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The Evaluation of Thyromental Height Test as a Single, Accurate Predictor of Difficult Laryngoscopy

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ABSTRACT

Background: Thyromental Height Test is a relatively new, easy method considered as a more accurate predictor of difficult laryngoscopy than existing methods. The aim of this study was to evaluate its accuracy in predicting difficult laryngoscopy as compared to commonly used methods.

Methods: This hospital based, cross-sectional, observational study was conducted on 246 patients scheduled for surgery under general anesthesia with endotracheal intubation. Airway assessment was done during pre-anesthetic assessment by Thyromental Height Test, Modified Mallampati Test, Thyromental Distance and Sternomental Distance measurements and predicted as 'difficult' or 'easy' laryngoscopy based on accepted cut-off values. Direct laryngoscopic view was assessed after administration of general anesthesia by a laryngoscopist unaware of the pre-anesthetic assessments and recorded as 'actual' difficult or easy laryngoscopy based on Cormack-Lehane grades. The sensitivity, specificity, positive predictive value, negative predictive value and accuracy of each clinical test were determined.

Results: Thyromental Height Test had the highest sensitivity (71.42%) and negative predictive value (98.9% respectively) but lowest accuracy (77.2%). Maximum specificity was observed with Thyromental Distance and Sternomental Distance (97.49% each). Thyromental Distance had the highest positive predictive value (25%) and accuracy (95.52%).

Conclusions: Thyromental Height Test, with its high sensitivity, is a useful predictor of difficult laryngoscopy. However, due a high number of false positives and relatively low accuracy, it cannot be considered as a sole, reliable and accurate predictor of difficult laryngoscopy.

Keywords: Accuracy; difficult laryngoscopy; predictor; thyromental height

INTRODUCTION

Adverse airway events resulting from difficult laryngoscopy or intubation are major causes of morbidity and mortality in patients undergoing general anesthesia.[1,2] The incidence of difficult intubation during routine anesthesia ranges from 1.5% to 18% and is estimated to be 4.9% in Nepalese population.[3-5] Thus, accurately predicting difficult intubation can improve safety in airway management.[6] Various clinical tests are used to predict difficult airway. However, no single test is known to be a reliable predictor, although combining a number of tests can improve accuracy of difficult airway prediction.[7,8]

A new clinical test called 'thyromental height test (TMHT)' was proposed by Etezadi et al in 2013. They suggested that it was a single, rapid, reliable predictor of difficult laryngoscopy as compared to other commonly used single clinical tests but validation would be required by further studies is diverse patient populations.[9] This study was conducted in Nepalese population to evaluate whether TMHT is a more accurate predictor of difficult laryngoscopy than other commonly used tests: modified mallampati test (MMT), thyromental distance (TMD) and sternomental distance (SMD).

METHODS

This cross-sectional, observational, hospital based study was conducted in Nepal Armed Police Force Hospital, Kathmandu, Nepal between May 2018 and August 2019, after ethical approval from Nepal Health Research Council (NHRC). Sample size was calculated to be 217 based on formula for studies with binary test outcome using pre-determined value of sensitivity for TMHT from previous study by Etezadi et al.[9] Purposive sampling was done to include all hospital patients 18 years and above of either sex scheduled for routine elective surgery requiring general anesthesia with endotracheal intubation. Patients with pre-existing limitation or pain with cervical spine movement, inadequate mouth opening, known abnormalities of the airway, altered level of consciousness or inability to follow commands,

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pregnant patients and those undergoing emergency surgeries were excluded from the study. A total of 246 patients were enrolled and written informed consent was obtained from each by a physician not involved in the study.

Pre-operative evaluation of each patient was done the day before the surgery which included detailed history, physical examination and relevant laboratory investigations of the patient. Airway assessment was done by four different methods by an anesthesiologist who was not involved in the laryngoscopy of the patient. Modified mallampati test (MMT) was done on the seated patient, with mouth maximally opened, tongue protruded, without phonation, while the observer looked from the patient's eye level and assessed the oropharyngeal view. It was graded as Class I where soft palate, fauces, uvula, tonsillar pillars were visible; Class II where soft palate, fauces, uvula were visible; Class III where soft palate, base of uvula were visible; and Class IV where soft palate was not visible at all. Classes I and II were considered predictive of easy laryngoscopy, and classes III and IV predictive of difficult laryngoscopy.[10]

Thyromental distance (TMD) was measured as the distance between the thyroid notch and the lower border of mental prominence, with the head fully extended and the mouth closed, was measured using a rigid ruler. A distance ≤6.5 centimetres (cms) was considered predictive of difficult laryngoscopy.[11]

Sternomental distance (SMD) was measured as the distance between the superior border of the manubrium sterni and the bony point of the mentum, with the head in full extension and the mouth closed, was measured using a rigid ruler. A distance ≤13.5 cms was considered predictive of difficult laryngoscopy.[11]

Thyromental height test (TMHT) was done by measuring the height (vertical distance) between the anterior border of the thyroid cartilage (on the thyroid notch) and the anterior border of the mentum, with the patient lying supine with her/his mouth closed and head in neutral position without using a pillow was measured with a depth gauge (INSIZE® Electronic Depth Gage, INSIZE Co. Ltd., Suzhou New District, China; Fig. 1), similar to the one used by Etezadi et al. A height ≤ 50 millimeters (mm), was considered predictive of difficult laryngoscopy.[9] Head in neutral position was defined as the patient's head resting on the occiput with the patient looking straight at the ceiling without rolling of the eyeballs.[12]

Additionally, age, sex, height, body weight, body mass index, and ASA physical status of all patients was recorded on pre-operative assessment. The patients were kept nil per oral overnight before the surgery.

Figure 1.Thyromental height measurement with electronic depth gage.

On arrival of the patient in the operating room, standard patient monitors were attached and intravenous access was obtained. Injection midazolam 0.04 mg/kg and fentanyl 2 mg/kg was given intravenously followed by gradual administration of 5 ml/kg ringer lactate. Anesthesia was induced with titrating dose of propofol (1.5 to 2.5 mg/kg) and after checking for mask ventilation, muscle relaxation was achieved with vecuronium 0.1 mg/kg. The patient was manually ventilated with oxygen and isoflurane for four minutes. Laryngoscopy was then performed by a conventionally trained anesthesiologist using a Macintosh #3 or #4 blade after placing the patient's head in sniffing position. If no laryngeal view was achieved, a second attempt was made after re-adjustment of head position along with optimal external laryngeal manipulation. The best view of the laryngeal inlet leading to successful intubation was assigned a grade of I to IV according to Cormack and Lehane (C-L) criteria described as: Grade 1 full view of the glottis, Grade 2 glottis partially exposed, Grade 3 only epiglottis seen, Grade 4 epiglottis not seen. C-L grades 1 and 2 were classified as "easy," and grades 3 and 4 as "difficult".[13] The patient was intubated with cuffed orotracheal tube of proper size. All intubation attempts were performed by the same anesthesiologist in all patients enrolled in the study but was unaware of airway assessments on pre-anesthetic check-up. A stylet or bougie was used to facilitate endotracheal intubation when the vocal cords were not fully visualized. All preparations and precautions were undertaken with reference to standard hospital protocol regarding safety measures and Difficult Airway Society Guidelines.[14]

Anesthesia was maintained with oxygen, isoflurane, vecuronium and intermittent positive pressure ventilation. At the end of surgery, anesthetics were discontinued and muscle relaxation was reversed with neostigmine 0.05 mg/kg and glycopyrrolate 0.01 mg/kg. Awake extubation was done and the patient was shifted to the post anesthetic care unit.

Collected data was analyzed using SPSS (Statistical Package for the Social Sciences), version 16.0 for windows. Mean± standard deviation values were computed for demographic variables and distance measurements of clinical tests. Pearson Chi square test with 95% confidence intervals was used to evaluate the significance of each clinical test and 'p' value < 0.05 was considered statistically significant. Relation of the four clinical tests with Cormack-Lehane grading was represented by numbers and expressed as true positives, true negatives, false positives and false negatives for each clinical test. These values were, in turn, used to calculate the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and accuracy for each clinical test.

RESULTS

Among 246 patients enrolled in the study, 109 were male and 137 were female and their demographic characteristics are described in terms of mean and range in table 1.

The sensitivity of TMHT was the highest (71.42%) while TMD and SMD had the maximum specificity (97.49% each). The PPV of all tests were observed to be low, TMD having the maximum value (25%). The NPV of all tests were high, TMHT having the highest (98.9%). TMD had the highest accuracy (95.52%) while TMHT had the lowest (77.2%).

There were no situations of failed intubation or airway related complications. There were seven patients with actual 'difficult' laryngoscopy (Cormack-Lehane grade III view) and 239 with 'easy' laryngoscopy (23 with C-L grade II view and 216 with grade I view). Thus, the prevalence of difficult laryngoscopy was observed to be 2.85% (7/246) in this study.

Table 2 shows the actual and predicted number of patients with difficult and easy laryngoscopy for each clinical test. All the tests produced results of statistical significance except Sternomental distance.

Laryngoscopy was predicted to be 'difficult' by TMHT in 59 patients but was observed to be actually difficult on C-L grading only in five patients among them (true positives= 5) and easy in 54 patients (false positives= 54). Out of 187 patients predicted to have easy laryngoscopy, two actually had difficult laryngoscopy on C-L grading (false negatives= 2) and 185 had easy C-L gradings (true negatives= 185). These values were similarly derived for the other three clinical tests and tabulated (table 3).

Table 1. Demographic characteristics of the patients.

Variables	Range	Mean± SD*	No of males= (%)	No of females= (%)
Age [years]	18 to 75 (57)	35.83± 12.01	109 (44.3%)	137 (55.7%)
Height [m]	1.40 to 1.82 (0.42)	1.58± 0.08		
Weight [kg]	38 to 97 (59)	60.94± 10.75		
Body mass Index [kg/m2]	16.93 to 35.85 (18.92)	24.08± 3.54	Total no. of participants = 246	

*SD = Standard Deviation

Table 2. Relation of the four clinical tests with Cormack-Lehane grades and their significance.

Airway assessment Methods		Cormack-Lehane grade		Total	Mean ± SD*	Range / Frequency of occurrence	Significance 'p'
		Difficult (n=7/246)	Easy (n=239/246)				
Thyromental Height Test	Difficult †	5	54	59	54.13±8.3 mm	22.74-75.19 mm	0.003
	Easy ‡	2	185	187			
Thyromental distance	Difficult	2	6	8	8.76±1.07 cm	6.4-12 cm	<0.001
	Easy	5	233	238			
Sternomental distance	Difficult	1	6	7	17.08±2.03 cm	13.0-26.5 cm	0.065
	Easy	6	233	239			
Modified Mallampati Test	Difficult	4	34	38	NA§	I 134 II 74 III 37 IV 1	0.002
	Easy	3	205	208			

*SD = Standard Deviation, †Difficult = TMH ≤50 mm, Mallampati class III and IV, TMD ≤6.5 cms, SMD ≤13.5 cms, C-L grade 3 and 4 views; ‡ Easy = TMH >50 mm, Mallampati class I and II, TMD >6.5 cms, SMD >13.5 cms, C-L grade 1 and 2 views).

§ NA= Not Applicable

Table 3. Evaluation of the different methods of airway assessment by statistical analysis.

Clinical test	TMHT*	TMD†	SMD‡	MMT§
True Positive (TP)	5	2	1	4
True Negative (TN)	185	233	233	205
False Positive (FP)	54	6	6	34
False Negative (FN)	2	5	6	3
Sensitivity %	71.42%	28.57%	14.29%	57.14%
Specificity %	77.4%	97.49%	97.49%	85.77%
Positive predictive value (PPV) %	8.47%	25%	14.28%	10.52%
Negative predictive value (NPV) %	98.9%	97.9%	97.49%	98.56%
Accuracy %	77.2%	95.52%	95.12%	84.96%

* TMHT = Thyromental Height test, † TMD= Thyromental Distance, ‡ SMD = Sternomental Distance, § MMT = Modified Mallampati Test,

DISCUSSION

Difficult laryngoscopy or intubation, especially when unanticipated, can result in various complications ranging from airway trauma to hypoxic brain damage or even death.[1,2] Preoperative airway assessment minimizes complications by facilitating appropriate preparation when difficulty is anticipated.[12,15] However, difficult intubation occurs infrequently and is not easy to define objectively. Therefore, research has been directed at predicting difficulty in visualization of vocal cords during conventional laryngoscopy, as a marker for difficult airway.[4] The Cormack-Lehane grading is a widely used classification that describes the best view of the larynx seen at laryngoscopy.[13] The prevalence of difficult laryngoscopy was observed to be 2.85% (7/246) in this study which is comparable to 4.9% as per previous study in Nepalese population.[4] This is also comparable to findings in other population groups.[16,17]

A number of bedside tests have been formulated for evaluating the airway but no single test is considered the best. The MMT is the most widely used clinical test of airway assessment globally, and also in Nepal.[4] However, other measurements such as TMD and SMD are also frequently used clinical tests for difficult laryngoscopy.[5,12] A combination of such tests can improve the predictability of difficult airway to some extent.[7,8] However, a single, simple clinical test provides quick and easy assessment. TMHT, a relatively new clinical test proposed in 2013, was claimed be a more accurate predictor of difficult laryngoscopy than existing clinical tests when used alone.[9]

TMHT was found to have a distinctly high sensitivity (71.42%) as compared to that of MMT (57.14%), TMD (28.57%) and SMD (14.29%) in our study. Two out of the seven difficult laryngoscopy patients on C-L grading were missed by TMHT. This sensitivity value was slightly lower than Etezadi et al's findings (82.6%) but, nonetheless, it can be inferred that TMHT has a high detection rate for difficult laryngoscopy. The sensitivities obtained by Jain et al (75%), Nurullah et al (92.7%), Rao et al (84.62%) and) were also highest for TMHT.[11,18,19] However, a low sensitivity of 50% was observed by Majigoudar et al, attributed to variations in measurement of thyromental height due to slight flexion or extension of neck.[12] TMHT also showed the highest NPV (98.9%) in our study with only two 'difficult' laryngoscopies (false negatives) on C-L grading out of 187 detected as 'easy' (negative) by the test. This finding is consistent with other studies on TMHT.[9,11,18] However, the occurrence of a large number of false positives (54) in our study greatly reduced the specificity (77.4%), PPV (8.47%) and accuracy (77.2%) of TMHT in contrast to Etezadi et al's findings of 99.31%, 90.47%, 98.08% respectively. A few authors reported similar results as Etezadi et al.[11,18,19] Majigoudar et al, however, showed that specificity, PPV and accuracy for TMHT could be as low as 57%, 76% and 56.6% respectively. They attributed these variations to lack of a uniform definition of ideal head position in different studies during measurement of thyromental height.[12] Recently, Yabuki et al also observed that TMHT alone was not a strong predictor of difficult visualization of larynx in Japanese population because of relatively low sensitivity (49.3%), specificity (70.5%), PPV (18.6%) and accuracy (68%).[20] Further research in larger and diverse populations has been recommended before the predictive ability of TMHT can be completely validated.[12,20]

TMD was observed to have the maximum specificity (97.49%), PPV (25%) and accuracy (95.52%) in our study. However, its sensitivity (28.57%) was relatively low, which has also been shown in other clinical trials.[9,11,12,19] This limits its use as a sole predictor of difficult laryngoscopy because failure to detect a large number of actually difficult airways is an undesirable outcome. SMD test also had the highest specificity (97.49%) but low sensitivity and PPV which parallels the findings by Etezadi and Jain

et al.[9,11] SMD, also, did not produce significant results as a clinical test in our study. This may be attributed to the low prevalence of difficult laryngoscopy in general (7/246 in our study) which can limit the discriminatory value of these clinical tests leading to variable outcomes in different studies.

Although MMT was shown to be a test of significance in our study, with a good NPV (98.56%), the sensitivity (57.14%), specificity (85.77%), PPV (10.52%) and accuracy (84.96%) were either fair or poor. Similar results were obtained by Rao et al in a study comparing MMT with TMHT and TMD.[19] The results for sensitivity and specificity of MMT are also comparable to the results of a meta-analysis by Shiga et al (49% and 86%, respectively) who concluded that MMT, TMD and SMD had only poor to moderate discriminatory value as a screening test for difficult intubation when used alone.[21] MMT can only be performed in highly co-operative patients and its usefulness is limited by inconclusive results.[22] Recent evidences also suggest that it is a poor predictor of difficult intubation when used alone due to high inter-observer variability.[19]

All the tests have a high negative predictive value (>90%), indicating that they are good predictors of easy laryngoscopy and intubation, rather than positive predictors of difficult intubation which has a very low incidence. Hence, none of these methods qualify to become a reliable screening test which is expected to demonstrate high sensitivity and low false positive values.

This study, however, has certain limitations. The cut-off value of 50 mm for TMHT used in the study has been obtained from Etezadi et al's study findings in a different population.[9] Hence, there may be slight underestimation or overestimation of the calculated predictive values for TMHT obtained in this study which has not been considered. A larger sample size may be required to minimize these effects and also neutralize the effect of high variability of difficult airway prevalence in different population groups. An expensive electronic depth gauge has been used for the assessment of TMHT. A simple, inexpensive ruler could be designed and used instead. Also, the study has been conducted in patients undergoing anesthesia in elective surgery and therefore, the results may not be applicable in emergency anesthesia situations.

CONCLUSIONS

Despite low accuracy, specificity and PPV as compared to other common tests of difficult laryngoscopy, TMHT showed high sensitivity and NPV due to low number of false negative values which are both desirable attributes of a predictive test. A large number of false positives (actual easy laryngoscopy predicted as difficult) may do no harm but the consequence of a false negative value (actual difficult laryngoscopy predicted as easy) may be disastrous in airway management. This favors the application of Thyromental Height Test over other commonly used screening tests, though, it cannot be considered as a solely reliable and accurate predictor of difficult laryngoscopy in Nepalese population.

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