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Relevance of ratio of neck circumference to thyromental distance in predicting difficult intubation

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Abstract---Background and Objectives: Airway assessment is the most important aspect of anaesthetic practice as a difficult intubation may be unanticipated. A study was done to know the relevance of ratio of neck circumference to thyromental distance in predicting difficult intubation in general Indian population coming for surgery. Materials and methods: 500 Patients with ASA PS I& II were enrolled in the study were preoperatively assessed for airway parameters such as Modified mallampati classification, thyromental distance, sternomental distance, neck circumference to thyromental distance ratio and Wilson score. Intra-operatively all patients were classified according to Cormack and Lehane laryngoscopic view. Results: The mean age, Weight, Height and BMI of patients in our study was 34.43 years, 61.07 kg, 69.2cms and 21.2 respectively. In our study we had a total of 15 difficult intubation with all of them belonging to Cormack-Lehane grade III. In our study we noted that among 15 patients with CLIII/IV only 4 had a SMD $\leq$ 15.75 cm. With that we noted a sensitivity, specificity, PPV and NPV of 26.7%, 75.1%, 3.2% and 97.1%. Among 15 patients with CLIII/IV only 2 of them had Wilson score of more than 3. That delivered a sensitivity, specificity, PPV and NPV of 13.3%, 100%, 100% and 97.4%. We noted a low sensitivity. But the

specificity and PPV of Wilson score were very high. In our study with NC/TM ratio (>4.92) had sensitivity, specificity, PPV and NPV of 60%, 43.9%, 3.2% and 97.3% with a AUC in ROC curve of 0.524. Conclusion: The ratio of neck circumference to thyromental distance ≥ 4.92 has a advantage of having good sensitivity and negative predictive value with least false negativity. So the ratio of neck circumference to thyromental distance ≥ 4.92 may be considered a good predictor of difficult intubation in general population but a combination of tests always have a better predictive value.

Keywords--neck circumference, thyromental distance, difficult airway, difficult intubation.

Introduction

Endotracheal intubation is a crucial and integral part of administration of general anaesthesia. Unanticipated difficult intubation can be challenging to anesthesiologists.¹ Numerous investigators have attempted to predict difficult intubation by using a simple bedside physical examination.² Mallampati score³, thyromental distance, sternomental distance and the Wilson score⁴ are widely recognized as tools for predicting difficult intubation.¹ However, none of these have high diagnostic accuracy particularly in the obese patients. Many attempts have been made to develop a reliable predictor for difficult intubation or laryngoscopy. Increased neck circumference (NC) is reported to be associated with difficult intubation especially in obese patients.²

The combinations of tests were thought to improve the predictive outcome but they did not contribute much as in obstetric or obese patients who have a higher risk of difficult airway.¹ There is evidence to suggest that neck circumference to thyromental distance ratio has a high sensitivity to predict difficult intubation but no such study has been done in Indian population.² Since there is no single available test which predicts difficult intubation accurately there is a need for further research for a difficult intubation predictor. So, in this study we try to find out the relevance of ratio of neck circumference to thyromental distance in predicting difficult intubation in Indian population, thus developing a predictor for difficult intubation that is simple and easy to perform with high specificity and sensitivity compared with established indices.

Materials and Methods

This study was conducted on 500 patients posted for elective surgery under general anaesthesia with endotracheal intubation in K.S. Hegde Charitable Hospital, Deralakatte, Mangalore from October 2011 to June 2013.

Inclusion criteria

- Adults aged 18-60 years scheduled to undergo elective surgery under general anaesthesia.
- Adults belonging to ASA physical status (ASA PS) I & II.

Exclusion criteria

- Patients undergoing general anaesthesia without tracheal intubation.
- Patients with obvious pathological condition in and around the mouth and neck.
- Uncooperative patients

Method of collection of data

500 ASA PS I and II patients of either sex in age group 18-60 years scheduled to undergo general anaesthesia needing endotracheal intubation were included in the study. Pre anaesthetic evaluation including informed consent to enroll the patient in the study group were obtained a day before surgery. All the patients were kept nil per oral for 8 hours, pre-medicated with oral diazepam (5 mg for patients less than 50 kg and 10 mg for patients more than 50 kg) and oral ranitidine 150 mg on the previous night and 2 hours prior to surgery. After shifting the patient to operation theatre, the patients were positioned with a pillow under the head and the neck extended. All the patients were monitored routinely with an electrocardiogram, pulse oximetry, and non-invasive blood pressure, and intravenous access was secured and a crystalloid infusion was started.

Difficult airway cart was kept ready for all the cases. Inj. fentanyl 2µg/kg was given over 30 seconds after preoxygenation with 100% oxygen for 5 minutes. Inj. propofol 2 mg/kg was administered for induction of anaesthesia. After confirming adequate mask ventilation neuromuscular blockade was achieved with Inj. succinylcholine 1.5 mg/kg. After ensuring complete relaxation, as defined by disappearance of fasciculation's from lower limbs, sniffing position was achieved, laryngoscopy done with an appropriately sized Macintosh laryngoscope blade and intubation was attempted with an appropriately sized cuffed endotracheal tube. All intubations were performed by an anaesthesiologist with more than 2 years of experience who was blinded to the study. The laryngoscopic view was graded according to Cormack and Lehane's scale.⁵ If there is a difficulty intubation following manoeuvres were attempted,

- Application of external laryngeal pressure,
- Use of extra force,
- Extra attempts,
- Any alternate techniques or
- Laryngoscopy by an additional anaesthesiologist is done

This was documented by intubation difficulty scale (IDS). A failure to intubate a patient after two attempts was managed according to ASA Difficult Airway Algorithm.

Intubation difficulty scale (IDS)

Difficulty of intubation was assessed using the IDS which was recorded by the senior anaesthesiologist. The IDS is 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 (grade 1- N4=0; grade 2- N4=1; grade 3- N4=2; grade 4- N4=3)
- N5, lifting force applied during laryngoscopy (N5=0 if inconsiderable and N5=1 if considerable)
- N6, needed to apply external laryngeal pressure for optimized glottic exposure (N6=0 if no external pressure or only the Sellick's manoeuvre was applied and N6=1 if external laryngeal pressure was used)
- N7, position of the vocal cords at intubation (N7=0 if abducted or not visible and N7=1 if adducted).

The IDS score is the sum of N1 through N7. A score of 0 indicates intubation under ideal conditions. The two groups of patients were classified further according to the IDS score. Those with an IDS score of ≥ 5 were considered as difficult intubation groups and < 5 as easy intubation groups. The value of different predictors were studied for their sensitivity, specificity, positive predictive value and negative predictive value in predicting difficult intubation. The predictive accuracy of ratio of neck circumference and thyromental distance in comparison to other predictive tests were evaluated. Receiver operating characteristic (ROC) Curve and the area under ROC curve (AUC) for each airway predictor in isolation and in combination were determined using SPSS 16 software.

Results

Total number of patients in the study (n) – 500

Table 1
Area under the curve

Test Result Variable(s)	Area
MALAMPATTI	.672
TMD	.531
NC/TM	.524
SMD	.484
Wilson score	.567

The test result variable(s): MALAMPATTI, TMD, NC/TM, SMD, Wilson score has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased. We noted a AUC in ROC curve of Malampatti being 0.672, thyromental distance had an AUC in ROC curve of 0.531. In our study with NC/TM ratio (>4.92) had a AUC in ROC curve of 0.524.

Table 2
MALLAMPATTI 3/4 * Cormack lehane Crosstabulation

			Cormack lehane		Total
			I/II	III/IV	
MALLAMPATTI III/IV	MALLAMPATY CLASS I/II	Count	458	13	471
		% within MALLAMPATTI III/IV	97.2%	2.8%	100.0%
		% within Cormack lehane	94.4%	86.7%	94.2%
	MALLAMPATY CLASS III/IV	Count	27	2	29
		% within MALLAMPATTI III/IV	93.1%	6.9%	100.0%
		% within Cormack lehane	5.6%	13.3%	5.8%
Total		Count	485	15	500
		% within MALLAMPATTI ¾	97.0%	3.0%	100.0%
		% within Cormack lehane	100.0%	100.0%	100.0%

In our study 58.8%, 35.4%, 5.8% of patients had Mallampati class I, II, III. Among the 15 having Cormack lehane grade 3 only 2 patients had a Mallampati class III.

Table 3
TMDCUTOFF * Cormack lehane Crosstabulation

			Cormack lehane		Total
			I/II	III/IV	
TMDCUTOFF	<=7.25	Count	325	8	333
		% within TMDCUTOFF	97.6%	2.4%	100.0%
		% within Cormack lehane	67.0%	53.3%	66. 6%
	>7.25	Count	160	7	167
		% within TMDCUTOFF	95.8%	4.2%	100.0%
		% within Cormack lehane	33.0%	46.7%	33.4%
Total		Count	485	15	500
		% within TMDCUTOFF	97.0%	3.0%	100.0%
		% within Cormack lehane	100.0%	100.0%	100.0%

Of the 15 patients with CL III/IV we noted that 8 patients had a thyromental distance >7.25cm, since we had calculated 7.25 cm as the cut off in our study.

Table 4
Wilson score * Cormack lehane Crosstabulation

			Cormack lehane		Total
			I/II	III/IV	
Wilson score	0	Count	485	13	498
		% within Wilson score	97.4%	2.6%	100.0%

	3	% within Cormack lehane	100.0%	86.7%	99.6%
		Count	0	2	2
		% within Wilson score	0.0%	100.0%	100.0%
		% within Cormack lehane	0.0%	13.3%	0.4%
Total		Count	485	15	500
		% within Wilson score	97.0%	3.0%	100.0%
		% within Cormack lehane	100.0%	100.0%	100.0%

Among 15 patients with CLIII/IV only 2 of them had Wilson score of more than 3.

Table 5
Comparing MMT, TMD, SMD, NC/TM, Wilson score

Test	TP	FP	TN	FN	Acc%	Se%	Sp%	PPV%	NPV%
MMT III/IV	2	27	458	13	92	13.3	94.4	6.89	97.2
TMD ≤7.25	8	325	160	7	33.6	53.3	32.9	2.4	95.8
SMD ≤15.25	4	121	364	11	73.6	26.7	75.1	3.2	97.1
NC/TM ≥4.92	9	272	213	6	44.4	60	43.9	3.2	97.3
WILSON ≥3	2	0	485	13	97.4	13.3	100	100	97.4

Statistical terms used for MMT, TMD, SMD, NC/TM and Wilson score as predicting tests-TP true positive, FP false negative, TN true negative, FN false negative, ACC accuracy or total correct prediction, Se sensitivity, Sp specificity, PPV positive predictive value, NPV negative predictive value. In our study with NC/TM ratio (>4.92) had sensitivity, specificity, PPV and NPV of 60%,43.9%,3.2% and 97.3%. Wilsons score had a sensitivity, specificity, PPV and NPV of 13.3%,100%,100% and 97.4%. We noted a low sensitivity. But the specificity and PPV of Wilson score were very high.

Discussion

Difficulty in endotracheal intubation constitutes an essential predisposing factor of morbidity and mortality, especially when it is not anticipated preoperatively. This unexpected difficulty in intubation is probably the result of a lack of accurate predictive tests and inadequate preoperative assessment of the airway. Risk factors if identified at the preoperative visit help to alert the anaesthesiologist so that alternative methods of securing the airway can be used or additional expertise sort beforehand. Many previous studies have combined risk factors. However, as these scores contain multiple risk factors, they are more time consuming to perform. Neck circumference to thyromental distance (NC/TM) ratio ≥5.0 has been considered to be a good predictor of difficult intubation in obese patients. Moreover NC/TM ratio is an easy preoperative test and is less time consuming.

Since NC/TM ≥ 5.0 ratio has been proved as a good predictor of difficult intubation in obese patients, in our study we used NC/TM ratio to predict difficult intubation in Indian adult population coming for surgery. 500 ASA 1 and 2 patients aged 18-60 years scheduled to undergo elective surgery under general anaesthesia were included for the study. The mean age of patients in our study was 34.43 years. Weight of the patients ranged from 37 to 92 kg with an average of 61.07 kg. Height of the patients ranged from 150cms to 178 cms with an average of 169.2cms. BMI of the patients ranged from 14.8 to 30.3 with an average of 21.2. Both males and females were adequately represented and 82.4% of the patients belonged to ASA physical status 1, and 17.6% of the patients ASA physical status 2. In our study we used intubation difficulty scale (IDS) score to define difficult intubation initially. We tried with statistical analysis IDS score considering scale value of ≥ 5 as actual difficult intubation and scale value of < 5 as easy intubation. As we did not get a single case of score value ≥ 5 we have to go ahead with comparing with Cormack-Lehane grade to predict difficult intubation in adults. Cormack-Lehane grade has been used in many previous studies to predict difficult intubation in adults. Cormack-Lehane grade III and IV was considered as difficult intubation.⁶ In our study we had a total of 15 difficult intubation with all of them belonging to Cormack-Lehane grade III. All the patients were successfully intubated and there were no cases of failed intubation.

Modified mallampati test

The original Mallampati test & modified Mallampati test (MMT) remains a time-tested bedside technique to date for recognizing an anticipated difficult tracheal intubation as assessed by Cormack-Lehane grade. However, the accuracy of the Mallampati test is different considering race, gender and even pregnancy.^{1,2} Atul P Kulkarni et al⁷ conducted a study Comparison of glottic visualisation and ease of intubation with different laryngoscope blades in 120 patients. They compared Macintosh, Miller, McCoy blades and the Trueview® laryngoscope for glottic visualisation and ease of tracheal intubation. In their study they recorded a 65.8% of patients with Mallampati class I, 29% of patients with Mallampati class II and 5% patients with Mallampati class III and no patients with Mallampati class IV.⁸ Their findings were similar to our study where we found 58.8% of patients in our study had Mallampati class I, 35.4% of patients were Mallampati class II and 5.8% of patients had Mallampati class III. There was no patient in Mallampati class IV. Among the 15 having Cormack-Lehane grade 3 only 2 patients had a Mallampati class III where the rest of the patients had Mallampati class I or II.

Thyromental distance (TMD) (Patil's test)⁹

It is defined as the distance from the mentum to the thyroid notch while the patient's neck is fully extended. This measurement helps in determining how readily the laryngeal axis will fall in line with the pharyngeal axis when the atlanto-occipital joint is extended. Alignment of these two axes is difficult if the TMD is < 3 finger breadths or < 6 cm in adults; 6-6.5 cm is less difficult, while > 6.5 cm is normal. Wide range of cut-off values are quoted for TMD ranging from 5.5-7 cm. A number of studies defined TMD < 7 cm to predict difficult intubation. In spite of higher cut-off, these studies observed low sensitivity, specificity and

PPV of TMD. In the present study, TMD showed high specificity but at the cost of very low sensitivity which is unacceptable.¹⁰ We chose 7.25 cm as the cut off based on statistical analysis. Of the 15 patients with Cormack Lehane III/IV we noted that 8 patients had a thyromental distance >7.25cm.

Neck circumference to thyromental distance ratio (NC/TM)

Neck circumference is traditionally (cm) measured at the level of cricoid cartilage with a measuring tape. However, there is conflicting data regarding its usefulness. Some recent data suggest that neck circumference measurement may be a useful method of predicting difficult tracheal intubation in obese patients.^{11,12} Gonzalez¹³ and co-workers evaluated Neck Circumference to predict Intubation difficulties in obese patients. They conducted the study in tracheal intubation in 70 obese and 61 lean patients and used IDS to evaluate intubating conditions. Average NC was 42 in obese and 39.4 in lean. With that they found a sensitivity, specificity, PPV and NPV of 92%, 84%, 37% and 99%. In our study mean NC was 35.31 cm. NC/TM ratio cut off ≥ 4.92 based on statistical analysis we got a sensitivity, specificity, PPV and NPV of 60%, 43.9%, 3.2% and 97.3%. This difference could be attributed to difference in population and the fact that their study had a combination of lean and obese patients as compared to our study where the mean weight of our population was 61kgs with a BMI of 21.2.

Sternomental distance (SMD)

In our study we noted that among 15 patients with CL III/IV, only 4 had a $SMD \leq 15.75$. With that we noted a sensitivity, specificity, PPV and NPV of 26.7%, 75.1%, 3.2% and 97.1%. Savva D evaluated three hundred and fifty patients using the modified Mallampati test, thyromental and sternomental distances, forward protrusion of the mandible and interincisor gap as predictors to difficult intubation. A sternomental distance of 12.5 cm or less with the head fully extended on the neck and the mouth closed predicted 14 of the 17 patients in whom tracheal intubation was difficult. As a screening test, sternomental distance appeared to be more sensitive (82.4%) and more specific (88.6%).¹⁴ The difference could be attributed to the fact that they used 12.5 cm as a cut off as compared to 15.75 cm in our study which could have led to higher sensitivity in their study. However, specificity was similar to our study.

WILSON Score

Among 15 patients with CL III/IV only 2 of them had Wilson score of more than 3. That delivered a sensitivity, specificity, PPV and NPV of 13.3%, 100%, 100% and 97.4%. Since we did not have many patients weighing more than 90 kg and we had excluded patients with anticipated difficult airway this resulted in low sensitivity. But the specificity and PPV of Wilson score were very high. Kim et al noted Wilson score with a cut off of ≥ 2 recorded a sensitivity, specificity, PPV and NPV of 47.1%, 91.5%, 47.1% and 91.5%. The variation in sensitivity could be attributed as they used 2 as cut off as compared to 3 in our study.² They noted an AUC of 0.693 in ROC curve where as we noted an AUC in ROC curve of 0.567.

Conclusion

Out of the predictive tests studied Wilson score has a high predictive value in terms of specificity and positive predictive value but may not be very practical and relevant in our Indian population as the test includes many factors including weight criteria. The ratio of neck circumference to thyromental distance ≥ 4.92 has an advantage of having good sensitivity and negative predictive value with least false negativity. So the ratio of neck circumference to thyromental distance ≥ 4.92 may be considered a good predictor of difficult intubation in general population but a combination of tests always have a better predictive value.

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