Clinical Investigation

Validation of modified Mallampati test with addition of thyromental distance and sternomental distance to predict difficult endotracheal intubation in adults

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ABSTRACT

Background and Aims: Intubation is often a challenge for anaesthesiologists. Many parameters assist to predict difficult intubation. The present study was undertaken to assess the validity of different parameters in predicting difficult intubation for general anaesthesia (GA) in adults and effect of combining the parameters on the validity. **Methods:** The anaesthesiologist assessed oropharynx of 135 adult patients. Modified Mallampati test (MMT) was used and the thyromental distance (TMD) and sternomental distances (SMD) for each of the patients were also measured. The Cormack and Lehane laryngoscopic grading was assessed following laryngoscopy. The validity parameters such as sensitivity, specificity, false positive and negatives values, positive and negative predictive values were calculated. The effect of combining different measurements on the validity was also studied. Univariate analysis was performed using the parametric method. **Results:** The study group comprised of 135 patients. The sensitivity and specificity of MMT were 28.6% and 93%, respectively. The TMD (<6.5 CM) had sensitivity and specificity of 100% and 75.8%, respectively. The SMD (<12.5 CM) had sensitivity and specificity of 91% and 92.7%, respectively. Combination of MMT grading and TMD and SMD measurements increased the validity (sensitivity of 100% and specificity of 92.7%). **Conclusion:** MMT had high specificity. The validity of combination of MMT, SMD and TMD as compared to MMT alone was very high in predicting difficult intubation in adult patients. All parameters should be used in assessing an adult patient for surgery under GA.

Key words: Anaesthesia, endotracheal intubation, modified Mallampatti test, validity

INTRODUCTION

Difficult or failed endotracheal intubations are one of the leading causes of anaesthesia-related morbidity and mortality. The incidence of difficult endotracheal intubation is 3.2%[1] and includes failed and difficult intubation, difficult laryngoscopy or difficult mask ventilation. This risk can be reduced if difficult airway is evaluated preoperatively.[2] Modified Mallampati grading (MMT) is a widely used preoperative evaluation. Other parameters of preoperative airway assessment including, thyromental distance, sternomental distance, cervical mobility and Inter-incisor-gap aid in assessing a difficult endotracheal intubation. The literature has shown uses of different preoperative measurement parameters in predicting difficult intubation. However, limited information is available on effect of combining these parameters in enhancing the validity parameters.

We undertook a study to compare MMT grading before surgery to the Cormack Lehane's grading (CLG) of difficulty in intubation during anaesthesia. We also evaluated the role of adding other measurements like thyro mental distance (TMD) and manubrium sterni to mentum distance (SMD) in enhancing the validity of

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MMT in predicting difficult intubation (based on CLG) in patients aged 15 years and older.

METHODS

The hospital research committee granted approval for this study. The study was conducted in 135 patients in a multi-specialty hospital between November and December 2010, aged 15 to 80 years requiring general anaesthesia with endotracheal intubation. In our hospital, children aged 15 years and older were grouped as adults. Hence for logistic reasons, we included patients aged 15 years and above as adults. Informed written consent was obtained from all patients. Patients with swelling, scars, contractures in front of the neck and those with pathological conditions making intubation a difficult task were excluded from the study. Data were collected on age, gender, weight, the type of surgical procedure and anaesthesia physical status (American Association of Anesthesiologists (ASA)).

The anaesthesiologist and patients sat at eye level and the patient opened his/her mouth as wide as possible with the tongue protruding. Depending on the visualization of the oropharyngeal structures, the patients were graded according to the MMT.[3] Grading the oropharynx was based on protruding maxillary teeth (overbite). With the patient in the sitting position with maximal extension of the head, the neck was palpated for thyroid notch. The distance between the thyroid notch and symphysis menti (TMD) was measured in centimetres with a measuring tape. With the patient in the sitting position and maximal extension of the head and the mouth closed, the straight distance between the upper border of the manubrium sterni and the bony point of mentum (SMD) was measured.[4] If TMD was less than 6.5 cm, it was considered as predictor for difficult intubation. If SMD was less than 12.5 cm, we considered it a predictor of a difficult intubation.

Of the 5,000 patients per month that undergo surgery in our institution, we assumed that 60% could correctly predict a difficult intubation through preoperative assessment.[5] For 95% confidence intervals and 10% precision with clustering effect of 1.5 due to different operation theatres (as the study sites), we required 136 patients in this validity study. To calculate the sample size, we used Open Source Epidemiologic Statistics for Public Health, Version 2.3.1. (Open Epi 2.3.1 - Sweden, Denmark).

An investigator performed a standard preoperative assessment and recorded the findings using a pretested data collection form. Another investigator who was not involved in preoperative assessment performed laryngoscopy without knowing the MMT outcomes of the patient. He documented the level of difficulty by grading the patient just prior to intubation and the actual difficulty during intubation using CLG. A statistician who was involved in analyzing the data was blinded to both the preoperative and intraoperative results.

Patients remained on an empty stomach for eight hours and glycopyrrolate 4 μg/kg and midazolam 20 μg/kg was given intravenously 15 minutes before surgery. For general anaesthesia, patients were given oxygen for 3 to 5 minutes. Subsequently, intravenous injection of fentanyl sodium (2 ug/kg) was administered, followed by a slow injection of propofol (2 mg/kg). After confirming that the patient could be ventilated by mask (100% oxygen given for 2-3 minutes), 1.5 mg/kg bolus of intravenous succinylcholine was administered. Neuromuscular relaxation was monitored and on confirmation, intubation was attempted. Before laryngoscopy, the head was extended on a 10 cm pack and neck was flexed to achieve the modified Jackson position. The laryngoscope was introduced and larynx visualized. The degree of visualization of larynx was classified according to the Cormack and Lehane laryngoscopic grading.[2]

A senior anaesthesiologist with at least two years of experience performed intubation. If on two or more attempts, inadequate glottis was visible or not visible at all, it was considered a difficult intubation. Different size of laryngoscope blades, McCoy blades, stylet, bougie, various size of mask, small size of endo-tracheal tubes, LMA, Combi-tube and Cricothyrotomy kit were part of difficult airway cart. Failed intubation was defined as inability to insert a tracheal tube from the oropharynx into the trachea. Details of the maneuvers during intubation were documented such as application of external pressure over the larynx, use of an extra-large blade of laryngoscope or stylet.

To assess the validity of MMT and TMD and SMD score, we calculated sensitivity, specificity, false positive, false negative, positive predictive and negative predictive values. The difficulty in endotracheal intubation for anaesthesia was the gold standard for assessing validity. As MPG is a categorical

variable, we used a 2 × 2 table to assess the validity parameters. The TMD and SMD measurements were continuous variables. Hence, the Receiver Operating Characteristic (ROC) curves were plotted to associate the sensitivity and the specificity. We also used the standards of TMD <6.5 cm and SMD <12.5 cm to define an abnormal length of the oropharynx that could negatively affect intubation. By clubbing these parameters to the MMT, we assessed the changes in the validity parameters. The Statistical Package for Social studies (SPSS version 12; IBM Corp., New York, NY, USA) was used for univariate analysis with the parametric method.

RESULTS

One hundred and thirty five patients (71 males and 64 females) participated in our study. The mean age of the participants was 29.7 ± 1.4 years. The mean weight of the participants was 54.9 ± 11.1 kg. Only two patients were graded ASA I anaesthesia risk and the remaining 133 cases were ASA II. Laparoscopic surgeries were planned for 61 patients. Other surgeries included orthopaedic (13 patients), ear nose and throat (ENT) (7 patients), urological (12 patients) and general surgeries (42 patients).

The incidence of difficult intubation was 8.1% (95% CI: 3.5-12.7)]. The mean age of patients classified as difficult intubation was 40.3 years [15.0 years standard deviation (SD)]. The mean age of patients not classified as difficult intubation was 30.7 years (10.7 years SD). The age difference in two groups was not statistically significant [Mean difference = 9.6 years; 95% CI: -0.6-19.8; $P > 0.05$].

The mean weight of patients classified under difficult intubation was 60.3 kg (13.1 kg SD). The mean weight of patients not classified as difficult intubation was 54.4 kg (10.8 kg SD). The weight difference between groups was not statistically significant [Mean difference = 5.86 kg; 95% CI: -1.0-12.9; $P > 0.05$].

The validity of MMT in predicting a difficult intubation was reviewed [Table 1]. The sensitivity of this assessment procedure was 27%. The sensitivity and specificity values of the TMD and SMD parameters to predict difficult intubation were studied with ROC curve. Both TMD and SMD parameters were highly sensitive [Figures 1 and 2].

The TMD of <6.5 cm predicted a difficult intubation in 41 cases. Eleven of these cases were 'difficult intubation'. All 94 cases in which the TMD was ≥ 6.5 cm, the intubation was performed without any difficulty. Thus the sensitivity and specificity of TMD measurement was 100% and 75.8%, respectively.

The SMD was <12.5 cm in 19 cases. Ten of these cases were a difficult intubation. Of these cases with SMD ≥ 12.5 cm, in only 1 out of 116 cases the intubation was difficult. Thus the sensitivity and specificity of SMD measurement was 91% and 92.7%, respectively.

By combining the parameters of TMD and SMD, we could increase the sensitivity and specificity parameters of predicting difficult intubation to 100% and 92.7%, respectively [Table 2].

By combining MMT and (TMD + SMD) parameters, the sensitivity and specificity of predicting a difficult intubation increased to 100% and 93%, respectively.

DISCUSSION

By combining parameters thyromental and steromental distance measurement to the modified Mallampati Test (MMT) outcomes, the sensitivity to predict difficult intubation increased from 27% to 100% and the specificity remained 93%. In view of high predictive values of the combined test, our study results could be applied to adult population with ASA II and II undergoing surgery under general anaesthesia.

Table 1: Validity of modified Mallampati test method of predicting difficulty in endotracheal intubation

	Grade	Difficulty in endotracheal intubation		Total
		Difficult	Not difficult	
Modified Mallampati test	III and IV	2	9	11
	I and II	5	119	124
		7	128	135

Sensitivity=2/7×100=28.6, Specificity=119/128×100=93.0, False positive=5/7×100=71.4, False negative=9/128×100=7.0, Positive predictive value=2/11×100=18.2, Negative predictive value=119/124×100=96.0

Table 2: Validity of combining all parameters in predicting difficult endotracheal intubation

	Grade	Difficulty in endotracheal intubation		Total
		Difficult	Not difficult	
All predictors together MMT+TMD+SMD	II and III	7	4	11
	I	1	123	124
		8	127	135

Sensitivity=7/8×100=87.5%, Specificity=123/127×100=96.9%, False positive=1/8×100=12.5, False negative=4/127×100=3.1%, Positive predictive value=7/11×100=63.6%, Negative predictive value=123/124×100=99.2%

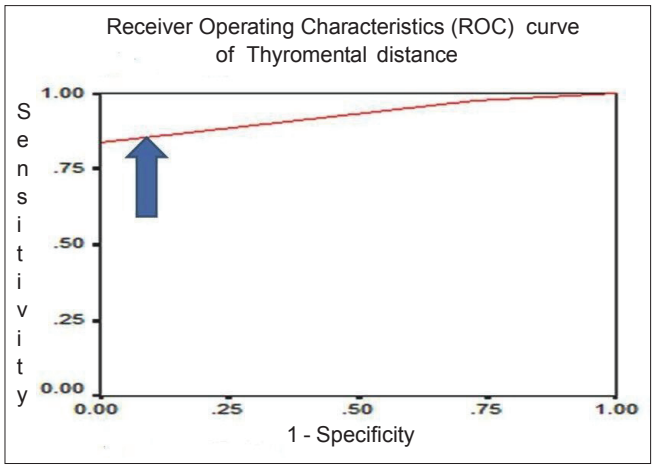

Figure 1: Validity of 'Thyro-Mental Distance' in predicting difficulty in endotracheal intubation. Sensitivity = 90% and specificity = 90%

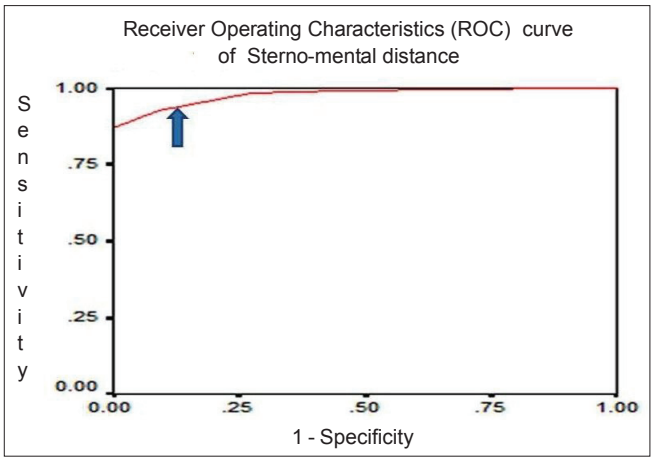

Figure 2: Validity of 'Sterno Mental Distance' in predicting difficulty in endotracheal intubation. Sensitivity = 80% and specificity = 90%

The incidence of a difficult laryngoscopy or intubation varies from 1.5 to 13% and failed intubation has been identified as one of the causes of death or permanent brain damage related to anaesthesia.[2] Problems in airway management can be predicted based on previous anaesthesia records, the medical history of the patients and a physical examination. Several radiologic measurements were reported to be associated with a difficult intubation. However, simple clinical examination is a widely used method to predict difficult intubation.

The incidence of difficult intubation in our study was 8.3%. The validity of MMT to predict a difficult intubation was low. The addition of TMP and SMT to MMT for preoperative assessment improved the validity of predicting difficult intubations.

In a study with a large sample size, researchers noted that the combination of MMT and TMD were good predictors of a difficult laryngoscopy in the Thai population.[5] However, they had used TMD <6 cm as a parameter instead of <6.5 cm used in the current study. In another study, investigators assessed Chinese females who were pregnant and those who were not pregnant and found that the combination of predictive variables could improve the validity.[6] A study from the USA found that by using as many as ten measurements, aggregate set of variables improved predictability of a difficult intubation.[7] Iohom *et al*. performed a study in Ireland and noted that the validity of positive predictive value of MMT increased from 27 to 100% after combining other predictors.[8] In contrast, the combination of MMT and TMD was not an adequate predictor of a difficult intubation in a study by Koh *et al*.[9]

The validity parameters could be affected by the rate of outcome variables prevalent in the population under study.[10] It was 8.1% in our study. Langaron *et al*. found it to be 6.1%.[4] The incidence ranged between 1.5% and 8%.[11] The higher rate of difficult intubation in our study with Indian population is worth noting, as we had not specifically included bariatric cases.[12] Perhaps, racial differences resulting in different anatomical features of oropharynx and larynx could be responsible for variability of difficult intubation among different studies.

Age and weight in our study was not different among those who had a difficult intubation compared to those who did not have a difficult intubation. Therefore, we did not attempt to use them as predicting factors. Sheff *et al*.[11] also found that body mass index (BMI) was not a predictor of difficult intubation. Older age was a predictor of difficult intubations in Turkey.[13]

The validity of the MMT and TMD varies widely. The sensitivity ranged from 42 to 91% while specificity ranged between 66% and 84%.[14] The TMD although is a more valid measurement for predicting a difficult intubation and it is influenced by height of patient.[15,16] The lack of data related to height due to clerical error in data management in our study was a limitation. We could not calculate BMI and role of height in predicting a difficult intubation.

Tripathi *et al*. used ≤ 5 cm TMD value whereas Khan *et al*. used SMD value of 13 cm in their respective studies.[17,18] This was different from the measurement of ≤ 6.5 cm for TMD and ≤ 12.5 cm for SMD used in our study. A lack of standardized TMD and SMD

values to categorize the patients has resulted in wide variation of predictability for a difficult intubation.

A more appropriate determination of validity is to conduct analysis using ROC and AOC parameters instead of categorizing it as continuous variable.[19] We therefore plotted ROC of TMD and SMD. This has been reported in previous studies; however, they used a ratio of height and thyromental distance to find the validity of a continuous variable.[15,16,20]

We conducted MMT in a sitting position. Singhal *et al*. proposed that the MMT shows higher grades if the patient is assessed in the supine instead of sitting position.[21] Intubation usually is performed in the supine position and hence validity of MMT measured in the sitting position was not helpful in accurately predicting a difficult intubation.

Adherence to the principles of the difficult airway management algorithm and widespread adoption of a precise plan for management of airway difficulties should result in reduction of respiratory catastrophes and a decrease in anaesthesia-related morbidity and mortality.[22]

CONCLUSION

MMT had high specificity. The validity of combination of MMT, SMD and TMD as compared to MMT alone was very high in predicting difficult intubation in adult patients. All the three parameters should be ideally used in assessing airway in adult patients for surgery under GA.

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