ORIGINAL ARTICLE

Clinical comparison of five different predictor tests for difficult intubation

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ABSTRACT

Introduction: The objective of this study was to compare various bedside tests including Modified Mallampati Test (MMT), thyro mental distance (TMD), sternomental distance (SMD), Inter Incisor Gap (IIG) and combination of the modified Mallampati test and thyromental distance for predicting difficult intubation.

Methodology: A cross sectional study was conducted on 301 nonobese patients (18-72 years of age) without obvious airway pathology. All patients belonged to the American Society of Anesthesiology (ASA) class 1 or 2 and were scheduled for elective surgery that required general anesthesia. Airway assessment was performed and the appropriate scores were assigned for each predictor test. Difficult intubation was defined as Grade III or IV based on the Cormack- Lehane classification on laryngoscopic view.

Results: All tests except TMD (71.43%) showed very poor sensitivity and very high specificity. Area under the curve was good (0.8 to 0.9) for all the tests. Posttest probability showed that all of the bedside tests have limited clinical value.

Conclusion: All four predictor tests for difficult intubation have only poor to moderate discriminative power when used alone. Combination of Modified Mallampati and Thyromental distance test adds some incremental diagnostic value in comparison to the value of each test alone.

Key words: Anesthesia, Evaluation studies, Intubation

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INTRODUCTION

Difficult intubation is defined as the need for more than three attempts for intubation of the trachea or more than 10 min to achieve it, a situation that occurs in between 1.5 and 8% of general anesthesia procedures.[1,2] It is a frequent cause of morbidity and mortality resulting from anesthesia.[3,4] Up to 30% of anesthetic deaths can be attributed to a compromised airway.[3] It is important for the anesthesiologist to recognize this problem during the preoperative examination.[5-7] This has generated the need for highly predictive tests for the identification of an airway with assumed intubation difficulty to be applicable in all anesthetic and surgical procedures.[8,9]

Numerous investigators have attempted to predict difficult intubation by using a simple bedside physical examination. Mallampati et al.[10] introduced in 1985 a currently well-known screening test that classifies visibility of the oropharyngeal structures. This test was subsequently modified and became known as the Modified Mallampati Test (MMT). The distance from the thyroid notch to the mentum is known as the Thyromental Distance (TMD). The distance from the upper border of the manubrium sterni to the mentum is known as the Sternomental Distance (SMD). These tests and the upper lip bite test are widely recognized as tools for predicting difficult intubation.[11,12] Wilson et al[12] studied a combination of different risk factors contributing to difficult intubation assigning scores. Wilson risk sum score combined five physical factors including weight, head and neck movement, jaw movement (inter incisory gap measured in mouth fully open and subluxation of lower incisors), receding mandible, protruding maxillary anterior teeth. Each risk factor was given three possible scores (0, 1 or 2). A total score greater than 2 predicts a greater chance of difficult intubation. Nevertheless, the diagnostic accuracy of these screening tests has varied from trial to trial,[13] probably because of differences in the incidence of difficult intubation, inadequate statistical power, different test thresholds, or differences in patient characteristics.[9] In a meta-analysis Shiga, et al[9] showed that, the most useful bedside tests for prediction was found to be a combination of the modified Mallampati classification and thyromental distance (MMT + TMD).

The objective of this study was to compare various bedside tests including Modified Mallampati Test (MMT), thyro mental distance (TMD), sternomental distance (SMD), Inter Incisor Gap (IIG) and combination of the modified Mallampati test and thyromental distance for predicting difficult intubation in nonobese patients with no airway pathology. Clinical value of all above mentioned tests was compared using ROC analysis. A receiver operator curve (ROC) was plotted and the Area under the curve was calculated for each predictor test for comparison. Posttest probability was calculated and compared for each test.

METHODOLOGY

After obtaining institutional ethics committee approval, a cross-sectional study was conducted at Pravara Institute of Medical Sciences, Loni (India) during the period from September 2011 to October 2012 on three hundred and one patients of age group between 18 to 72 and of both sexes, of ASA Class I or II, and scheduled for an elective surgical procedure that required general anesthesia. Every fourth patient willing to participate and fulfilling our criteria was included. Obese patients (BMI >30), pregnant women, patients having severe systemic disorder including diabetes mellitus, hypertension, and heart disease changing ASA class to more than II, and those with rheumatoid arthritis and collagen diseases were excluded from the study. Patients having obvious airway pathology like swellings or tumors in or around oral cavity, abnormal teeth like buck teeth or loose or missing teeth were also excluded.

All patients were assessed on the evening before surgery by a single observer (third Author).

Data was collected on an information flow chart designed for this purpose. General data was obtained such as, age, sex, type of surgery to be performed, ASA class and presence of added pathologies. Airway assessment was done and the score was assigned for each predictor test as shown in Table 1 and Figures 1 to 3 Anesthesia was induced with fentanyl (2 μg/kg), pentothal sodium (5 mg/kg) and pancuronium or vecuronium (80-100 μg/kg) after preoxygenation with 100% oxygen. After induction of anesthesia and full relaxation of cords with muscle

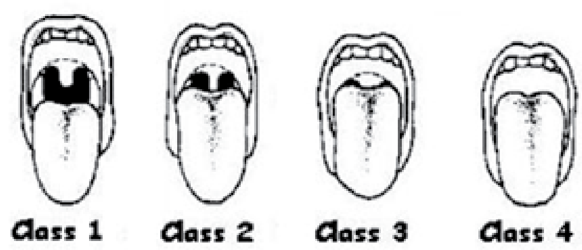


Figure 1: Modified Mallampati scale

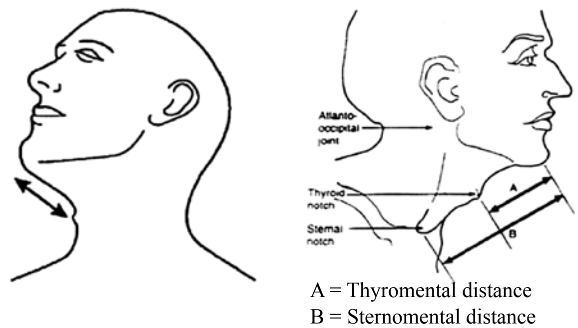


Figure 2: Patil-Aldreti scale (Thyromental distance)

Figure 3: Inter Incisor Gap

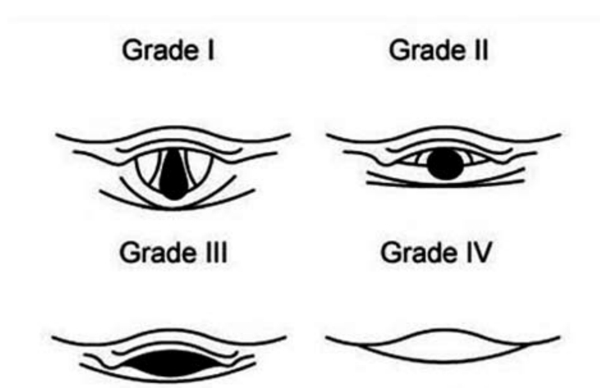


Figure 4: Cormack-Lehane classification on Laryngoscopic view

Table 1: Scales used in the prediction of difficult airway

Predictive test	Technique	Classification
Modified Mallampati scale	Patient seated with head in complete extension, carrying out phonation and with the tongue protruding out	Class I: visibility of soft palate, uvula and amygdaline pillars Class II: visibility of soft palate and uvula Class III: visibility of soft palate and base of uvula Class IV: impossibility of visualizing soft palate
Patil-Aldreti scale (Thyromental distance)	Patient seated, head extended and mouth closed, distance that exists between the thyroid cartilage (upper recess) and the lower border of the chin is evaluated	Class I: >6.5 cm Class II: 6 -6.5 cm Class III: <6 cm
Sternomental distance	Patient seated, head in complete extension and mouth closed, distance of a straight line going from the superior border of the manubrium of the sternum to the point of the chin is evaluated	Class I: >13.5 cm Class II: 12-13.5 cm Class III: 10-12 cm Class IV: <10 cm
Inter Incisor Gap	Distance between incisors when mouth fully open	Class I : > 3.5 cm Class II : ≤ 3.5 cm
Cormack-Lehane classification	Direct laryngoscopy is carried out, grade of difficulty achieving endotracheal intubation according to visualized anatomic structures is evaluated	Grade I: Glottic ring is observed in total (intubation very easy) Grade II: Commissure or upper half of glottic ring is observed (difficult) Grade III: Only epiglottis is observed with visualization of the glottic opening (very difficult) Grade IV: impossible to visualize the epiglottis (intubation only possible with special techniques)

Table 2: Cormack-Lehane classification according to age and sex

Study parameter		Cormack-Lehane Class I and II N=280	Cormack-Lehane Class III and IV N=21
Age yrs (Mean ± S.D.) and Range		36.75 ±13.90 (18–72)	38.28 ± 11.92 (22–60)
Sex	Male	85(28.24%)	4(1.33%)
	Female	195(64.78%)	17(5.65%)

relaxant direct laryngoscopy was done with Macintosh blade of proper size by another anaesthesiologist (fourth Author) who was blinded to the preoperative assessment. Glottic exposure was graded as per Cormack Lehane classification on laryngoscopic view [14] as shown in Table 1 and Figure 4. Difficult intubation was defined as a grade III or IV. Cormack-Lehane grade I and II were considered as normal easy intubation. In the cases of difficult intubation we proceeded according to the algorithm for airway management established by the ASA.[8] Monitoring of these patients included continuous EKG, noninvasive arterial blood pressure, pulse oximetry and capnography.

Statistical Analysis: Statistical analysis was done with Stata 10 software. We performed a calculation of sensitivity (S), specificity (Sp), positive predictive value (PPV) and negative predictive value (NPV), positive likelihood ratio (+LR) and negative likelihood ratio (-LR) using 2 x 2 contingency tables. A receiver operator curve (ROC) was plotted and the Area under the curve was calculated for each predictor test for comparison. Posttest probability was calculated for each test. A prevalence rate of 6.98% was used for the calculation of pretest and posttest probability. Cut off point for considering predictor test as positive was taken as class ≥ III for MMT, ≤ 6.5 cm (class II and III) for TMD, ≤ 13.5 cm (class II, III and IV) for SMD and ≤ 3.5 cm (Class II) for IIG. These cut off points for different positive tests were chosen considering their previous use by many of the earlier studies.[9]

RESULTS

Table 2 shows age and sex wise distribution of all patients. Females represented 70.43% of the sample population and males represented the remaining 29.57%. Both the easy and difficult intubation groups were comparable regarding age and sex wise distribution. ($p > 0.05$). Frequency distribution of different grades of all tests is shown in Table 3. All

Table 3: Frequency analysis of different predictor tests

Predictor Test	Classification	Number	%	Cormack-Lehane Grade I & II	Cormack-Lehane Grade III &IV
MMT	I	194	64.45	193	1
	II	101	33.55	85	16
	III	5	1.66	2	3
	IV	1	0.34	0	1
	Total	**301**		**280**	**21**
TMD	I	253	84.05	247	6
	II	40	13.29	27	13
	III	8	2.66	6	2
	Total	**301**		**280**	**21**
SMD	I	295	98.01	277	18
	II	4	1.33	1	3
	III	0	0	0	0
	IV	2	0.66	2	0
	Total	**301**		**280**	**21**
IG	I	265	88.04	25	11
	II	36	11.96	275	10
	Total	**301**		**280**	**21**
Cormack-Lehane classification	I	224	74.42	Easy intubation	
	II	56	18.60		
	III	16	5.32	Difficult intubation	
	IV	5	1.66		
	Total	**301**			

MMT = Modified Mallampati Test TMD = Thyro Mental Distance test
SMD = Sterno Mental Distance test IIG = Inter Incisor Gap test

tests except TMD showed very poor sensitivity. MMT had a sensitivity of 19.05%, SMD of 14.29% and IIG of 52.38%. Only TMD showed a sensitivity of 71.43%, which increased to 76.19% after combining MMT and TMD. All of the tests, however, had very high specificity. Receiver operator characteristic curves are a plot of false positives against true positives for all cut-off values.

The area under the curve of a perfect test is 1.0 and that of a useless test, no better than tossing a coin, is 0.5. In general ROC with area under the curve 0.5 to 0.7 is associated with marginally useful test, an area of 0.7 to 0.9 with a good test, and an area greater than 0.9 with an excellent test. The area under the curve was good for all the tests and this is shown in Table 5 and Figure 5. All tests had area under the curve more than 0.8 and less than 0.9. Posttest probability changes are shown in Table 6. A positive MMT increases the posttest probability to 58.68% from the pretest probability of 6.98%, a positive TMD increases the posttest probability to 30.75%, a positive SMD to 51.22% and a positive IIG to 30.24%. A combination of MMT + TMD increases it to 32.19%. Negative MMT and SMD reduce the posttest probability very marginally to 6.15% and 6.13%, respectively, from 6.98%. While a negative TMD reduces it to 2.42% and combination of MMT + TMD further reduces it to 1.98%

DISCUSSION

The incidence of difficult intubation observed in our study was 6.98% and this is in agreement with other studies analyzed by Shiga et al.[9] who found the overall incidence of difficult intubation to be 5.8% (95% confidence interval, 4.5–7.5%) in normal nonobese nonpregnant patients. Obviously predicting difficult intubation in apparently normal patients is highly essential. For a predictor test to be clinically useful to the anesthesiologist it must predict the chance of difficult intubation with certainty (very high sensitivity). It should have minimal false negative results avoiding false security and minimizing incidences of unexpected difficult intubation for which the anaesthesiologist is not fully prepared physically or

Table 4: Comparison of different predictor tests for difficult intubation

Predictor test	Sensitivity	Specificity	PPV	NPV	+ L.R.	- L.R.
MMT	19.05	99.28	67	94	19	0.82
TMD	71.43	88.21	31.25	97.63	5.92	0.33
SMD	14.29	98.93	50	93.90	14	0.87
IIG	52.38	91.07	30.56	96.23	5.78	0.53
MMT + TMD	76.19	87.50	31.37	98	6.33	0.27

MMT = Modified Mallampati Test; TMD = Thyro Mental Distance test; SMD = Sterno Mental Distance test; IIG = Inter Incisor Gap test
PPV = Positive Predictive Value; NPV = Negative Predictive Value; + L.R = Positive Likelihood Ratio; -L.R= Negative Likelihood Ratio

Table 5: First alphabets of 'operator curve' capital

Predictor Test	Area	Std. Error [a]	Asymptotic Sig. [b]	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
MMT	0.847	0.037	0.000	0.775	0.919
TMD	0.895	0.024	0.000	0.849	0.941
SMD	0.805	0.049	0.000	0.708	0.902
IIG	0.860	0.032	0.000	0.797	0.922

MMT = Modified Mallampati Test; TMD = Thyro Mental Distance test
SMD = Sterno Mental Distance test; IIG = Inter Incisor Gap test

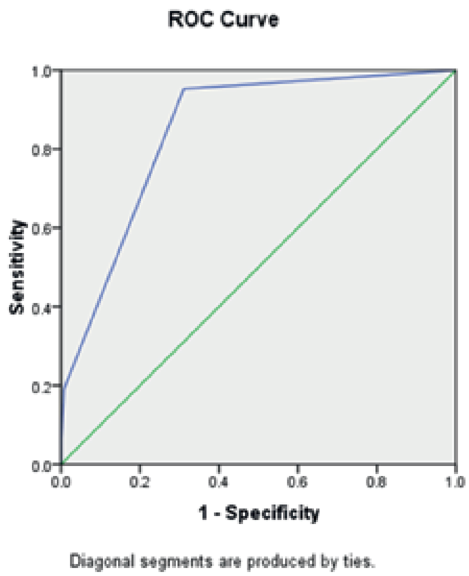
Table 6: First alphabet of 'Posttest' small

Test		Pretest probability Percent	Pretest odds	Pretest odds * LR	Post test Probability percent
MMT	Positive	6.98	0.075	1.43	58.68
	Negative	6.98	0.075	0.0615	6.15
TMD	Positive	6.98	0.075	0.444	30.75
	Negative	6.98	0.075	0.0247	2.42
SMD	Positive	6.98	0.075	1.05	51.22
	Negative	6.98	0.075	0.065	6.13
IIG	Positive	6.98	0.075	0.433	30.24
	Negative	6.98	0.075	0.039	3.82
MMT + TMD	Positive	6.98	0.075	0.474	32.19
	Negative	6.98	0.075	0.020	1.98

MMT = Modified Mallampati Test; TMD = Thyro Mental Distance test
SMD = Sterno Mental Distance test; IIG = Inter Incisor Gap test

mentally. On the other hand a false positive test will do less harm than a false negative because an easy intubation in the predicted event of a difficult intubation will not be hazardous. Keeping this in mind we compared four different tests with respect to their clinical value. We found TMD to have the highest sensitivity (71.43%) among all four individual tests and the combination test of MMT + TMD to have a higher sensitivity of 76.19%. MMT and SMD had poor sensitivity (19.05% and 14.29%, respectively). All the tests showed high specificity highest being 99.28% with MMT and lowest being 87.50% with MMT + TMD. A meta-analysis of 32 studies on 50760 patients[9] showed that each test yielded poor to moderate sensitivity (20–62%) and moderate to fair specificity (82–97%). The most useful bedside test for prediction was found by Shiga T et al [9] to be a combination of the Mallampati classification and thyromental distance (positive likelihood ratio, 9.9; 95% confidence interval, 3.1–31.9). Our results are concurrent to them.

The relatively crude measures of sensitivity and specificity fail to take into account the cut-off point for a particular test. If the cut-off point is raised, there are fewer false positives but more false negatives—the test is highly specific but not very sensitive. Similarly, if the cut-off point is low, there are fewer false negatives but more false positives—the test is highly sensitive but not very specific.[15] Receiver operator characteristic curves (so called because they were originally devised by radio receiver operators after the

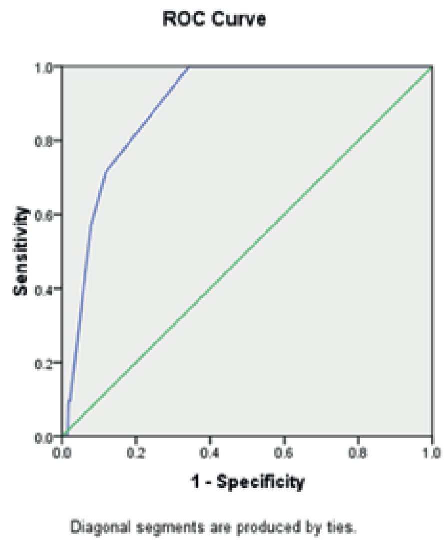


The line in blue color shown in the graph represents the ROC for Modified Mallampati Test (MMT)

Area under the curve: 0.847

The line in green color shown in the graph represents the line of zero discrimination with an AUC of 0.5.

Figure 5-a: Receiver operator curve (ROC) for Modified Mallampati Test (MMT)

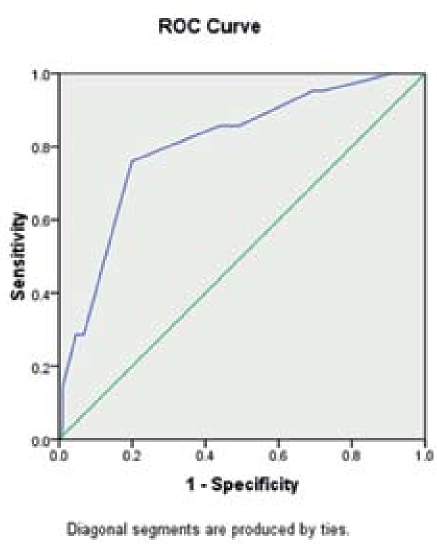


The line in blue color shown in the graph represents the ROC for Thyro Mental Distance test (TMD)

Area under the curve: 0.895

The line in green color shown in the graph represents the line of zero discrimination with an AUC of 0.5.

Figure 5-b: Receiver operator curve (ROC) for Thyro Mental Distance test (TMD)

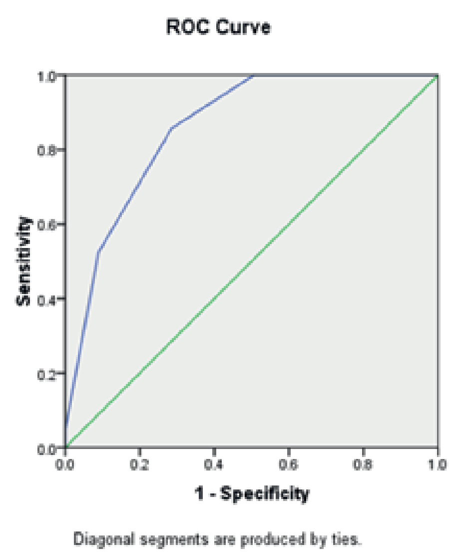


The line in blue color shown in the graph represents the ROC for Sterno Mental Distance test (SMD)

Area under the curve: 0.805

The line in green color shown in the graph represents the line of zero discrimination with an AUC of 0.5.

Figure 5-c: Receiver operator curve (ROC) for Sterno Mental Distance test (SMD)



The line in blue color shown in the graph represents the ROC for Inter Incisor Gap test (IIG)

Area under the curve: 0.860

The line in green color shown in the graph represents the line of zero discrimination with an AUC of 0.5.

Figure 5-d: Receiver operator curve (ROC) for Inter Incisor Gap test (IIG)

attack on Pearl Harbour to determine how the US radar had failed to detect the Japanese aircraft) are a plot of (1 - specificity) of a test on the x-axis against its sensitivity on the y-axis for all possible cut-off points.[15] The area under this curve (AUC) represents the overall accuracy of a test, with a value approaching 1.0 indicating a high sensitivity and specificity and a value of 0.5 indicating a useless test, no better than tossing a coin.

For a better comparison of all tests, we did ROC analysis and plotted the graphs. (Figures 5-a through 5-d). The line in green color shown in the graph represents the line of zero discrimination with an AUC of 0.5. It is drawn for comparison of ROC of particular test shown in blue color. ROC analysis of all the tests shows that no test is excellent. All the four tests are good and comparable showing Area under the curve between 0.805 to 0.895. Likelihood ratios (LRs) constitute one of the best ways to measure and express diagnostic accuracy. They provide a way to estimate the pre- and Posttest probabilities of having a condition. With Pretest probability and likelihood ratio given, then, the Posttest probabilities can be calculated. When a clinician decides to order a diagnostic test, he wants to know which test (or tests) will best help him rule-in or rule-out disease in his patient. In the language of clinical epidemiology, he takes his initial assessment of the likelihood of disease ("Pretest probability"), do a test to help him shift his suspicion one way or the other, and then determine a final assessment of the likelihood of disease ("Posttest probability"). We applied the same principle over here to compare the clinical value of all the tests equating disease with difficult intubation. Clinical value of the test depends upon the fact that how much it helps to increase or decrease posttest probability.

When we compare clinical value of all the tests it is seen that all positive tests have limited clinical value. A positive MMT enhances posttest probability to 58.68%, positive TMD to 30.75 %, positive SMD to 51.22% and positive IIG to 30.24 % from pretest probability of 6.98%. Even a combination of MMT + TMD increases it to 32.19%. On the other hand negative tests have good screening value. Though a negative MMT and SMD reduce the posttest probability very marginally, negative TMD that reduces it to 2.42 has a good screening value. The combination of MMT + TMD further reduces the Posttest probability to 1.98. As no predictor test either singly or in combination reduces Posttest probability to zero percent, still there are many instances of unexpected difficult intubation for which anaesthesiologist has to remain alert. Wilson [16] stated, "No test is likely to be perfect, therefore, it remains essential that every anesthetist must be trained and equipped to deal with the now much less common, unexpected failure to intubate." We also agree with Shiga et al. [9] who stated, "attempts at prediction are much less important than knowing what to do when difficulty is encountered.

CONCLUSION

In conclusion, all four predictor tests for difficult intubation have only poor to moderate discriminative power when used alone. Combination of Modified Mallampati and Thyromental distance test adds some incremental diagnostic value in comparison to the value of each test alone.

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