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ORIGINAL ARTICLE

A comparison of Mallampati classification, thyromental distance and a combination of both to predict difficult intubation

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ABSTRACT

Background and Objective: Failed intubation is an important cause of anesthetic related mortality. The purpose of this study was to determine the ability to predict difficult visualization of the larynx from the preoperative tests, either Mallampati classification (MPC) and thyromental distance (TMD) alone or in combination.

Methodology: The cross-sectional study was conducted at the main operation theatre of Liaquat National Medical Hospital and Medical College Karachi from September 2012 to April 2013 after an approval from hospital ethics committee and a written informed consent was obtained, 501 patients meeting the inclusion criteria for a non-emergency elective surgery under general anesthesia requiring tracheal intubation were included in the study. We assessed the two preoperative tests, e.g. MPC and TMD, either alone or combined. Data were collected after induction, laryngoscopy and grading was performed (as per Cormack Lehane classification). Sensitivity and positive predictive value (PPV) for each test alone and in combination were determined.

Results: Difficult laryngoscopy (Grade 3 or 4) occurred in 55 patients (11%). Used alone MPC and TMDs were associated with poor sensitivity specificity, PPV: Negative predictive value combining Mallampati with TMD – sensitivity decreases but specificity and PPV increases.

Conclusion: Our study shows that a combination of MPC and TMD is preferable for assessment of the airway because of its better specificity and positive predictive value than MPC, TMD alone, but the tests alone or in combination have low sensitivity.

Key words: Difficult laryngoscopy; Mallampati classification; Thyromental distance; Incisor/anatomy & histology; Intubation, Intratracheal; Laryngoscopy/methods

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INTRODUCTION

The major responsibility of anesthetist is to maintain adequate respiration during anesthesia. The most vital element is to keep the airway patent and failure in managing the airway may result in anesthesia related death or brain damage. About 31% of deaths or permanent brain damage attributed to anesthesia are related to unsuccessful management of difficult airway. According to one study the incidence of difficult laryngoscopy, difficult intubation, and failed intubation was 12.3%, 9%, and 0.005%, respectively. Mallampati classification (MPC) of the oropharyngeal structures is a simple test to assess the airway for anticipated difficulty of endotracheal intubation. A positive Mallampati test indicates the possible limited mouth opening or a limited oropharyngeal space,[3] while thyromental distance (TMD) gives a

measure of head extension in addition to the degree of receding of the jaw (retrognathia).[4]

The American Society of Anesthesiology define difficult airway as a clinical situation in which a conventionally trained anesthesiologist experiences difficulty with face mask ventilation, difficulty with tracheal intubations or both.[5] A rational approach to airway assessment includes a detailed history, a careful physical examination and in certain cases inspection of relevant x-ray. Mallampati score, TMD, sternomental distance (SMD) and neck mobility have low sensitivities when used alone.[6,7]

The complications related to poor/inappropriate management of difficult airway are trauma to airway and teeth, emergency surgical airway, prolonged recovery and ICU admission, brain damage and death which require high level care and extra cost.[8-10] Difficult intubation is when more than 3 attempts for tracheal intubation or if a bougie is required to aid intubation with a laryngoscopy grade II,[11] while difficult laryngoscopy is when not possible to visualize any portion of the vocal cord after multiple attempts (more than 3 attempts) at conventional laryngoscopy.[12] MPC is the test that suggests higher incidence of difficult laryngoscopy if posterior pharyngeal wall is not visible. Pre-operatively this test is performed using a pen torch with the patient in sitting position, mouth wide open with a tongue protruding and the patient not phonating.[3] Mallampati Grade III and IV are considered as predictor of difficult intubation. TMD is the distance from thyroid notch to the lower border of the mentum with head fully extended on the neck and the mouth closed. Distance < 6.5 cm is considered as predictor of difficult intubation.[4]

METHODOLOGY

This cross-sectional study was conducted at the main operating rooms of Liaquat National Medical Hospital & Medical College Karachi from September 2012 to April 2013 after an approval from hospital ethics committee and a written informed consent was obtained from 501 patients meeting the inclusive criteria i.e. patients above age of 16, ASA-I and II of either sex requiring tracheal intubation for any type of non-emergency surgical procedures. Exclusion criteria were patients with known airway abnormalities or with obvious head and neck pathology, e.g. maxillofacial trauma, limited cervical movements, limited temporomandibular joints movement and tumors, patients treated radiotherapy on face, neck and head, patients with trismus, and morbidly obese patient with BMI $\geq$ 30 kg/m^2.

The basic demographic information including name, age, sex and address were recorded.

Pre-operatively modified Mallampati test (MMT) was performed using a pen torch with the patient in a sitting position, mouth wide open with tongue protruding and patient not phonating. Mallampati class III and IV were considered difficult.

The TMD was measured as the straight line distance (in cm) from the thyroid notch to the lower border of mentum with head fully extended on the neck and mouth closed. A scale was used and distances were approximated to the nearest 0.5 cm. TMD less than 6.5 cm was considered difficult.

Before induction of anesthesia, intravenous access and standard monitoring was established with pulse oximeter, electrocardiogram and non-invasive arterial pressure monitoring regardless of the predictive score, a complete trolley for difficult intubation was present in every case.

Induction of anesthesia was performed in a conventional way with administration of intravenous induction techniques i.e. propofol (1.5 to 2.5 mg/kg), depolarizing muscle relaxant suxamethonium (1.5 mg/kg) and nalbuphine (0.1 mg/kg). In case where difficult intubation was suspected i.e. Mallampati III and IV or TMD < 6.5 cm, the induction was performed with inhalation anesthetic agent, i.e. sevoflurane 3-4% in 100% oxygen and suxamethonium (1-1.5 mg/kg) was given after confirmation of mask ventilation. Then laryngoscopy was performed using a Macintosh blade and the laryngoscopic view classified according to the method described by Cormack and Lehane (C-L).

An intubation was considered difficult if the patient had a C-L laryngoscopy grade III and IV or if a bougie was required to aid intubation with a laryngoscopy grade II.

Pre-operative assessment data and intubation findings were co-related to determine the accuracy of two tests in predicting difficult intubations. Each test, alone and in combination, was evaluated by calculating sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV).

All the information, pre-operative assessment and intubation findings were collected in a specially designed Performa.

The obtained data were analyzed using statistical package for social sciences (SPSS software, version 15.0; Chicago, IL, USA). Frequency in percentage was computed for categorical variables like gender, C-L criteria and Mallampati grades. Cross intubation were presented for frequency of each predictor's outcome like false positive (FP), false negative (FN), true positive (TP) and true negative (TN). Mean $\pm$ standard deviation, 95% confidence interval were computed for age. The sensitivity, specificity, PPVs and NPVs for MPC, TMD and their combination of both were calculated by using C-L score as gold

standard. Stratifications were done to control effect modifier like gender.

RESULTS

A total of 500 admitted patients with ASA I and II undergoing surgery under general anesthesia were included in this study. Most of the patients were 31 to 60 y of age. The mean age of the patients was 41.76 ± 11.30 y (95% CI: 40.77 to 72.25). Out of 500 patients, 224 (44.8%) were male and 276 (55.2%) were female.

C-L system of grading of laryngoscopic view showed 225 (45%) were grade I, 220 (44%) were grade II and 55 (11%) had grade III while grade IV were not observed, consequently the incidence of difficult intubations were 11% patients.

According to Mallampati test 232(46.4%), 197(39.4%), 60(12%) and 11(2.2%) had score I, II, III and IV respectively. In Table 2 Mallampati grade III and IV were observed in 71 (14.2%) cases that showed difficult tracheal intubations in which only 22 (TP) were confirmed difficult tracheal intubations and 49 (FP) were confirmed easy tracheal intubations by C-L criteria. Similarly Mallampati grade I and II were observed in 429 (85.5%) patients that were showing easy intubations in which 396 (TN) were confirmed easy and 33 (FN) were confirmed difficult tracheal intubation by C-L criteria. The sensitivity, specificity, PPV and NPV of Mallampati grade were 40%, 89%, 31% and 92.3% respectively (Table 1).

Table 1: Mallampati score predicting difficult tracheal intubations

Mallampati Score (MT)	Cormack and Lehane criteria		Total n (%)
	Difficult	Not Difficult	
MT-III (Difficult)	22 (TP)	49 (FP)	71 (14.2)
MT-I & II (Not Difficult)	33 (FN)	396 (TN)	429 (85.5)
Total	55	445	500

*Sensitivity=22/55*100=40% Specificity=396/445*100=89%*
*PPV=22/71*100=31% NPV=396/429*100=92.3%*
TP-true positive, FP-falce positive, FN-falce negtive, TN-true negtive

Table 2: TMD predicting difficult tracheal intubations

TMD	Cormack and Lehane criteria		Total n (%)
	Difficult	Not Difficult	
<6.5 cm (Difficult)	18 (TP)	21 (FP)	39 (7.8)
>6.5 cm (Not Difficult)	37 (FN)	424 (TN)	461 (92.2)
Total	55	445	500

*Sensitivity=18/55*100=32.7% Specificity=424/445*100=95.3%*
*PPV=18/21*100=46.2% NPV=424/461*100=92%*
TP-true positive, FP-falce positive, FN-falce negtive, TN-true negtive

Table 3: Combination of Mallampati and TMD predicting difficult tracheal intubations

Combination of Mallampati and TMD	Cormack and Lehane criteria		Total n (%)
	Difficult	Not Difficult	
Difficult	7	0	71 (14.2)
Not Difficult	48	445	493 (98.6)
Total	55	445	500

*Sensitivity=7/55*100=12.7% Specificity=445/445*100=100%*
*PPV=7/7*100=100% NPV=445/493*100=90.3%*

Table 4: Sensitivity, specificity, positive and NPV of airway predictors

Predictors	Gender	Sensitivity	Specificity	PPV	NPV
Mallampati score	Overall	40%	89%	31%	92.3%
	Male	36.4%	87.1%	23.5%	92.6%
	Female	45.4%	90.5%	37.8%	92.1%
TMD	Overall	32.7%	95.3%	46.2%	92%
	Male	50%	94.1%	47.8%	94.5%
	Female	21.2%	96.3%	43.8%	90%
Mallampati + TMD	Overall	12.7%	100%	100%	90.3%
	Male	18.2%	100%	100%	91.8%
	Female	9.1%	100%	100%	89%

Predictibility of TMD is presented in Table 2. Difficult tracheal intubations were observed in 39 (7.8%) cases in which 18 [True Positive (TP)] were confirmed difficult tracheal intubations and 21[False Positive (FP)] were confirmed not difficult while easy tracheal intubations were observed in 461(92.2%) cases by TMD in which 424 [True Negative (TN)] were easy and 37 [False Negative (FN)] were difficult intubations confirmed by C-L criteria. The sensitivity, specificity, PPV and NPV of TMD were 32.7%, 95.3%, 46.2% and 92% respectively.

Combined predictability of difficult and tracheal intubations of Mallampati and TMD is presented in Table 3. The sensitivity, specificity, PPV and NPV were 12.7%, 100%, 100% and 90.3% respectively.

Sensitivity, specificity, positive and NPVs of all predictors with respect to gender is presented in Table 4.

DISCUSSION

Maintaining a patent airway is essential for adequate oxygenation and ventilation and failure to do so, even

for a brief period of time, can be life threatening. Wide variation in the incidence of difficult tracheal intubation has been ascribed to various factors, lack of uniformity in describing or grading laryngeal values, cricoid pressure, head position, degree of muscle relaxation and type and/or size of laryngoscope blades. The incidence of difficult intubation is one in every 65 pateints,[13] while the incidence of failed intubation is approximately one in every 2000 patients of surgery, but it is one in every 300 patients in obstetrics.[14]

Our study data revealed that sensitivity decreases with combination as compared with alone but specificity, PPV and NPV increases (MMT has sensitivity 40%, specificity 89%, PPV 31% and NPV 92.3%; TMD ≤ 7 cm has sensitivity 32.7%, specificity 95.3%, PPV 46.2% and NPV 92%, whereas an MMT and TMD combination has sensitivity 12.7%, specificity 100%, PPV 100%, and NPV 90.3%).

Shiga et al. published a meta-analysis of studies regarding airway physical examination screening test.[15] Their aim was to determine the diagnostic accuracy of bedside tests for predicting difficult intubation in patients with no airway pathology. Thirty five studies (50,760 patients) were selected from electronic data bases. Screening tests included were Mallampati oropharyngeal classification, TMD, SMD, mouth opening and Wilson risk score. Each test yielded poor to moderate sensitivity (20 – 62%) and moderate to fair specificity (82 – 97%) when alone. They found that most useful bedside test for prediction of difficult tracheal intubation was a combination of MPC and TMD, with a sensitivity 36% and specificity 87%. Our study too, suggests MPC of oropharyngeal view in combination with TMD may be a useful routine screening test for pre-operative prediction of difficult tracheal intubation as compared with each test alone.

Banjong Krobbuaban et al. evaluated four predictive tests for difficult tracheal intubation which were MMT, TMD, ratio of height to TMD (RHTMD), neck movement less than ≤ 80 degrees. According to them single test most predictable for difficult intubation was RHTMD.[16] Their result for MMT was sensitivity 70%, specificity 60%, PPV 20%, NPV 93 and for TMD ≤ 6.5 cm sensitivity 52%, specificity 69%, PPV 21%, NPV 91%. Our result is different from Banjong Krobbuban; the probable reasons are lack of inter-observer variance in our study as well as ethnic differences. The anthropological literature well-documented human craniofacial variations and the dental literature confirms significant variations in mandibular and maxillary morphology and morphometery.[17,18,19] The effect of inter-observer reliability was confirmed by various studies.[20,21,22]

Bhavdip Patel conducted a prospective study[6] in which they compared MMT grading before surgery to C-L's grading of difficulty in intubation. They also evaluated the role of adding other measurements like TMD and SMD in enhancing the validity of MTT in predicting difficult intubation based on C-L's grading in patient age 16 y and older. The sensitivity, specificity, PPV, NPV of each test is calculated alone and in various combinations, which were MMT sensitivity 28.6%, specificity 93%, TMD measurements were sensitivity 100%, specificity 75.8%. Combination of MMT grading and TMD and SMD measurements increase the validity (sensitivity 100% and specificity 92.7%). Marked difference in the sensitivity of TMD comparatively in our study is due to difference in sample size.

Nkihu A. Merah and his colleagues conducted a prospective study of 308 patients.[23] The aim of their study is to predict difficult visualization of larynx from pre-operative tests, which include MNT, TMD, SMD, horizontal length of the mandible (HLM) and inter-incisor gap.

The cut off value of airway predictors were MPC III and IV, TMD < 6.5 cm, SMD, 13.5 cm, HLM 9 cm and inter-incisor gap, 4 cm. during direct laryngoscopy the laryngeal view is graded according to C-L classification grade III and IV were considered difficult. Sensitivity, specificity and PPV for each airway predictor alone and in combination were determined. They found sensitivity, specificity and PPV of MNT (61.5%, 98.4%, 57.1%) and TMD (15.4%, 98.1%, 22.2%). MMT > 3 + TMD < 6.5 cm (76.9%, 96.7%, 45.5%). In our study we did the comparison between the MMT and TMD separately and in combination and found that our result differs to their study because we did our study in Pakistani population only.

There was a study conducted by Badhe VK[24] to compare various bedside tests including MMT, TMD, SMD, Inter Incisor Gap (IIG) and combination of the MMT and TMD for predicting difficult intubation All tests except TMD (71.43%) showed very poor sensitivity and very high specificity conclude that All four predictor tests for difficult intubation have only poor to moderate discriminative power when used alone.

This study shows that a combination of Modified Mallampati and TMD tests adds some incremental diagnostic value in comparison to the value of each test alone. These certain possibilities lead to the variation in result in previous studies that need discussion.

1. Difficulty in defining a difficult airway. Most anesthesiologists use a C-L grades III and IV of the direct laryngoscopic view as difficult airway. But American Society of Anesthesiologists defined it as a clinical situation in which a conventional trained anesthesiologist experiences difficulty

with mask ventilation, difficulty with tracheal intubation or both.

2. Although many cases can be anticipated but some still go undiscovered before intubation, thereby exposing the patient to unexpected risks and anesthesiologist to unexpected challenges.
3. The poor sensitivity, specificity and PPV of MPC as a single screening test as is clear by viewing Table 1. Mallampati sign had sensitivity of 100% and specificity of 80% in the original paper. But subsequent experience showed that it had not lived up to expectations.
4. Unexpected difficult intubation in a patient with normal airway on assessment and with certain pathologies of temporomandibular joints and oropharyngeal structures became clear only after induction of anesthesia as muscles loose power and tone.
5. The inter observer variabilities also influence the result of the study. Inter observer variation is considerable for modified MPC.

CONCLUSION

We conclude that no single airway test can provide a high index of sensitivity and specificity for prediction of difficult airway. Therefore, a combination of multiple tests should be used in order to predict anticipated difficult ventilation or intubation. Our study shows that a combination of MPC and TMD is preferable for assessment of the airway because of its better specificity and positive predictive value than MPC, TMD alone.

Conflict of interest: None declared by the authors

Authors' contribution:

AIM: Concept, conduction and manuscript editing

NA: Supervisor of the study

SMNN: Contribution in manuscript writing and conduction of study

GM: Contribution in conduction of study

MR: Data collection and conduction of study

SSA: manuscript editing and writing

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