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Modified Mallampati Test, Sternomental Distance, and Thyromental Distance for Prediction of Difficult Intubation in Patients Undergoing General Anaesthesia

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Abstract
Background and Objectives: *Airway management is the fundamental responsibility of every anesthesia-logist. Difficult intubation is one of the major causes of anesthesia-related morbidity and mortality. The risk and complications related to difficult intubation can be reduced if difficult airway is anticipated preoperatively. There are many simple bed side tests to predict difficult intubation preoperatively. There are several studies comparing the different preoperative bedside tests in predicting difficult intubation with varying results. However, limited information is available on effect of combining these parameters in enhancing the preoperative prediction of a difficult airway*
Aim: *To assess the validity and efficacy of modified Mallampati test (MMT), sternomental distance (SMD), Thyromental distance (TMD) individually and in combination in predicting difficult intubation.*
Methodology: *This is an observational study, conducted in the **d**epartment of Anaesthesiology Government Medical College Thiruvananthapuram, a tertiary care centre . 305 Patients aged between 18 to 65 years, undergoing elective major surgeries in Govt: Medical College Hospital, Thiruvananthapuram, Kerala, were selected as the study population. The airway was assessed by Modified Mallampati test (MMT), class III & IV were considered as difficult intubation. Thyromental distance (TMD) of every patient was recorded. A measurement of less than 6.5 cm was considered to be a predictor of difficult intubation. Sternomental distance (SMD) was measured and a measurement of less than 12.5cms was considered to be a predictor of difficult intubation.*
A senior anesthesiologist with more than three years of experience assessed the laryngeal view by direct laryngoscopy using Cormack &Lehane grading during intubation. Grade 3 and 4 was considered difficult laryngoscopy and intubation.
The validity parameters such as sensitivity, specificity, false positive and negative values, positive predictive value (PPV) and negative predictive value (NPV) were calculated. The effect of combining different measurements on the validity was also studie

Results
MMT: Sensitivity 40.7%, Specificity 92.4%, PPV 34.4%, NPV 94.1%, Accuracy 87.9%
SMD: Sensitivity 81.5%, Specificity 93.9%, PPV 56.4%, NPV 98.1%, Accuracy 92.8%
TMD: Sensitivity 88.9%, Specificity 80.9%, PPV 31.2%, NPV 98.7%, Accuracy 81.6%
MMT + SMD: Sensitivity 100.0%, Specificity 86.7%, PPV 42.2%, NPV 100.0%, Accuracy 87.9%
MMT + TMD: Sensitivity 96.3%, Specificity 75.2%, PPV 27.4%, NPV 99.5%, Accuracy 77.0%
SMD + TMD: Sensitivity 92.6%, Specificity 78.4%, PPV 29.4%, NPV 99.1%, Accuracy 79.7%
MMT + SMD + TMD: Sensitivity 100.0%, Specificity 72.7%, PPV 26.2%, NPV 100.0%, Accuracy 75.1%
Conclusion: *TMD had high sensitivity. MMT and SMD had high specificity. The validity and efficacy of combination of MMT and SMD as compared to any single test alone was very high in predicting difficult intubation. Efficacy of combining MMT, SMD and TMD is also significantly higher than any single test. Hence all the three tests should be ideally used in assessing the airway in adult patients for surgery under GA.*
Keywords: *endotracheal intubation, larngoscopy, mallampati test, sternomental distance, thyromental distance.*

Introduction

Airway management is the fundamental responsibility of every anaesthesiologist. Difficult intubation is one of the major causes of anaesthesia-related morbidity and mortality. Difficult laryngoscopy (characterized by poor glottic visualization) is synonymous with difficult intubation in most patients [1]. Difficult intubation is described in 1.5-13% of patients [2]. The prevalence of a difficult intubation or a difficult laryngoscopy varies between 0.7% and 31.3% [3]. Intubation difficulties and problems with airway management during emergence remain among the leading causes of serious intraoperative problems, [4] and it has been estimated that inability to manage successfully very difficult airways is responsible for as many as 30% of deaths totally attributable to anesthesia[5] [6]. Generally, failed tracheal intubation occurs once in every 2230 attempts. [7]

Most of the airway catastrophes have occurred when difficulty with the airway was not recognized[8]. The risk and complications related to difficult intubation can be reduced if difficult airway is anticipated preoperatively. Therefore, airway assessment is an integral part of pre-anesthetic evaluation, as it helps in recognizing a potentially difficult airway. Most of the predicted cases of difficult intubation are found after clinical examination and application of simple clinical tests[9]. A range of bedside screening tests are available to predict a difficult airway. These include Modified Mallampati test, Thyromental distance, Sternomental distance, Upper lip bite test, Cervical mobility, Inter-incisor-gap, Mandibular length, Ratio of height to sternomental distance, Mentohyoid distance, Retrognathia, TMJ movement etc. There are several studies comparing the different preoperative bedside tests in predicting difficult intubation with varying results. However, limited information is available on effect of combining these parameters in enhancing the preoperative prediction of a difficult airway

We thus undertook this study to find out the validity of different tests namely modified Mallampati (MMT) test, sternomental distance (SMD), and Thyromental distance (TMD) individually and in combination in predicting difficult intubation in people of Thiruvananthapuram who underwent elective surgeries under general anaesthesia

Materials and Method

The study was an observational study conducted in the **d**epartment of Anesthesiology Government Medical College Thiruvananthapuram for a period of 1 year , after obtaining the approval of the institutional ethical committee

Study population

Patients undergoing elective major surgeries under general anesthesia with cuffed oral endotracheal

tube, in Medical College Hospital, Thiruvananthapuram, Kerala.

Inclusion Criteria

- Patients undergoing elective surgery under general anesthesia.
- Patients of either gender between age of 18 years and 65 years
- ASA grade 1 and 2.

Exclusion Criteria

- Emergency surgeries.
- ASA grade 3 and 4.
- Pregnant patients.
- Body Mass Index more than 30.
- Patients with known abnormalities or obvious malformations of the airway, with head or neck trauma, edentulous patients.

Sample size and sampling technique

Sample size is calculated based on the following assumptions,

i. Proportion of difficult intubation is 31% .
ii. Sensitivity and specificity of Sternomental distance measurement is 91% and 92.7% respectively.

305 patients were selected using simple random sampling technique

Methodology

After the approval of the institutional ethical committee, a minimum of 305 patients aged between 18 to 65 years, scheduled for elective surgery requiring general anesthesia were selected by purposive sampling technique.

Pre anesthetic checkup were done on the previous day of the surgery and routine investigations carried out.

Informed written consent was taken after explaining the procedure to the patient

Preoperative Airway assessment was done using Modified Mallampati test, Sternomental distance measurement and Thyromental distance measurement.

Modified Mallampati test was done by instructing the patient, to sit with head in neutral position with their mouth open as wide as possible and tongue protruded, while the observer looking from the patient's eye level will inspect the pharyngeal structures with a pen torch, without the patient phonating and oropharyngeal view graded. Class III & IV were classified as difficult intubation.

Thyromental distance was recorded by using a measuring tape to measure the distance between the mentum of the mandible to thyroid notch in the mid-line with neck in full extension with mouth closed. It was measured twice and average of the values taken for the sake of accuracy. A measurement of less than 6.5 cm was considered to be a predictor of difficult intubation.

Sternomental distance was recorded by using a measuring tape to measure the distance between the sternal notch and the point of chin with neck in full extension and mouth closed. It was measured twice and average of the values taken for the sake of accuracy. A measurement of less than 12.5cms was considered to be a predictor of difficult intubation.

Premedication was given the night before and on the day of surgery with sips of water 2hrs before the scheduled time: Tab Pantoprazole 40mg+Tab Midazolam 0.5mg. Patients were kept nil oral overnight before surgery

Patients were shifted on day of surgery to OT, monitors connected, baseline values of non-invasive blood pressure, heart rate, ECG, oxygen saturation recorded, 18 G IV line secured, premeditated with Inj Metoclopramide (0.5mg/kg body weight), Inj Fentanyl (1.5 µg/kg body weight), Inj Midazolam (0.02mg/kg bodyweight), Inj Glycopyrolate (0.004mg/kg body weight), followed by preoxygenation for 3mins. Inj Lignocaine (1mg/kg body wt.) given. Induced with Thiopentone (5 mg/kg body wt.) given over 20 seconds after confirming adequate ventilation and sedation, Vecuronium (0.1mg/kg body weight) given. Ventilation will be assisted for 3 minutes. Macintosh blade, size 3 or 4 blade size, was used for intubation by a senior

anesthesiologist with more than three years' experience and laryngeal view assessed using Cormack & Lehane grading. Patients were then intubated with appropriate sized cuffed oral endotracheal tube, secured after confirming bilateral equal air entry, and anesthesia maintained. Failed intubation was encountered in none of these patients.

The efficacy of direct laryngoscopy is measured in terms of the best view the larynx achieved.

The most widely used scale is that described by Cormack and Lehane (CL) The definitions used are grade 1, most of the glottis is visible; grade 2, only the posterior extremity of the glottis is visible; grade 3, no part of the glottis and only the epiglottis is visible; and grade 4, not even the epiglottis can be seen. The most useful modification is a sub classification of grade 3 into 3a when the epiglottis can be lifted from the posterior pharyngeal wall and 3b when it cannot be lifted.

Statistical analysis is done using computer software "Software Statistical Package for Social Sciences (SPSS) version 16 "

Sensitivity, specificity, PPV, NPV, accuracy of each test are calculated and compared.

Analysis and Results

Sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of each test are calculated. Three hundred and five ASA 1 and ASA 2 patients in the age group 15 – 60 years scheduled for elective surgical procedures requiring endotracheal intubation were included in the study. Out of the 305 patients included in the study, 174 were females (57%) and 131 were males (43%). The mean age group was 38.4 ± 8.8 years (Mean ± SD). Difficult laryngoscopy was seen in 27 patients (8.9%). Failed intubation was encountered in none of these patients.

Distribution of the Sample According to Age, Sex and Body Weight

In this study, 18 % of the patients were under the group of 15 to 30 years. There are 42% patients under the age group of 31 to 40 years and 31.5% of patients under the age group of 41 to 50 years. There are 8.5% patients under the age group of 51 to 60 years. The maximum strength is under the group of 31 to 50 years which is 73.5% and hence this study is more applicable for the age group of 31.Total study population (sample size) is 305, out of which 57% are females and 43% are males.

Table1: weight of the patients

Mean	59.3
SD	7.0
Median	60.0
Minimum	40.5
maximum	78.0

The mean body weight of the participants was 59.3 kg.

Diagnostic Value of Modified Mallampati Test

Modified Mallampati class 1 and 2 are considered easy intubation and class 3 and 4 are considered difficult intubation. 10.5%of the study population were predicted to have difficult intubation according to this test, and 89.5% of the study population were classified as easy intubation .32 patients were predicted to have difficult intubation out of which only 11 of them were difficult as per the gold standard test, the Cormack and Lehane grading. 273 patients were predicted to have easy intubation out of which only 257 patients had an easy intubation as per Cormack and Lehane grading. With these values the sensitivity, specificity, positive predictive value, negative predictive value, accuracy were calculated. Kappa value of 0.31 and P value of 0 showed fair agreement

Table 2: MMT validity indices

Sensitivity	40.7
Specificity	92.4
False Negative	59.3
False positive	7.6
Positive predictive value	34.4
Negative predictive value	94.1
Accuracy	87.9

Diagnostic Value of Sternomental Distance

Sternomental distance of < 12.5 cmspredicted difficult intubation in 12.8% of the study population, and 87.2% of the study population

were classified as easy intubation with sternomental distance of >/= 12.5 cms.

39 patients were predicted to have difficult intubation out of which only 22 of them were difficult as per the gold standard test, the Cormack and Lehane grading. 266 patients were predicted to have easy intubation out of which 261 patients had an easy intubation as per Cormack Lehane grading. With these values the sensitivity, specificity, positive predictive value, negative predictive value, accuracy were calculated. Kappa value of 0.63 and P value of 0 showed substantial agreement.

Table 3: SMD validity indices

Sensitivity	81.5
Specificity	93.9
False Negative	18.5
False positive	6.3
Positive predictive value	56.4
Negative predictive value	98.1
Accuracy	92.8

Diagnostic Value of Thyromental Distance

77 patients were predicted to have difficult intubation out of which only 24 of them were difficult as per the gold standard test, the Cormack and Lehane grading. 228 patients were predicted to have easy intubation out of which 225 patients had an easy intubation as per Cormack Lehane grading. Kappa=0.38**, p=0, Fair agreement.

With these values the sensitivity, specificity, positive predictive value, negative predictive value, accuracy were calculated. Kappa value of 0.38 and P value of 0 showed fair agreement

Table:4. TMD validity indices

Sensitivity	88.9
Specificity	80.9
False Negative	11.1
False positive	19.1
Positive predictive value	31.2
Negative predictive value	98.7
Accuracy	81.6

Diagnostic Value of Modified Mallampati Test Combined with Sternomental Distance

Out of 305 study population, difficult intubation predicted by both Modified Mallampati test and Sternomental distance are 64 and there were 27 difficult intubations as per the gold standard test, the Cormack and Lehane grading. 241 patients were predicted to have easy intubation, and all the 241 patients had easy intubation. Sensitivity, specificity, Positive predictive value, negative predictive value and accuracy was calculated and is shown in the below table.

Table 5 : Combination of MMT and SMD

Sensitivity	100
Specificity	86.7
False Negative	0.0
False positive	13.3
Positive predictive value	42.2
Negative predictive value	100
Accuracy	87.9

Diagnostic Value of Modified Mallampati Test Combined with Thyromental Distance

Out of 305 study population, difficult intubation predicted by both Modified Mallampati test and Thyromental distance are 95 and there were 27 difficult intubations as per the gold standard test, the Cormack and Lehane grading. 210 patients were predicted to have easy intubation, out of which there were 209 easy intubations. Sensitivity, specificity, Positive predictive value, negative predictive value and accuracy was calculated and is shown in the below table.

Table 6: Combination of MMT and TMD

Sensitivity	96.3
Specificity	75.2
False Negative	3.7
False positive	24.8
Positive predictive value	27.4
Negative predictive value	99.5
Accuracy	77.0

Diagnostic Value of Sternomental Distance Combined with Thyromental Distance

Out of 305 study population, difficult intubation predicted by both Sternomental distance and Thyromental distance are 85 and there were 27 difficult intubations as per the gold standard test, the Cormack and Lehane grading. 220 patients were predicted to have easy intubation, out of

which there were 218 easy intubations. The sensitivity, specificity, Positive predictive value, negative predictive value and accuracy was calculated and is shown in the below table.

Table 7: Combination of SMD and TMD

Sensitivity	92.6
Specificity	78.4
False Negative	7.4
False positive	21.6
Positive predictive value	29.4
Negative predictive value	99,1
Accuracy	79.77

Diagnostic Value of Combination of modified Mallampati Test, Sternomental Distance and Thyromental Distance for Prediction of Difficult Intubation

Out of 305 study population, difficult intubation predicted by combining all three tests, i.e., Modified Mallampati test, Sternomental distance and Thyromental distance are 103 and there were 27 difficult intubations as per the gold standard test, the Cormack and Lehane grading.

202 patients were predicted to have easy intubation, and all the 202 patients underwent an easy endotracheal intubation. The sensitivity, specificity, Positive predictive value, negative predictive value and accuracy was calculated and is shown in the below tabl

Table 8: Combination of MMT, SMD, TMD

Sensitivity	100.0
Specificity	72.7
False Negative	0.0
False positive	27.3
Positive predictive value	26.2
Negative predictive value	100.0
Accuracy	75.1

Discussion

Airway management is the fundamental responsibility of every anaesthesiologist. Difficult intubation is one of the majorcauses of anesthesia-related morbidity and mortality. Intubation difficulties and problems with airway management during emergence remain among the leading causes of serious intraoperative problems, and it has been estimated that inability to manage successfully very difficult airways is responsible for as many as 30% of deaths totally attributable to anesthesia. Generally failed intubation occurs 1 in every 2230 attempts Most of the airway catastrophes have occurred when difficulty with the airway was not recognized[8].

The risk and complications related to difficult intubation can be reduced if difficult airway is anticipated preoperatively. Therefore, airway assessment is an integral part of pre-anaesthetic evaluation, as it helps in recognizing a potentially difficult airway. Most of the predicted cases of difficult intubation are found after clinical exami-nation and application of simple clinical tests [9]

A range of bedside screening tests are available to predict a difficult airway. These include Modified Mallampatitest (MMT), sternomental distance (SMD), thyromental distance (TMD), upper lip bite test, cervical mobility, inter-incisor-gap, mandibular length, ratio of height to sternomental distance, mentohyoid distance, retrognathia, TMJ movement etc. There are several studies comparing the different preoperative bedside tests in predicting difficult intubation with varying results .So we conducted this study to evaluate the efficacy and validity of Modified Mallampati test, Sternomental distance, and Thyromental distance individually and in combination in predicting a difficult intubation and to draw possible correlation between the tests and Cormack and Lehane grading of laryngoscopic view. The estimated sample size was 305.

Out of the 305 patients included in the study, 174 were females (57%) and 131 were males (43%). The incidence of difficult airway in this study was 8.85% which is consistent with a meta-analysis of nine studies that included 14,438 patients and a DVL incidence of 6% to 27 %[10]. Failed intubation was encountered in none of these patients. the study conducted by Bhavdip Patel, Rajiv Khandekr. et al the incidence of difficult intubation was 8.3% which is almost same as our study[11]. The wide variations in the incidence of DVL may be related to factors such as age and

ethnic differences among patients, or types of laryngoscope blade used and skill of the anaesthesiologist.

In this study, 18 % of the patients were under the group of 18 to 30 years. There are 42% patients under the age group of 31 to 40 years and 31.5% of patients under the age group of 41 to 50 years. There are 8.5% patients under the age group of 51 to 60 years. The maximum strength is under the age group of 31 to 50 years which is 73.5% and hence this study is more applicable for the age group of 31 to 50 years. The mean body weight of the participants was 59.3 kg. Study of sheff et al found that the BMI was not a predictor of difficult intubation[12]

Modified Mallampati class 1 and 2 are considered easy intubation and class 3 and 4 are considered difficult intubation. 10.5% of the study population were predicted to have difficult intubation according to this test, and 89.5% of the study population were classified as easy intubation. Sensitivity was 40.7%, Specificity 92.4% and Positive Predictive value was 34.4% which is nearly consistent to a study conducted by Oates et al in 1991(13) which was a prospective study of 751 patients, to compare the Mallampati classification with Wilson's risk sum in the prediction of difficult laryngoscopy and assessed the inter-observer variations in performing these tests. The incidence of difficult intubation in this study was 1.3%. In the study of Bhavdip Patel, Rajiv Khandekr. etal the sensitivity of MMT was 28.6% and specificity was 93.0% and positive predictive value was 18.2% only and the values less than our study . But the study of Nkihu A. Merahetal The sensitivity, specificity and the positive predictive value for MMT was 61.5%; 98.4%; 57.1% and their result were different from our study[14], The sensitivity, specificity and positive predictive value of Mallampati classification was assessed to be 0.42, 0.84 and 4.4 respectively. So the validity of MMT alone to predict a difficult intubation was low.

Sternomental distance of < 12.5cms predicted difficult intubation in 12.8% of our study population, and 87.2% of the study population were classified as easy intubation with sternomental distance of >/= 12.5cms. 39 patients were predicted to have difficult intubation out of which only 22 of them were difficult as per the gold standard test, the Cormack and Lehane grading. 266 patients were predicted to have easy intubation out of which 261 patients had an easy intubation as per Cormack and Lehane grading. Sensitivity was 81.5%, Specificity 93.9%, PPV 56.4%, NPV 98.1% and Accuracy 92.8% .The study of Savva, in a largely non- obstetric population, found sternomental distance to be the most sensitive (82.4%) and specific (88.6%) determinant of difficult intubation and the results were almost same as our study [15]. The study of S.A.L Ramdhani, A. Mohamed etal, a SMD of 13.5 cmor less had a sensitivity, specificity, positive and negative predictive valueof 66.7%, 71.1%, 7.6%and 98.4% respectively, which were different from our study [16]. This may be due to difference in cut-off value of SMD. Accourding to Savva sternomental distance of 12.5 or less was the best predictor of difficult intubation. The cut –off value for SMD was vary from </=12.5cms to<,/= 13.5 cm in different studies.

Thyromental distance of < 6.5 cms predicted difficult intubation in 25.2% of the study population, and 74.8% of the study population were classified as easy intubation with thyromental distance of >/= 6.5 cms. 77 patients were predicted to have difficult intubation out of which only 24 of them were difficult as per the gold standard test, the Cormack and Lehane grading. 228 patients were predicted to have easy intubation out of which 225 patients had an easy intubation as per Cormack Lehane grading. Sensitivity was 88.9%, Specificity 80.9%, PPV 31.2%, NPV 98.7% and Accuracy 81.6 %. Merah et al found that sensitivity, specificity, and positive predictive value of TMD were 15.4%, 98.1%, and 22.2% respectively. Their sensitivity results were lower than the other studies; which suggested that this difference may be due to anthropometric specialties in the study population.

Frerk et al reported the sensitivity of thyromental distance as 90.9%, the specificity as 81.5%, and the negative predictive value as10%. [17]

Out of 305 study population, difficult intubation predicted by both Modified Mallampati test and Sternomental distance are 64 and there were 27 difficult intubations as per the gold standard test, the Cormack and Lehane grading. 241 patients were predicted to have easy intubation, and all the 241 patients had easy intubation. Sensitivity 100.0%, Specificity 86.7%, PPV 42.2%, NPV 100.0%, Accuracy 87.9%.By combining SMD to MMT the sensitivity increased from 40.7% to 100%, specificity remains at 86.7%, PPV increased from 34.4% to 42.2%. The sensitivity and NPV is increased to 100% which means all patients who will be having a difficult intubation are correctly predicted to have a difficult intubation and those who are tested negative will not have a difficult intubation. However the specificity and PPV is low which means patients who are actually easy to intubate are to be subjected to the protocol for management of a difficult airway. But practically as an anaesthesiologist it is better for us to be prepared for a difficult airway, than to face an unanticipated difficult airway.

By combining TMD to MMT, 95were predicted to have difficult intubation and there were 27 difficult intubations as per the gold standard test, the Cormack and Lehane grading. 210 patients were predicted to have easy intubation, out of which there were 209 easy intubations. Sensitivity was 96.3%, Specificity 75.2%, PPV 68 27.4%, NPV 99.5%, Accuracy 77.0%. 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. However, they had used TMD <6 cm as a parameter instead of <6.5 cm used in the current study.

Out of 305 study population, difficult intubation predicted by combining both Sternomental distance and Thyromental distance are 85 and there were 27 difficult intubations as per the gold standard test, the Cormack and Lehane grading. 220 patients were predicted to have easy intubation, out of which there were 218 easy intubations. Sensitivity was 92.6%, Specificity 78.4%, PPV 29.4%, NPV 99.1%, Accuracy 79.7%.

When we combined all three tests MMT, SMD and TMD, 103 patients were detected to have difficult intubation and there were 27 difficult intubations as per the gold standard test, the Cormack and Lehane grading. 202 patients were predicted to have easy intubation, and all the 202 patients underwent an easy endotracheal intubation. Sensitivity was 100.0%, Specificity 72.7%, PPV 26.2%, NPV 100.0% and Accuracy 75.1%. The efficacy of MMT to predict a difficult intubation was low. The addition of TMD and SMD to MMT for preoperative assessment improved the validity of predicting difficult intubations.

A similar study was done by Patel B,Khandekar R, Diwan R, and Shah A in 2014 and they concluded that, 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.

Conclusion

TMD had high sensitivity. MMT and SMD had high specificity. The validity and efficacy of combination of MMT and SMD as compared to any single test alone was very high in predicting difficult intubation. The sensitivity and NPV is increased to 100% which means all patients who will be having a difficult intubation are correctly predicted to have a difficult intubation and those who are tested negative will not have a difficult intubation. Efficacy of combining MMT, SMD and TMD is also significantly higher than any single test. Hence all the three tests should be ideally used in assessing the airway in adult patients for surgery under GA. Combination of MMT and SMD can also be used as a very good bedside test to predict difficult intubation as it is simple and can be easily performed

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