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ORIGINAL ARTICLE

PREDICTION OF DIFFICULT INTUBATION BY USING UPPER LIP BITE, THYROMENTAL DISTANCE AND MALLAMPATI SCORE IN COMPARISON TO CORMACK AND LEHANE CLASSIFICATION SYSTEM

DOI: 10.36740/WLek202109211

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ABSTRACT

The aim: To evaluate efficacy of Modified Mallampati test (MMT), upper lip bite test (ULBT) and Thyromental distance (TMD) or combination of two method Modified Mallampati test (MMT)+ upper lip bite test (ULBT), Thyromental distance (TMD) + upper lip bite test (ULBT) in prediction of difficult intubation in patients undergoing GA.

Materials and methods: Three tests were carried out in all patients by a single anesthesiologist. These were MMT, ULBT and TMD. Laryngoscopy was performed with patient's head in the sniffing position. The laryngoscopy view was graded according to modified Cormack and Lehane classification system. Study was prospective, single cross sectional, in 151 adult patients who required GA with endotracheal intubation for elective surgery. On arrival in the operating room, routine monitoring and venous cannula were introduced. Midazolam, Fentanyl. and rocuronium, ketamine , propofol were given to facilitate endotracheal intubation.

Results: Out of 150 assessed patients, 18 (12%) had difficult intubation. Of those 18 patients, 17 (83.33%) patients had Cormack and Lehane classification III and one patient (16.67%) had classification IV. Compared with Cormack and Lehane classification system as the gold standard for difficult intubation, the sensitivity and specificity of MMT was 66.67% and 96.97% respectively, while ULBT had a sensitivity of 77.78% and a specificity of 93.18%, and TMD had a sensitivity of 55.56% and specificity of 94.97% respectively. A combination of different tests improved their efficiencies. The sensitivity and specificity MMT and TMD combinations was 77.78% and 92.42% respectively, while it was 88.89% and 93.18%, respectively for MMT and ULPT. The combination of TMD and ULBT has a sensitivity of 88.33% and a specificity of 91.67%.

Conclusions: Upper lip biting test has the best sensitivity while MMT had the best specificity. No single test alone can be reliable for predicting of difficult intubation. The combination of ULBT and MMT was the best in terms of both sensitivity and specificity for prediction of difficult intubation.

KEY WORDS: assessment to predict difficult intubation, Mallampati test, Upper lip biting, thyromental distance

Wiad Lek. 2021;74(9 p.II):2305-2314

INTRODUCTION

AIRWAY MANAGEMENT

A standard definition of the difficult airway cannot be identified in the available literature. For these Practice Guidelines, a difficult airway is defined as the clinical situation in which a conventionally trained anesthesiologist experiences difficulty with facemask ventilation of the upper airway, difficulty with tracheal intubation, or both. The difficult airway represents a complex interaction between patient factors, the clinical setting, and the skills of the doctor. Analysis of this interaction requires precise collection and communication of data [1].

ALGORITHM FOR AIRWAY MANAGEMENT (FIGURE 1)

Despite the lack of hard supporting evidence, common sense dictates that all airway providers should gain expertise in difficult airway management skills, and should have an algorithm of dealing with the difficult airway. Which published algorithm iteration is used is likely not as important as the act of learning and implementing it. Institutional specific algorithms based upon the types of patients to be cared for, local experience, and available equipment may have a greater impact than broader, society-based difficult airway algorithms. Recent reports support this notion for elective surgical patients and in the prehospital setting. Every institution should have an organized team for responding to dealing with critical airways, with minimal training standards for all designated responders, equipment standards, and a mechanism of providing the rare emergency surgical airway [2].

INDICATIONS FOR ENDOTRACHEAL INTUBATION

Patients requiring endotracheal intubation have at least one of the following indications:

1. Inability to keep airway open (dislocation of the tongue toward the pharynx, obstruction of the upper respiratory tract, obstructive sleep apnea, burns).

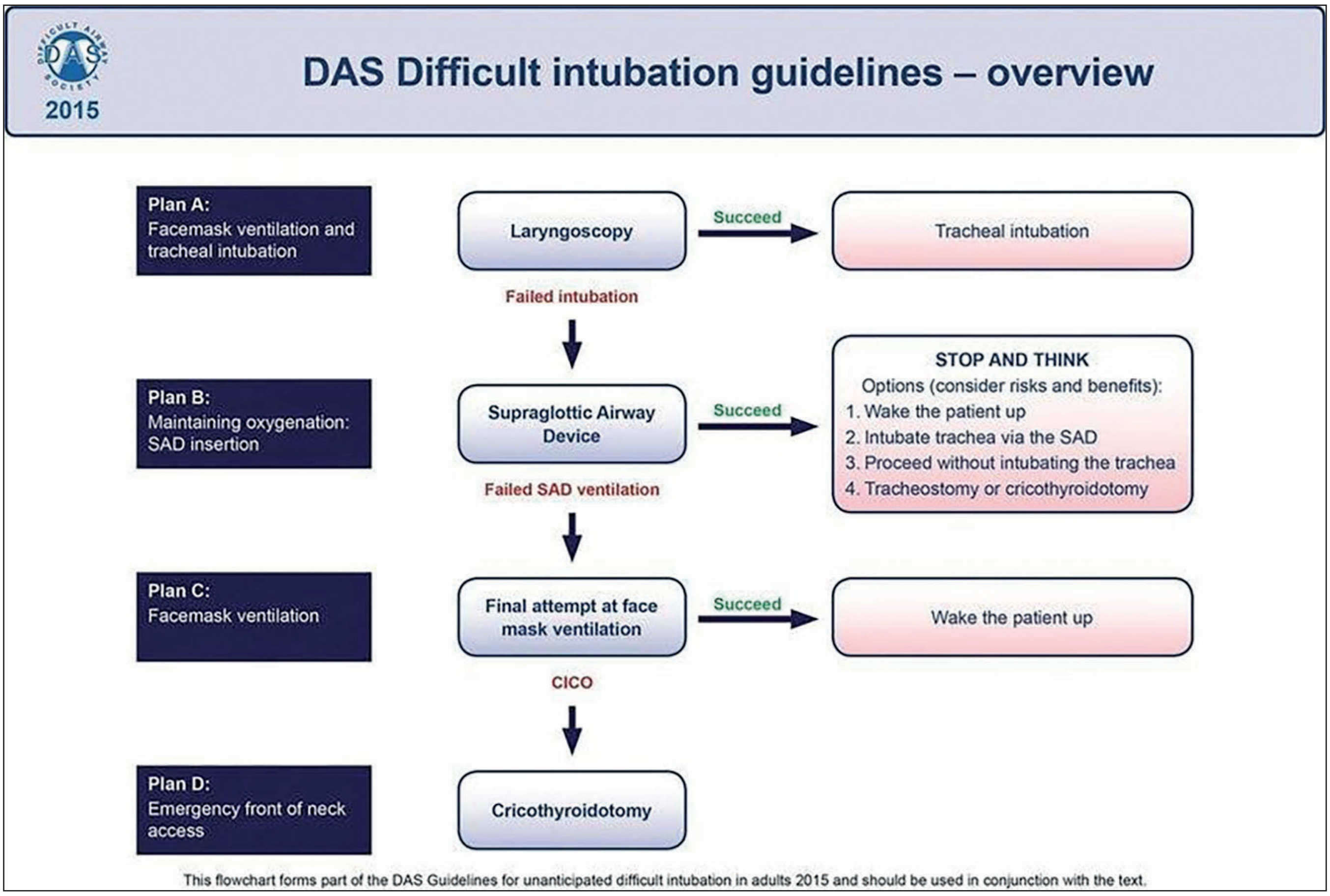

Fig. 1. Airway management algorithm for emergent tracheal intubation; DI, difficult intubation; ETT, endotracheal tube [3].

Fig. 2. Mallampati Airway Classification. From left to right: Class 1: soft palate, fauces, uvula, and anterior and posterior tonsillar pillars visible; Class 2: soft palate, fauces, uvula visible; Class 3: soft palate, base of uvula visible; and Class 4: hard palate only [3].

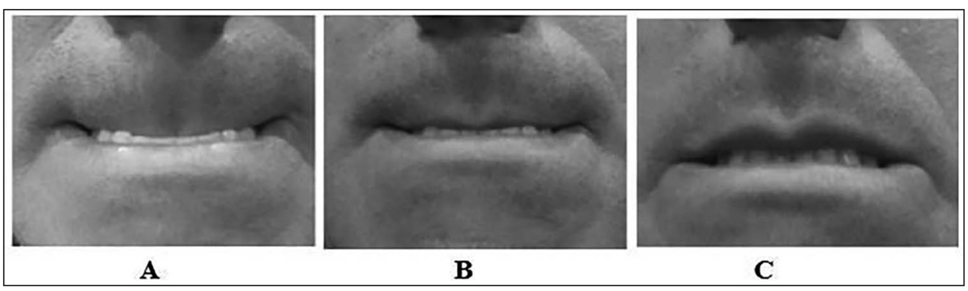

Fig. 3. A frontal view of the upper-lip bite test. In Class 1, the lower incisors are able to bite the upper lip past the vermilion border, making the mucosa of the upper lip totally invisible (A). In Class 2, a part of the lip below the vermilion border remains visible (B). In Class 3, the lower incisors fail to bite any part of the upper lip (C) [6].

2. General anesthesia condition.
3. Respiratory failure.
4. Failure to protect airway from aspiration (oral and nasal bleeding in trauma patients, secretion, full stomach, gastroesophageal reflux).
5. Upper airway obstruction (abnormalities in airway anatomy: short neck, wide mandible, the upper jaw being in front, mandible being behind, small mouth, obesity) and difficult mask ventilation may be accompanied with difficult intubation.
6. Insufficiency in oxygenation (cyanosis, insufficiency of chest wall movements, presence of obstruction findings in lower respiratory tracts in auscultation, gradual decrease of saturation, inadequacy of spirometry and expiratory measurements).
7. Possible conditions that may lead to respiratory failure

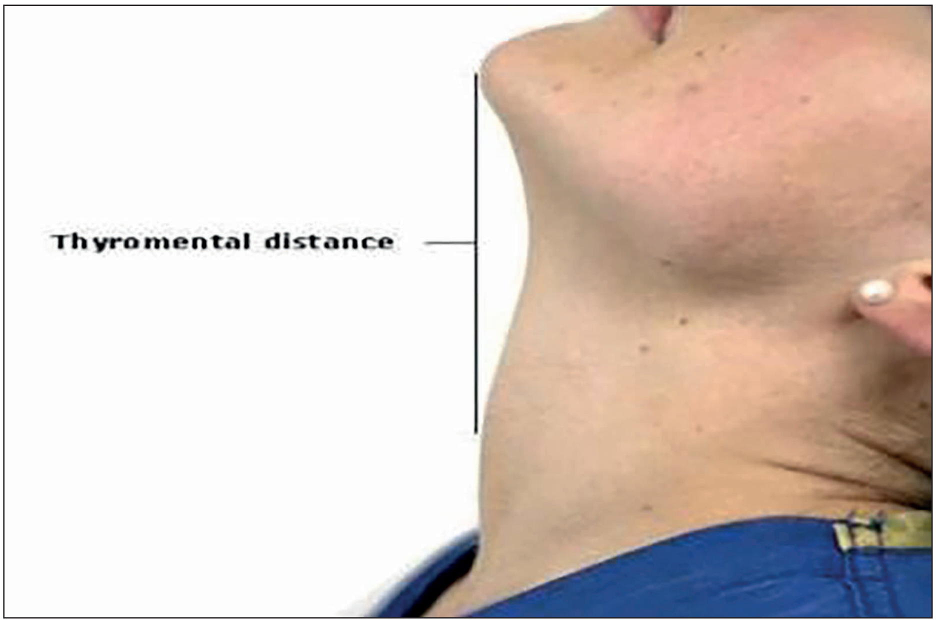

Fig. 4. Thyromental distance [14]

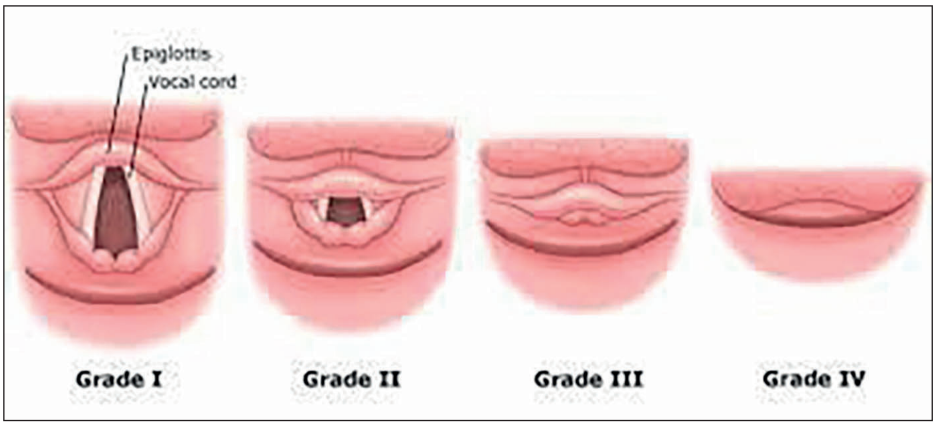

Fig. 5. The laryngoscopy view [15]

(hemodynamic changes as a result of progressive hypoxemia and hypercarbia such as tachycardia-hypertension-arrhythmia) [4].

PREDICTION OF DIFFICULT INTUBATION

Difficult laryngoscopy and difficult tracheal intubation occur in 1.5% to 13% of patients undergoing general anesthesia and have always been a concern for anesthesiologists [5]. With difficult laryngoscopy, it is not possible to visualize any portion of the vocal cords after multiple attempts at conventional laryngoscopy.

Generally accepted predictors of difficult intubation are [6]:

1. History of prior difficult intubation
2. Long, protruding upper incisors
3. Prominent –overbite (maxillary incisors override mandibular incisors)
4. High upper lip biting (ULB) test scores
5. Inter-incisor distance less than 3 cm
6. Mallampati Class of III or IV
7. Noncompliant submandibular space
8. Thyromental distance less than 6 cm (three ordinary finger breadths)
9. Highly arched or very narrow hard palate
10. Short thick neck
11. Limited cervical spine range of motion (flexion or extension)
12. Body mass index (BMI) > 35 kg/m^2.

Since none of the current tests can reliably predict difficult airway in patients whose airway looks normal, it is imperative for the anesthesia provider to be prepared to deal with unforeseen difficulties at any time [6].

THE MODIFIED MALLAMPATI SCORE

The Mallampati score is a graded 4-level pictorial scale (Figure 2) created to predict difficult intubation before general anesthesia and is now routinely used on this purpose in operating rooms worldwide [7]. The score is widely embedded in medical records as a standard assessment step before both general anesthesia and procedural sedation. It is intended to supplement, yet not replace, the baseline clinical assessment of a general multidimensional airway evaluation [8].

During the assessment, the patient should stay in sitting position (if possible), with the neck in neutral position for proper access. The mouth should be opened maximally and the tongue protruded without phonation. An observer grades the view depending on oropharyngeal structures seen.

Class I – soft palate, fauces, uvula, and tonsillar pillars (anterior and posterior) visible

Class II – soft palate, fauces, and uvula visible

Class III – soft palate and base of the uvula visible

Class IV – soft palate is not visible at all.

Although Mallampati classes III and IV correlate with almost six-fold increase of difficult intubation, only about 35% of the patients with difficult intubation are correctly identified using the score [6].

UPPER LIP BITE TEST (ULBT)

The ULBT evaluates mandibular movement, which reflects not only differences in skeletal hard tissue but also the conjoined movements of the ligaments, connective tissues, and soft tissues (Figure 3). ULBT evaluates the presence of mandibular subluxation and buckteeth at once. Additionally, one should look for a recessed mandible or protruding jaw [9].

Class I—lower incisors can bite above the vermilion border of the upper lip

Class II—lower incisors cannot reach vermillion border

Class III—lower incisor cannot bite upper lip [6].

THYROMENTAL DISTANCE (TMD)

Thyromental distance is measured along a straight line from the thyroid cartilage prominence to the lower border of the mandibular mentum with full head extension and mouth closed (Figure 4). It is a common method to predict difficult airways. The smaller the TMD is, the greater the probability of a difficult airway [10]. However, the reported predictive values may vary greatly. The sensitivity of the TMD varies from 15 to 95%, and the specificity of the TMD varies from 24 to 98% [11]. The cut-off points of TMD also differ greatly. Most scholars suggest that the cutoff point should be 6.5 cm in a normal adult [12], whereas many studies considered cut-off points of 7.0 cm, 6.0 cm, 5.5 cm and even 4 cm. However, there is almost a general agreement that this distance is categorized into the following classes [13]:

Class I: the distance > 6.5 cm

Class II: the distance between 6-6.5 cm

Class III: the distance < 6 cm.

THE AIM

To evaluate efficacy of Modified Mallampati test (MMT), upper lip bite test (ULBT) and Thyromental distance (TMD) or combination of two method Modified Mallampati test (MMT)+ upper lip bite test (ULBT), Thyromental distance (TMD) + upper lip bite test (ULBT) in prediction of difficult intubation in patients undergoing GA.

MATERIALS AND METHODS

SETTING AND DESIGN

This is a cross sectional study including 151 adult patients in whom general anesthesia was prescribed with endotracheal intubation for elective surgery during the period from September 2017 to December 2019 in the department of surgery of Al-Imamain Al-Kadhumain Medical City.

INCLUSION CRITERIA

1. Patients aged 18 to 60 years undergoing elective surgical procedures requiring general anesthesia.
2. American Society of Anesthesiologists (ASA) physical status I–II.

EXCLUSION CRITERIA

1. Patient refusal;
2. The patient with previous history of difficult intubation, anatomical deformities of neck and face;
3. Edentulous;
4. Body mass index (BMI) >35 Kg/m2;
5. Pregnant women;
6. Patient who cannot sit upright;
7. Burns or trauma to the airways or in the cranial, cervical and facial regions;
8. Patients with restricted motility of the neck and mandible (e.g., rheumatoid arthritis or cervical disk disorders).

TESTS FOR PREDICATION OF DIFFICULT INTUBATION

A consent form was obtained from each patient. Patient's history was reported and physical examination was implemented in each patient before the recruitment. The following three predictive tests were executed in all patients by one physician:

1. Upper lip bite test: Patients were asked to bite their upper lip by lower incisors as high as they can. Classification of the ULBT was according to how high the lower incisors can touch the upper lip. Both class I and class II were deemed as predictor of easy intubation, while class III as predictor of difficult intubation.
2. Mallampati score: patients were asked to sit perpendicular with the head in the neutral position and to open the mouth as widely as possible and emerge the tongue to the utmost. They were also asked not to phonate. The observer took a seat at the opposite and assessed the pharyngeal structures. Class-3 and class-4 according to the score were regarded as predictive for difficult tracheal intubation.
3. Thyromental Distance (TMD) was estimated from the bone prominence of the mentum to the thyroid cartilage prominence while the head was completely extended with the mouth closed, using a proper ruler. The distance was rounded to nearest 0.5 cm and graded according to [23]. A TMD less than or equal to 4 cm was considered to be predictive of a difficult intubation.

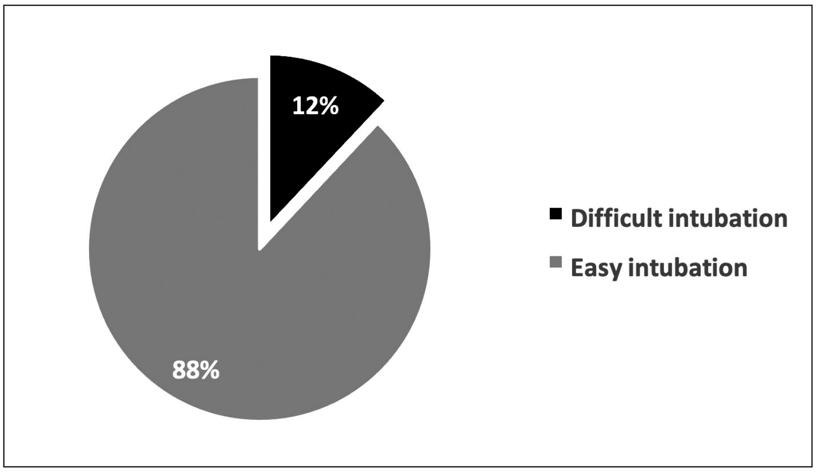

Fig. 6. Proportion of difficult intubation

Table I. Demographic and clinical characteristics of the study population

Variable	Value
Age, years (mean±SD)	42.71±12.8
Sex	
Male	92(61.33%)
Female	58(38.67%)
Weight, kg (mean±SD)	73.82±11.7
Height, cm (mean±SD)	163.14±9.63
BMI, kg/m2 (mean±SD)	26.51±6.22
ASA	
I	112(74.67%)
II	38(25.33%)

ANESTHESIA INDUCTION

All patients had anesthesia protocol. AT operating room, standard ASA monitoring involving ETco2, noninvasive arterial blood pressure measuring, electrocardiogram, and pulse oximeter test, were performed. Standardized anesthetic protocol was followed in all the patients. After establishing venous access all the patients were administered intravenous (i.v.) midazolam (0.03 mg/kg) and Fentanyl (1-2 microgram) following preoxygenation anesthesia was induced with ketamine (0.5mg/kg), propofol (1.5-2.5 mg/kg), rocuronium (0.6 mg/kg) was given to facilitate endotracheal intubation. The lungs were ventilated with 100% oxygen through a facemask. Any suspicion of difficult intubation was a signal to prepare for difficulties.

Table II. Sensitivity and specificity of MMT in detection of difficult intubation

		Cormack and Lehane classification		Total
		Grade 3,4	Grade 1,2	
MMT	Grade 3,4	12	4	16
	Grade 1,2	6	128	134
	Total	18	132	150

Notes:
Sensitivity = 12/ (12+6) ×100 = 66.67%
Specificity = 128/ (128+4) ×100 = 96.97%
Positive predictive value= 12/ (12+4)× 100= 75%
Negative predictive value= 128/ (128+6) ×100= 95.52%

Table III. Sensitivity and specificity of TMD in detection of difficult intubation

		Cormack and Lehane classification		Total
		Grade 3,4	Grade 1,2	
TMD	Difficult	10	7	17
	Easy	8	125	133
	Total	18	132	150

Notes:
Sensitivity = 10/ (10+8) ×100 = 55.56%
Specificity = 125/ (125+7) ×100 = 94.7%
Positive predictive value= 10/ (10+7)× 100= 58.82%
Negative predictive value= 125/ (125+8) ×100= 93.98%

Table IV. Sensitivity and specificity of ULBT in detection of difficult intubation

		Cormack and Lehane classification		Total
		Grad 3,4	Grade 1,2	
ULBT	Difficult	14	9	23
	Easy	4	123	127
	Total	18	132	150

Notes:
Sensitivity = 14/ (14+4) ×100 = 77.78%
Specificity = 123/ (123+9) ×100 = 93.18%
Positive predictive value= 14/ (14+9)× 100= 60.87%
Negative predictive value= 123/ (123+4) ×100= 96.85%

Table V. Sensitivity and specificity of MMT+TMD in detection of difficult intubation

		Cormack Lehane Grading		Total
		Grade 3,4	Grade 1,2	
MMT + TMD	Difficult	14	10	24
	Easy	4	122	126
	Total	18	132	150

Notes:
Sensitivity = 14/ (14+4) ×100 = 77.78%
Specificity = 122/ (122+10) ×100 = 92.42%
Positive predictive value= 14/ (14+10)× 100= 58.33%
Negative predictive value= 122/ (122+4) ×100= 96.83%

Table VI. Sensitivity and specificity of MMT+ULBT in detection of difficult intubation

		Cormack and Lehane classification		Total
		Grade 3,4	Grade 1,2	
MMT + ULBT	Difficult	16	9	25
	Easy	2	123	125
	Total	18	132	150

Notes:
Sensitivity = 16/ (16+2) ×100 = 88.89%
Specificity = 123/ (123+9) ×100 = 93.18%
Positive predictive value= 16/ (16+9)× 100= 60%
Negative predictive value= 123/ (123+2) ×100= 98.4%

Table VII. Sensitivity and specificity of TMD+ULBT in detection of difficult intubation

		Cormack and Lehane classification		Total
		Grade 3,4	Grade 1,2	
TMD + ULBT	Difficult	15	11	26
	Easy	3	121	124
	Total	18	132	150

Notes:
Sensitivity = 15/ (15+3) ×100 = 88.33%
Specificity = 121/ (121+11) ×100 = 91.67%
Positive predictive value= 15/ (15+11)× 100= 57.69%
Negative predictive value= 121/ (121+3) ×100= 96.8%

ENDOTRACHEAL INTUBATION

Laryngoscopy was performed with patient's head in the sniffing position, laryngoscopy was performed with a Macintosh 4 laryngoscope blade by an anesthesiologist. Glottic vision was evaluated according to the classification of modified Cormack and Lehane system (CL). The laryngoscopy view was graded according to this classification as follows [15]:

- Grade I - Glottis was fully viewed
- Grade II a- Glottis was partially seen
- Grade II b-Only arytenoids were seen
- Grade III-Only epiglottis was seen
- Grade IV-Neither epiglottis nor glottis were seen (Figure 5).

Difficult visualization of the larynx (DVL) was classified as CL III or IV views in direct laryngoscopy. Easy visualization of the larynx (EVL) was defined as CL I or II view in direct laryngoscopy. Confirmation of successful intubation was done by bilateral auscultation over the lung fields and capnography.

STATISTICAL ANALYSIS

Statistical analyses were performed using SPSS software version 16.0 (SPSS, Chicago, IL, USA). Data were compared using *t* test for quantitative variables and Chi square for categorical variables. For each test, sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated both separately and combined. A $p < 0.05$ value was considered significant.

STATISTICAL TERMINOLOGY USED IN THE STUDY

True positive (TP) = difficult intubation which was predicted to be difficult.

False positive (FP) = easy intubation which was predicted to be difficult.

True negative (TN) = easy intubation which was predicted to be easy.

False negative (FN) = difficult intubation which was predicted to be easy.

Sensitivity = percent of truly predicted difficult intubations as a proportion of all intubations that were correctly difficult = TP/(TP + FN).

Specificity = percent of truly predicted easy intubations as a proportion of all intubations that were correctly easy = TN/(TN + FP).

Positive predictive value (PPV) = percent of truly predicted difficult intubations as a proportion of all predicted difficult intubations = TP/(TP + FP).

Negative predictive value (NPV) = percentage of correctly predicted easy intubations as a proportion of all predicted easy intubations = TN/ (TN + FN).

Accuracy = percentage of correct results (both true positives and true negatives) as a proportion of all intubations = (TP + TN)/ (TP + TN + FP + FN).

RESULTS

DEMOGRAPHIC AND CLINICAL CHARACTERISTICS OF THE PATIENTS STUDIED

Mean age of the patients was 42.71±12.8 years (range 18-60 years). The majority of patients (61.33%) were males, while females represented only 38.67%. Mean weight and height of the patients was 73.82±11.7 kg and 163.14±9.63 cm respectively. According, the mean BMI was 26.51±6.22 kg/m2. About three-third (74.67%) of the patients had score I of ASA while 25.33% of them had score II (Table I).

THE PROPORTION OF DIFFICULT INTUBATION

Out of 150 assessed patients, 18 (12%) had difficult intubation (Figure 6).

Of those 18 patients, 17 (83.33%) patients had Cormack Lehane system grade III and one patient (16.67%) had Cormack Lehane system grade IV. All patients with difficult intubation were intubated using laryngeal mask airway. The other 132 patients were intubated at first attempt.

SENSITIVITY AND SPECIFICITY OF DIFFERENT TESTS

MODIFIED MALLAMPATI TEST

Out of 18 patients having difficult intubation according to Cormack Lehane Grading, 12 also had difficult intubation using MMT. On the other hand, 128 patients out of 132 patients having easy intubation based on Cormack Lehane Grading were also found to have easy intubation using MMT. Accordingly, the sensitivity and specificity of MMT was 66.67% and 96.97% respectively (Table II).

THYROMENTAL DISTANCE

The concordance between TMD and Cormack and Lehane classification and difficult and easy intubation was 10 patients and 125 patients respectively. Thus, the sensitivity and specificity of TMD was 55.56% and 94.97% respectively (Table III).

UPPER LIP BITING TEST

Regarding difficult intubation, ULBT coincides with Cormack and Lehane classification in 14 patients and disagreed in 4 patients. On the other hand, 123 patients were assigned to have easy intubation according to the two tests` result. This give ULBT a sensitivity of 77.78% and a specificity of 93.18% (Table IV).

COMBINATION BETWEEN DIFFERENT TESTS

MALLAMPATI TEST AND THYROMENTAL DISTANCE

As none of the described tests satisfies the required sensitivity, a combination between these tests was evaluated. For the combination between MMT and TMD, the concordance with Cormack and Lehane classification was 14 patients (difficult) and 122 (easy). According the sensitivity and specificity for this combination were 77.78% and 92.42% respectively (Table V).

MALLAMPATI TEST AND UPPER LIP BITING TEST

A relative high agreement between this combination and Cormack and Lehane classification in detection of difficult intubation (16 patients) while this agreement was restricted to 123 patients to have easy intubation. As such, the sensitivity and specificity of MMT+ ULPT were 88.89% and 93.18% respectively (Table VI).

THYROMENTAL DISTANCE AND UPPER LIP BITING TEST

According to this combination, 30 patients were found to have difficult intubation, 15 of whom were classified in accordance with Cormack and Lehane classification, while 120 patients were reported to have easy intubation, 117 of whom were detected in accordance with Cormack and Lehane classification. Therefore, the combination of TMD+ ULBT has a sensitivity of 88.33% and a specificity of 91.67% (Table VII).

DISCUSSION

A comparison of upper lip bite with thyromental distance and Mallampati score in predicting difficult intubation.

According to laryngoscopy, the rate of difficult intubation in the current study was 12%. Various worldwide studies have stated an incidence rate of difficult intubation extended between as low as 1.3 and as high as 18%, compared to some studies [16, 17], the present rate is high, but is lower than that reported by Allahyray et al. [18] which was 18.2% and comparable to Oates et al. [19] (13%). These differences in the incidence of difficult intubation between studies may be caused by a numbers of factors including anthropometric differences, variation in sample size, the criteria used to characterize the difficult intubation, lack of uniformity in describing or grading laryngeal view, head position, degree of muscle relaxation, type or size of laryngoscopic blade [20], and varying skills of anesthesiologists [21].

Generally, all evaluated tests, when tested separately, showed very high specificity and NPV, and moderate to very good sensitivities and PPV.

For MMT, the sensitivity and specificity were 66.67% and 96.97% respectively. The PPV and NPV for this test in the present study were 75% and 95.52% respectively. In a similar study, Khan et al. [22] evaluated 300 adult patients undergoing elective surgery for the efficiency of MMT in prediction of difficult intubation. The sensitivity of this test equaled 82.4% while the specificity was 66.8%, with PPV and NPV of 13% and 98.4% respectively.

In another prospective study, Srinivasan and Kuppuswamy [23] evaluated the sensitivity and specificity of MMT in 354 patients which were found to be 70.5% and 54.7%, respectively with 20.8% PPV and 91.7% NPP.

Other studies which investigated MMT as a single predictor showed a wide range of sensitivity (40%-82.4%) [22, 24, 24, 26, 27]. Similarly, the specificity of the test ranged from 54.7% [23] to as high as 91% [28] and 91.3% [29].

The wide variation in reported sensitivity and specificity of MMT in different studies may be explained by several factors, the most important of which are inter-observer disagreements. This is because there is no clear definite demarcation between class 2 and class 3 and between class and class 3 and class 4 [30]. Some limitations for MMT are that it does not evaluate neck mobility which is a critical factor in predicting difficult intubation [31]. Furthermore, it has been shown that a low prediction value of MMT is referred to the involuntary phonation during the test, which can affect the MMT score [20]. Other studies demonstrated that the critical factor for achieving a reliable MMT is the maximum extrusion of the tongue and opening the mouth. Failure to perform these maneuvers will adversely affect the result of test [19].

In the present study, TMD had 55.56% sensitivity and 94.7%. specificity, while the PPV and NPV were 58.28%. and 93.98% respectively. These results are partially agreed with the study of Salimi et al. [32] who conducted a prospective, observational study in 350 patients undergoing elective surgery. The sensitivity, specificity, PPV and NPV for TMD in this study were 70%, 93.3%, 39% ,98% respectively. Also, the present study was comparable with Inal et al. [33] who assessed the value of TMD test as well as other tests in prediction of difficult intubation. The study revealed a sensitivity of 61.54%, and specificity 99.11% of the test, while the PPV and NPV were 93.8% and 92.1% respectively.

In contrast Shah et al. [34] obtained very low sensitivity for the test (only 7.4%) with high specificity (98.06%), 38.44% PPV, and 86.70% NPP. Also, the current sensitivity of TMD was higher than that reported by Kaniyil et al. [35] who reported 28.72% sensitivity, 97.5% specificity, 53.3% PPV and 97.2% NPV for this test.

This variation in the results of different studies also has its justifications. TMD can have a high inter-observer variability as the definition is not clear whether to measure the distance from thyroid cartilage to the inner or outer aspect of mentum. The cut-off values of TMD are disputed and range widely between studies. Also, both short and long TMD measurements may be associated with difficult intubation. it focuses the examiner's attention on the geometry of the airway [36].

The present study revealed that ULBT was the best test among the three assessed tests. The sensitivity and specificity of ULBT were 77.78% and 93.18% respectively with PPV of 60.87% and NPV of 96.85%.

The present results are comparable with that obtained by Shah et al. [34] who recruited 480 adult patients to assess the prediction efficiency of ULBT and some other tests for the presence of difficult intubation. The sensitivity and specificity were found to be 71.63% 91.5% respectively while PPV was 58.82% and NPV was 95.7%. Also in partial agreement with the present study is the study of Salimi et al. [32] in which the authors reported 70% sensitivity, 93.7% specificity, 39% PPV and 98.1 and NPV.

The ULBT was initially proposed to combine two important features that affects the intubation: jaw subluxation and the presence of buck teeth which interfere with inhalation [22]. It was reported to have a high interobserver reliability because of its precise and easy demarcation between classes [37]. However, racial differences can greatly influence the results, and it cannot be applied to edentulous patients [30]. Clinically, the mean encountered difficulty in this test was that some patients could not understand that taste even with demonstrations made by anesthesiologist [15]. Moreover, ULBT does not take into account relative tongue and pharyngeal size, mandibular space and a narrow arched palate. Also, it requires the ability to move the teeth and their presence at all [29].

Although there are several predictors and clinical tests, it seems that no single test could correctly predict all cases of difficult intubation. In the current study, the best combination for difficult intubation prediction was MMT+ULBT, in which the sensitivity and specificity were 88.89% and 93.18%, while the PPV and NPV were 60% and 98.4% respectively. These results were slightly higher than that obtained from the combination of TMD+ULBT.

Compared with other studies, MMT and ULBT combination had very high sensitivity 99.3%, very low specificity (7.32), and very high PPV (93.6%) and low NPV (42.9%) [38]. In another study, by Srinivasan and Kuppuswamy [15], such a combination gives 83.3% sensitivity 52.34% specificity, 5.78% PPV and 98.9% NPV. These variations in different studies are expected because the sensitivity and specificity of the two components of MMT + ULBT combination varies among different populations and are affected by several factors like interobservers variation and patients' cooperation.

CONCLUSIONS

1. The frequency of difficult intubation in the present series is within the context of international series
2. Upper lip biting test has the best sensitivity while modified Mallampati test had the best specificity among the three evaluated tests in predicting difficult intubation.
3. No single test alone can be reliable for predicting of difficult intubation
4. the combination of ULBT and MMT was the best in terms of both sensitivity and specificity for prediction of difficult intubation.

RECOMMENDATIONS

1. More than one test should be used as predictors for DI before conducting a tracheal intubation
2. Investigation of the other simple tests such as neck circumference, jaw protrusion, sternomental distance, cervical spine mobility and hyomental distance, separately or in combination for more reliable test to be recommended for general use.

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Conflict of interest:

The Authors declare no conflict of interest.

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Received: 28.09.2021
Accepted: 30.08.2021

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