve (AUC) was compared to obtain the most discriminative test. $P < 0.05$ was considered as statistically significant.

Statistical Analysis: The association between the groups and BMI, Neck circumference, Thyromental distance and TMD to Neck Circumference Ratio was assessed by comparing the distribution and mean values. The comparison was done by ANOVA test at 95% of confidence level. Sensitivity and

specificity was calculated using ROC analysis. The association between the groups and age, MMD was assessed by cross tabulation and comparison of percentages. Chi-square test was used to test statistical significance. P value < 0.05 was considered statistically significant. SPSS version 25.0.0.0 was used for statistical analysis.

RESULTS

90 subjects with a mean age of 37.2 ± 13.831 years (range 30 - 50 years) participated in this study. Demographic data and characteristics of all patients are shown in Table -1. Laryngoscopy and intubation were possible for all of the patients.

Table 1 Age-Wise Distribution of Patients

Age in years	No. of Cases	Percentage
Less than 30 years	32	35.6%
30 - 50 years	42	46.7%
Greater than 50 years	16	17.8%
Total	90	100%

The majority of patients were between 30 - 50 years (46.7%). 35.6% of patients were Less than 30 years and 17.8% of patients were Greater than 50 years old.

Table 2 Age Wise Distribution of Patients

Min	Q1	Median	Q3	Max
17	26.00	35.00	47.25	78

The mean and standard deviation of Age in years is 37.2 ± 13.831 . The median Age in years is 35 and the range is 61 (1778). The inter-quartile range is 21.25 which we get from Q1 (26) and Q3 (47.25).

Table 3. Distribution of Cases Based on Gender

Gender	No. of Cases	Percentage
Male	43	47.8%
Female	47	52.2%
Total	90	100%

The maximum numbers of patients were Female (52.2%). 47.8% of patients were Male.

Table 4: Distribution of Cases Based on ASA Grade

ASA Grade	No. of Cases	Percentage
Grade I	42	46.7%
Grade II	41	45.6%
Grade III	7	7.8%
Total	90	100%

Out of 90 patient's majority of them were in Grade I (46.7%). 45.6% of patients were in Grade II and 7.8% of patients were in Grade III.

Table 5: Distribution of Cases Based on Height

Min	Q1	Median	Q3	Max
140	150.00	156.50	165.00	185

The mean and standard deviation of Height is 158.256 ± 9.271 . The median Height is 156.5 and the range is 45 (140-185). The inter-quartile range is 15 which we get from Q1 (150) and Q3 (165).

Table 6: Distribution of Cases Based on Weight (Kg)

Min	Q1	Median	Q3	Max
10	54.75	60.00	70.00	93

The mean and standard deviation of Weight is 61.722 ± 13.044 . The median Weight is 60 and the range is 83 (10-93). The inter quartile range is 15.25 which we get from Q1 (54.75) and Q3 (70).

Table 7: Distribution of Cases Based on BMI

Min	Q1	Median	Q3	Max
16	22.00	26.00	29.00	43

The mean and standard deviation of BMI is 26.411 ± 5.444 . The median BMI is 26 and the range is 27 (16-43). The interquartile range is 7 which we get from Q1 (22) and Q3 (29).

Table 8: Distribution of Cases Based on MMP

MMP	No. of Cases	Percentage
Grade I	25	27.8%
Grade II	47	52.2%
Grade III	15	16.7%
Grade IV	3	3.3%
Total	90	100%

In our study, most of the patients had Grade II (52.2%). 27.8% of patients had Grade I and 16.7% of patients had Grade III. Similarly 3.3% of patients had Grade IV.

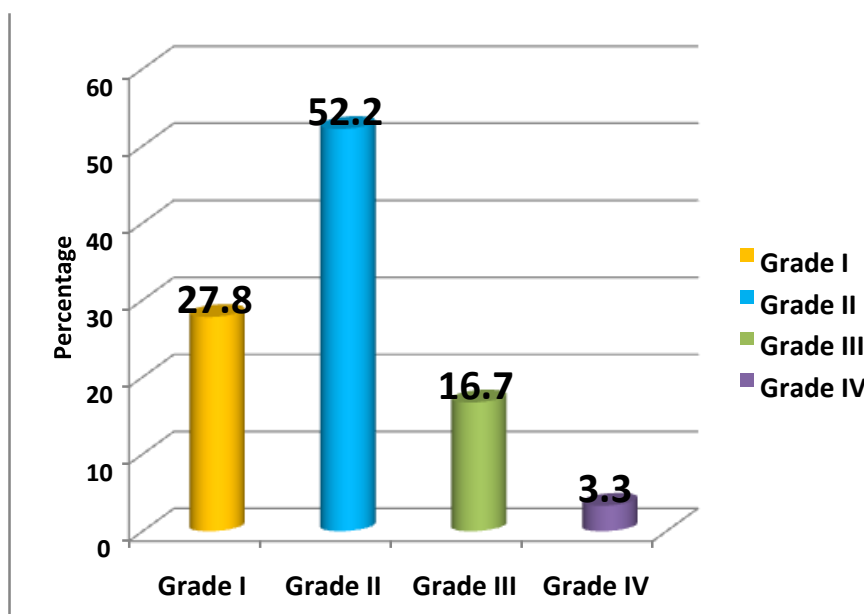


Figure 1 MMP

Table 9 Distribution of Cases Based on Neck Circumference

Min	Q1	Median	Q3	Max
28	32.00	34.00	38.00	49

The mean and standard deviation of Neck Circumference is 34.922 ± 4.056 . The median Neck Circumference is 34 and the range is 21 (28-49). The inter-quartile range is 6 which we get from Q1 (32) and Q3 (38).

Table 10: Distribution of Cases Based on Thyromental Distance

Min	Q1	Median	Q3	Max
4	6.50	7.00	7.00	8

The mean and standard deviation of Thyromental Distance is 6.706 ± 0.653 . The median Thyromental Distance is 7 and the range is 4 (4-8). The inter-quartile range is 0.5 which we get from Q1 (6.5) and Q3 (7).

Table 11. Distribution of Cases Based on Tmd to Neck Circumference Ratio

Min	Q1	Median	Q3	Max
4	4.50	4.85	5.73	10

The mean and standard deviation of TMD to Neck Circumference Ratio is 5.249 ± 1.1 . The median TMD to Neck Circumference Ratio is 4.85 and the

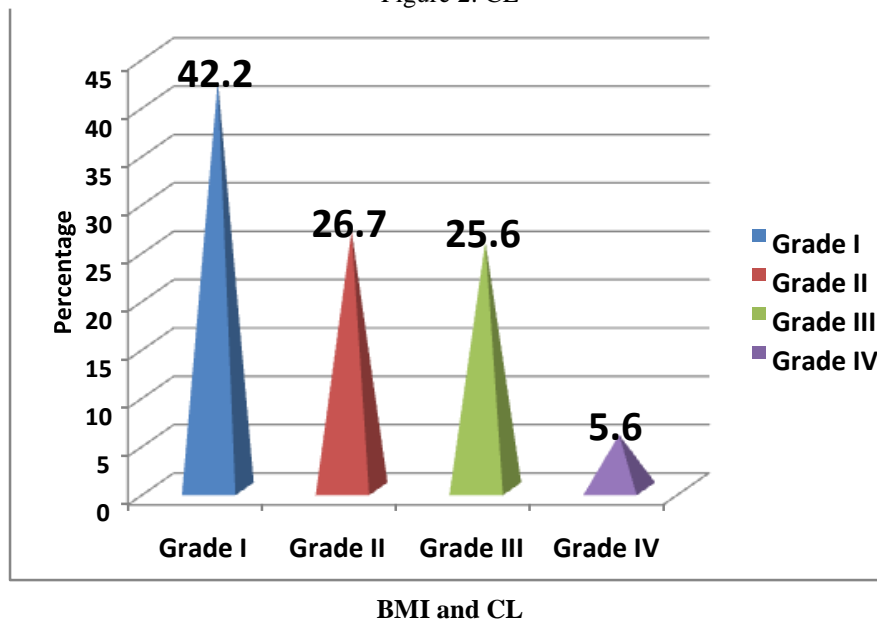
range is 6.3 (3.7-10). The interquartile range is 1.225 which we get from Q1 (4.5) and Q3 (5.73).

Table 12. Distribution of Cases Based on CI

CL	No. of Cases	Percentage
Grade I	38	42.2%
Grade II	24	26.7%
Grade III	23	25.6%
Grade IV	5	5.6%
Total	90	100%

The result shows that majority of patients had CL Grade I (42.2%). 26.7% of patients had CL Grade II and 25.6% of patients had CL Grade III. Similarly 5.6% of patients had CL Grade IV.

Figure 2: CL



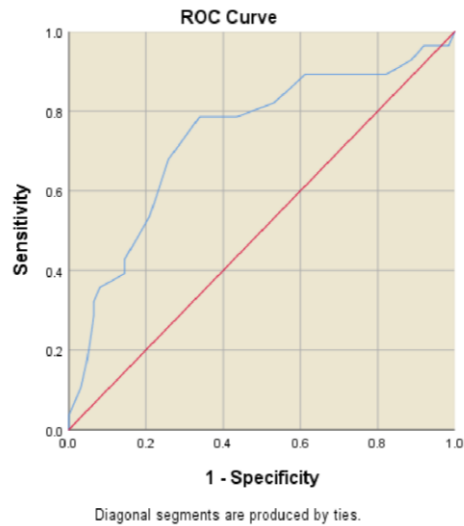


Figure 3: Roc Analysis

Area Under the Curve				
Test Result Variable(s): BMI				
Area	Std. Error	Asymptotic Sig.	Asymptotic 95% Confidence Interval	
			Lower Bound	Upper Bound
.735	.060	.000*	.617	.853

*-Significant

Cut-off point is 26.5

Table 13: Sensitivity Analysis

		CL		Total
		Difficult	Easy	
BMI Category	>=26.5	22	21	43
	<26.5	6	41	47
Total		28	62	90

Chi-Square Value = 15.447 P Value < 0.001 Significant

True positive	22
True negative	41
False positive	21
False negative	6
Accuracy	70%
Sensitivity	78.6%
Specificity	66.1%
Positive predictive value	51.2%
Negative predictive value	87.2%

Sensitivity is 78.6%, Specificity is 66.1% and Accuracy is 70%.

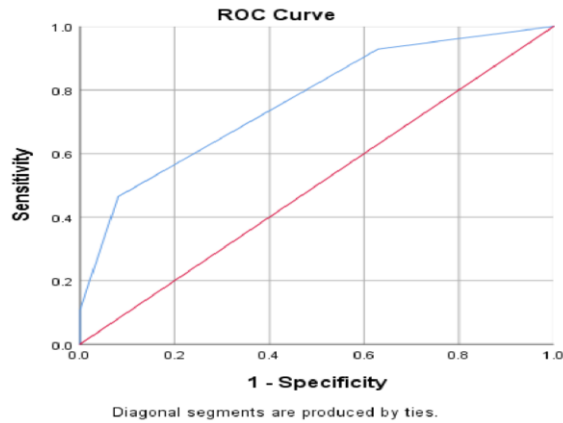


Figure 4: MP and CL

Area Under the Curve				
Test Result Variable(s): MMP				
Area	Std. Error	Asymptotic Sig.	Asymptotic 95% Confidence Interval	
			Lower Bound	Upper Bound
.763	.055	.000*	.655	.871

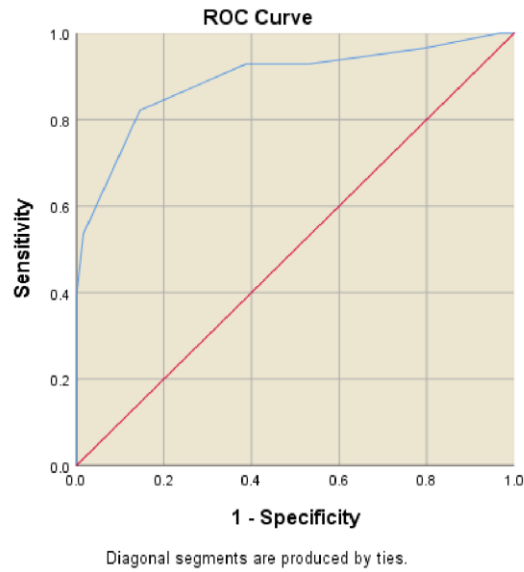
*-Significant
MMP and CL

Table 14: Sensitivity Analysis

		CL		Total
		Difficult	Easy	
MMP	Grade III & IV	13	5	18
	Grade I & II	15	57	72
	Total	28	62	90
True positive				13
True negative				57
False positive				5
False negative				15
Accuracy				77.8%
Sensitivity				46.4%
Specificity				91.9%
Positive predictive value				72.2%
Negative predictive value				79.2%

Chi-Square Value = 17.743 P Value < 0.001 Significant
Sensitivity is 46.4%, Specificity is 91.9% and Accuracy is 77.8%.

Figure 5: Neck Circumference and CI



Area Under the Curve				
Test Result Variable(s): Neck Circumference				
Area	Std. Error	Asymptotic Sig.	Asymptotic 95% Confidence Interval	
			Lower Bound	Upper Bound
.892	.042	.000*	.811	.974

*-Significant

Table 15: Cut-off point is 36.5

		CL		Total
		Difficult	Easy	
NC Category	≥ 36.5	23	9	32
	< 36.5	5	53	58
Total		28	62	90

Chi-Square Value = 38.499 P Value < 0.001 Significant

True positive	23
True negative	53
False positive	9
False negative	5
Accuracy	84.4%
Sensitivity	82.1%
Specificity	85.5%
Positive predictive value	71.9%
Negative predictive value	91.4%

Sensitivity is 82.1%, Specificity is 85.5% and Accuracy is 84.4%.

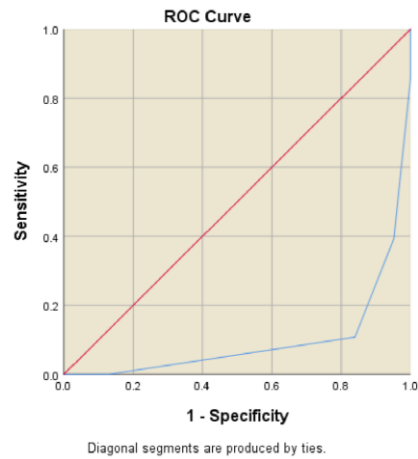


Figure 6: Thyromental Distance and CL

Area Under the Curve				
Test Result Variable(s): Thyromental Distance				
Area	Std. Error	Asymptotic Sig.	Asymptotic 95% Confidence Interval	
			Lower Bound	Upper Bound
.096	.037	.000*	.025	.168

*-Significant

Table 16: Cut-Off Point Is 6.75

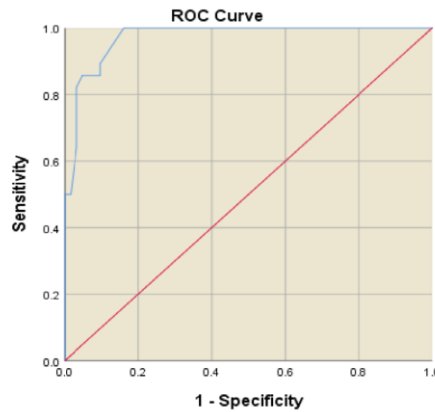
		CL		Total
		Difficult	Easy	
TMD Category	<=6.75	25	10	35
	>6.75	3	52	55
Total		28	62	90

Chi-Square Value = 43.438 P Value < 0.001 Significant

True positive	25
True negative	52
False positive	10
False negative	3
Accuracy	85.6%
Sensitivity	89.3%
Specificity	83.9%
Positive predictive value	71.4%
Negative predictive value	94.5%

Sensitivity is 89.3%, Specificity is 83.9% and Accuracy is 85.6%.

ROC Analysis



Diagonal segments are produced by ties.

Figure 7: TMD to Neck Circumference Ratio and CL

Area Under the Curve				
Test Result Variable(s): TMD to Neck Circumference Ratio				
Area	Std. Error	Asymptotic Sig.	Asymptotic 95% Confidence Interval	
			Lower Bound	Upper Bound
.972	.014	.000*	.944	1.000

*-Significant

Table 17: Cut-Off Point Is 5.25

		C	L	Total
		Difficult	Easy	
TMD to NC Ratio	≥5.25	25	6	31
	<5.25	3	56	59
Total		28	62	90

Chi-Square Value = 54.137 P Value < 0.001 Significant

True positive	25
True negative	56
False positive	6
False negative	3
Accuracy	90%
Sensitivity	89.3%
Specificity	90.3%
Positive predictive value	80.6%
Negative predictive value	94.9%

Sensitivity is 89.3%, Specificity is 90.3% and Accuracy is 90%.

Table 18: Overall Sensitivity Analysis Results

Parameter	Sensitivity	Specificity	Accuracy
BMI	78.6%	66.1%	70%
MMP	46.4%	91.9%	77.8%
Neck Circumference	82.1%	85.5%	84.4%
Thyromental Distance	89.3%	83.9%	85.6%
TMD to NC Ratio	89.3%	90.3%	90%

By comparing all five parameters, TMD to NC ratio has the highest accuracy (90%) with 89.3% of sensitivity and 90.3% of specificity.

DISCUSSION

Prediction of a difficult airway to prevent unanticipated difficult tracheal intubation and consequent events and develop a plan to convert a difficult intubation into an easy one is an important concern for anesthesiologists. In this study, the incidence of difficult laryngoscopy was 27.7% that is more than what has been reported by previous studies^{11, 40}

Short TMD has been introduced as a simple, clinically used criterion that could predict a difficult airway. Various cutoff points have been reported for this distance in previous studies. Patil *et al.*²² suggested 6.5 cm as the cutoff point in adult patients; TMD >6.0–6.5 cm could predict the difficult, but usually possible laryngoscopy and intubation if there are no other anatomical abnormalities and laryngoscopy may be impossible in TMD <6 cm.

However, the presence of anatomical difficulties may increase this cutoff point to 6.0–6.5. Frerk suggested 7 cm as the cutoff point for difficult intubation where the posterior pharyngeal wall could not be visualized during inspection of the oropharynx⁴⁰. In this study, the incidence of difficult laryngoscopy was 71% in the patients with TMD <6.7. Short neck, decreased head extension, short mandible, deep mandible and high anterior larynx are factors that contribute to difficult laryngoscopy and may all influence TMD²².

Though there are various studies to predict the diagnostic accuracy of screening tests for predicting difficult intubation, there is a significant difference between the trials. This variation could be because of the difference in the patient characteristics as most of these studies were conducted in Western population. There is a significant difference in the anthropometry of Indian and the Western population that is also translated into the anatomical indices used to predict difficult laryngoscopy⁴¹. Thus, it is important to analyze whether the same parameters and cut-off values can be applied in the Indian population to predict difficult airway. Previous studies reported that NC at the thyroid cartilage is a valuable predictor of difficult laryngoscopy in both obese and non-obese patients.^{9,43} However, NC does not indicate the amount of soft tissue at various topographic regions within the neck.

Distribution of fat in specific neck areas, especially the anterior neck, may provide a better indication of difficult intubation than NC.⁹ TMD is considered to be an indicator of mandibular space⁴² this test also reflects whether the displacement of the tongue by the laryngoscope blade will be easy or difficult. The diagnostic value of TMD as an individual predictor proved unsatisfactory in a meta-analysis conducted by Shiga *ET al.*² NC/TMD might represent the distribution of fat in the neck better than either NC or TMD alone. Intubation difficulty index is the ratio between the NC/TMD developed by Kim *et al.*¹⁰ with an assumption that patients with both a large

NC and a short neck might be more difficult to intubate than patients with a large NC or a short neck alone. They concluded that NC/TMD is a better indicator than either the NC or TMD alone. This finding correlates with our study. In a previous study, other variables using NC, the NC/BMI, and NC/SM distance were also assessed. However, multivariate analysis revealed that the NC/BMI and NC/SM did not show a definite connection with difficult intubation.⁴⁴

The Mallampati score may estimate the size of the tongue relative to the oral cavity and may possibly indicate whether the displacement of the tongue by the laryngoscope blade is likely to be easy or difficult. Also, it assesses whether the mouth can be opened adequately to permit intubation. The Mallampati test evaluates not only the pharyngeal structure but also head and neck mobility.² In our study also Mallampati score of 3 or 4 was found to be a good predictor of difficult intubation.

One of the limitations of our study is that observer bias in Cormack and Lehane's grading could be possible as laryngoscopy was done by different anaesthesiologists, their skill and experience may vary, though all were experienced anesthesiologists. Our result may not be applicable to other racial groups. Anthropometric variations in different populations make it impossible to get an optimum cutoff value, for many indices predicting difficult intubation, which can be applied to other population groups.

CONCLUSION

The study indicated that NC/TMD as simple preoperative bedside tests have a higher level of accuracy compared to TMD, NC, MMP, and BMI in predicting a difficult airway.

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