ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 11, Issue, 09, pp.6893-6898, September, 2019

DOI: https://doi.org/10.24941/ijcr.36481.09.2019

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

RESEARCH ARTICLE

A STUDY TO EVALUATE THE DIFFICULT ENDOTRACHEAL INTUBATION BY USING SIMPLE BED SIDE TESTS

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ARTICLE INFO

Article History:
Received 17th June, 2019
Received in revised form
20th July, 2019
Accepted 28th August, 2019
Published online 30st September, 2019

Key Words:
Difficult endotracheal intubation,
Modified Mallampati test,
Thyromental and Sternomental distance.

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ABSTRACT

Introduction: The fundamental responsibility of an anesthesiologist is to maintain adequate ventilation / gas exchange during operations. Failure to maintain a patent airway for more than few minutes results in brain hypoxia, damage or death and has medico legal implication also. When a difficult airway is unrecognized before attempting the intubation, the result can be catastrophic because the personnel and necessary equipment needed for specialized tracheal intubation may not be available in such emergent situation. ***Aims and objectives:*** To assess the reliability of simple bedside tests to predict difficult endotracheal intubation and to determine if a combination of any of these tests could enhance the sensitivity and specificity in predicting difficult intubation. ***Material and method:*** This double blind prospective study was conducted on 100 adult patients who presented for pre-anesthesia checkup in the Department of Anesthesiology, Rama Medical College Hospital and Research Centre NH 24 Pilkhuwa, Hapur. ***Summary and conclusions:*** From this study it is concluded that no methods either individual or in combination identifies all the cases of difficult intubation and so the "difficult intubation drill" should always be ready. Amongst the individual tests the best balance of sensitivity and specificity was that of Modified Mallampati Test, Thyromental Distance and Sternomental Distance.

Citation: Dr. Surendra Kumar, *Dr. Praveen Kumar, Dr. Atul Kaushik and Dr. Desh Pal Singh, **2019.** "A study to evaluate the difficult endotracheal intubation by using simple bed side tests", *International Journal of Current Research*, 11, (09), 6893-6898.

INTRODUCTION

The fundamental responsibility of anesthesiologists is to maintain adequate ventilation / gas exchange during critical care and operations. Failure to maintain a patent airway for more than few minutes result in hypoxia, brain damage or death and has medico legal implication also. When a difficult airway is unrecognized before attempting the intubation, the result can be catastrophic because the personnel and equipments necessary for utilizing the specialized tracheal intubation techniques may not be immediately available and the patient's spontaneous respiratory effort may have been eliminated by anesthesia or muscle relaxants (Benumof, 1991). Inadequate ventilation is a big culprit (38%) with esophageal intubation and difficult intubation being responsible in 17% and 18% cases respectively (Caplan *et al.,* 1990). In 85% of these cases the outcome was death or brain damage. Caplan suggested that most of the outcomes were preventable (72%) and improved strategies for the difficult intubation was urgently required (Caplan *et al.,* 1993). Most important reason for doing airway assessment is to identify a difficult airway so that one can develop a plan for airway management. It is important to remember that use of regional anesthesia does not ruleout the possible need for general anesthesia and intubation. However for all practical purposes difficult airway can be defined as that which by the virtue of disproportionate anatomy or pathology is likely to offer moderate to severe difficulty in bag-mask ventilation, direct laryngoscopy or both. As a practical matter difficult airway is recognized in one of the following ways:

- As obvious anatomical challenge.
- In association with complications of medical diseases.
- After poor or failed visualization of glottis during direct laryngoscopy and endotracheal intubation.

Obvious causes of difficult airway include abnormal faces, neck swelling due to malignancy or inflammation, traumatized airway and obesity. On the other hand the causes may be hidden when the difficult airway occurs in relation to diseases like diabetes mellitus, acromegaly, thyroid disease, scleroderma and rheumatoid arthritis. Therefore assessment of the airway is more important than many of the investigations we routinely order in our pre-anesthetic clinic. Unexpected difficult intubations are probably the result of lack of accurate predictive test for difficult intubation and inadequate preoperative assessment of the patient's airway (Tse *et al.,* 1995). There is substantial literature available about the difficulties which may be encountered and how to handle them (Rose and Cohen, 1994; Wilson *et al.,* 1988). Research aimed at predicting difficult endotracheal intubation falls into two categories. One is concerned with defining the underlying

anatomical problems and the other category is aimed directly at producing a simple bedside test that will reliably predict those patients in whom laryngoscopy may be difficult (Wilson *et al.,* 1993). In the second category of research a number of airway assessment schemes based on physical examination findings have been proposed and tested. The first category of research was carried out by Bellhouse and Dore (Bellhouse and Dore, 1988). The simpler schemes fail to address the multifactorial nature of the problem while the more complex systems are clinically demanding (Mallampati *et al.,* 1985). Amongst the individual tests the test most widely advocated is that devised by Mallampati and colleagues (Oates *et al.,* 1991) but unreliable (Cohen *et al.,* 1998) and it gives good results if only combined with other tests (Nath and Sekar, 1997). Wilson (Arne *et al.,* 1988) also found several factors associated with difficult intubation. These tests were quick and simple. But this too has been found to fail in predicting difficult laryngoscopies. Atlanto-occipital jointis now known to be especially important (The Airway, 2003). Also many subjective factors like receding mandible, protruding teeth and extent of the temporomandibular joint, all of which may affect the laryngoscopic view and have not been taken into account in many earlier studies, have been incorporated in our study by including the relatively simple new tests (Cases *et al.,* 1956). Clearly no single test is ideal as difficult laryngoscopy is a multifactorial problem. Mallampati sign which had a very high sensitively and specificity in some studies had a much lower sensitivity in subsequent larger prospective series (White and Kander, 1975). Wilson's multi-factorial index picked up only 71% of the difficult intubations even in the original study when a criteria of 2 or more was taken as positive. The sensitivity dropped in a prospective study done by Oates (Nicola and Zuck, 1983). Bellhouse and Dore suggested a combination of Mallampati sign, Thyromental distance and restricted head extension which they found to be 100% sensitive.[19] This study was conducted in an attempt to devise a method of predicting difficult intubation which is more comprehensive and accurate as well as simple and clinically applicable on day to day basis.

Aims and objectives

1) To assess the reliability of simple bed side tests to predict difficult intubation.
2) To determine if a combination of any of these tests that could enhance the sensitivity and specificity in predicting difficult intubation

MATERIALS AND METHODS

This double blind prospective study was conducted on 100 adult patients who presented for pre-anesthesia checkup in the Department of Anesthesiology and Critical Care at Rama Medical College Hospital and Research Centre, NH 24 Pilkhuwa, Hapur.

Selection of Patients: Patients in age group 18-55 years scheduled for elective surgery under anesthesia requiring tracheal intubation were selected for the study.

Exclusion Criteria

1) Edentulous patients
2) Patients with loose or missing incisors
3) Pregnant patients
4) Patients unable to sit up
5) Patients with temporomandibular joint ankylosis and facial trauma
6) Patient with intraoral mass/tumor

The study was approved by the ethics committee of Rama Medical College Hospital and Research Centre, NH 24 Pilkhuwa, Hapur. All patients were examined either in the pre-anesthesia clinic or in the day before the operation. They were explained the procedure and an informed consent was obtained. The demographic data collected included age, sex, weight and height.

The airway of these patients was assessed using simple bed side tests and was scored as under:

Modified Mallampati test

The patients were seated straight in front of the observer with head in central position and were asked to open the mouth maximally and protrude the tongue as much as possible. Phonation was avoided during the examination. The oropharyngeal structure was examined with the observer's vision in line with the oral cavity using a well illuminating torch. The view was graded as follows:

Thyromental distance

It was measured as the straight distance between thyroid prominence and the bony point of the mentum with the head of the patient fully extended on the neck and the mouth closed. The distance was measured using a ruler. The measurement was scored as under:

Measurement	Points
>7 cm	1
>6-7cm	2
>5-6cm	3
>4-5cm	4
≥4cm	5

Thyromental distance of ≤7cm was considered to be a predictor of difficult intubation.

➢**Sternomental distance**

It was measured with the patient seated erect with the head fully extended over the neck the mouth remaining closed. The straight distance between the upper border of the manubrium sterni and the bony point of the mentum was measured using a ruler and scored as follows:

Measurement	Points
>12.5cm	1
>11.5-12.5cm	2
>10.5-11.5cm	3
≤10.5cm	4

Sternomental distance of ≤ 12.5 cm was considered as predictor of difficult intubation.

➢**Intubation difficulty score**

The points allotted in each test were then added and patient was given an "intubation difficult score".

The predictive easy or difficult endotracheal intubation was graded as:

Probably easy intubation 3-5 points
Probably difficult but possible intubation 6-12 points
Impossible intubation >13 points

After the above pre-operative tests a standard induction and intubation protocol was used in the operation room for all patients which included:

- Premedication: Inj.Glycopyrolate 0.2mg, Inj. Emeset 4mg, Inj Midazolam 1 mg before induction was given..
- Position of the patient: The patient was placed in a supine position with the head resting on a head ring in "sniffing position" and the patient`s face kept at the level of the anesthesiologists' xiphoid process.

All available equipment for difficult intubation drill was arranged for each patient. Pre-oxygenation was done with 100% oxygen for 3 minutes. General anesthesia was induced with Inj. Propofol 2mg/kg body weight i.v.. Following this Inj. Succinylcholine i.v. 2 mg per kg body weight was given to facilitate laryngoscopy and endotracheal intubation. After the disappearance of fasciculation laryngoscopy was performed using a #3 or #4 standard Macintosh blade by a consultant who was unaware of the preoperative scoring. The best view was obtained both with and without applying external laryngeal pressure and noted using the classification of Cormack and Lehane as follow:

Grade 1. Vocal cords visible
Grade 2. Only posterior commissure or arytenoids visible
Grade 3. Only epiglottis visible
Grade 4. No glottic structure visible

A note was also made whether the tracheal intubation was difficult or not. Intubation was termed "difficult'' if either laryngoscopic view was grade 3 or 4 or if a gum elastic bougie was required for tracheal intubation after failing twice with direct placement.

➢Statistical analysis

The association between different variables and difficulty in intubation was evaluated using the Chi-square test for qualitative data and the Student's test for quantitative data. $P<0.05$ was regarded as significant. Clinical data of each test was collected, tabulated and analyzed.

➢Observations and results

In the study one hundred patients scheduled to undergo ENT, Gynecological, Orthopedic and General surgical procedures under general anesthesia were included. Among these 41 were male and 59 were female. They were between 18-55 years of age and at laryngoscopy 28 of them were found to have airways that were difficult to intubate (laryngoscopy grade III or IV)

Demographic Data

The mean age of the patients in easy and difficult group was 34.58 ± 12.6 and 39.29 ± 11.12. The mean weight of patients in the easy intubation group was 53.75+11.08 kg whereas it was 53.75+13.09 kg in those with difficult laryngoscopy. The mean height among those with easy intubation was 156.25+8.05 cm and among those with difficult intubation was 156.28+10.08cm ($P>0.05$). In 41 male patients 12(29.26%) had difficult laryngoscopy. Amongst the 59 female patients 16 (27.1%) had difficult laryngoscopy. The incidence of difficult laryngoscopy amongst obese patients was statistically significant ($p<0.05$).

Table 1. Demographic Data (Mean ± S.D.)

Variable	Laryngoscopic Assessment Easy(72)	Difficult(28)	P value
Age	34.58±12.61	39.29±11.12	0.1
Weight	53.75±11.05	53.75 ±13.09	0.002*
Height	156.25±8.05	156.28±10.08	0.9
Sex (M/F)	29/43	12/16	0.8

*statistically significant

Table 2: Cormack-Lehane's Laryngoscopic grading

Easy = 72		Difficult = 28	
Grade I	Grade II	Grade III	Grade IV
52	20	25	3

Table 3. Distribution of laryngoscopic grading in Modified Mallampati classification

Cormack-lehane grading					
MMT	**I**	**II**	**III**	**IV**	**Total**
I	32	6	3	0	41
II	11	10	5	1	27
III	8	4	6	1	19
IV	1	0	11	1	13
Total	52	20	25	3	100

Table 4. Relation between Modified Mallampati v/s Cormack-Lehane laryngoscopic Grading

		Cormack-Lehane grading		Total
		Difficult	**Easy**	
MMT	Difficult	19	13	32
	Easy	9	59	68
TOTAL		28	72	100

Table 5. Distribution of laryngoscopic grading in Thyromental distance

TMD	CORM I	ACK II	LEHA III	NE IV	TOTAL
>7	40	14	17	0	71
>6-7	7	6	5	1	19
>5-6	5	0	2	2	9
>4-5	0	0	1	0	1
≤4	0	0	0	0	0
TOTAL	52	20	25	3	100

Table 6. Relation between Thyromental distance v/s Cormack-Lehane laryngoscopic Grading

		Cormack-Lehane grading		Total
		Difficult	**Easy**	
TMD	Difficult	11	18	29
	Easy	17	54	71
TOTAL		28	72	100

Sensitivity39.2% ; Specificity75% ; Positive predictive value37.9% ; Negative predictive value76.05%

Using discriminated analysis a TMD of 8 cm or less was calculated to be the most accurate cut off point for

discriminating between difficult (Grade III and IV) and easy laryngoscopy (Grade I and II).

Table 7. Sensitivity and specificity at various cut off values in the TMD test

TMD	Sensitivity	Specificity
6	17.86	93.05
6.5	17.86	90.27
7	39.28	75
7.5	39.28	72.22
8	64.28	51.38
8.5	64.28	38.88
9	82.14	29.16
9.5	82.14	20.83
10	100	9.72

Table 8. Distribution of Laryngoscopic Grading in various grades of Sternomental Distance

Sternomental Distance (cm)	Cormack-lehane grading				Total
	I	II	III	IV	
>12.5	45	16	22	1	84
>11.5&12.5	7	3	2	3	15
>10.5&11.5	0	0	0	0	0
≤10.5	0	1	0	0	1
Total	52	20	24	4	100

Means and SD together with the number of patients in each class of SMD are shown for each laryngoscopy grade in Table-7.The mean SMD was16.96cms (SD 2.69) with sensitivity, specificity and negative predictive values for each cut off.

Points are shown in Table-8. The SMD test at a cut off of 12.5 cm correctly predicted 5 out of 28 difficult intubations (sensitivity = 17.85%) also of 72 cases graded as Cormack-Lehane laryngoscopic grade I and II, SMD correctly predicted 61(specificity=84.72%)

Table 9. Relation between Sternomental distance v/s Cormack and Lehane Laryngoscopic grading

		Cormack-Lehane grading		Total
		Difficult	Easy	
SMD	Difficult	05	11	16
	Easy	23	61	84
TOTAL		28	72	100

Sensitivity17.85%; Specificity84.72%; Positive predictive value31.25%; Negative predictive value72.62%.

Using discriminate analysis a SMD of ≤17cm was calculated to be the most accurate cut off point for discriminating between difficult laryngoscopy (Grade III and IV) an easy laryngoscopy (Grade I and II) (Table-9).

Table 10. Sensitivity and specificity at various cutoff values in the SMD test

SMD	Sensitivity	Specificity
11	0	98.61
12	14.28	84.72
13	17.85	83.33
14	25	83.33
15	32.14	76.38
16	35.71	70.83
17	53.57	56.94
18	82.14	33.33
19	92.85	19.44
20	100	5.55

Table 11. Comparative analysis of Sensitivity, Specificity, PPV and NPV of various tests

TEST	Sensitivity	Specificity	PPV	NPV
MMT	67.86	81.9	59.37	86.76
TMD	39.2	75.0	37.9	76.05
SMD	17.85	84.72	31.25	72.61
IDS	64.28	81.94	58.06	85.50

Combination of tests: With a view to improve the sensitivity and specificity, various combinations of these tests in the two groups were done. A difficult intubation was predicted when each of the test combination was positive.

Combination of 2 tests: Different combinations were possible among the tests. Table–12 shows the sensitivity and specificity for the various combinations. It was seen that the combinations had excellent specificity but had a low sensitivity. Among them the combination of Modified Mallampati Test had the best balance of sensitivity and specificity.

Table 12. Sensitivity and Specificity for various combinations at two tests

Combination of two tests	Sensitivity	Specificity
MMT+TMD	25	94.44
MMT+SMD	7.14	98.61
TMD+SMD	14.28	98.61

DISCUSSION

The management of the airway with induction of anesthesia is the primary and unique responsibility of the anesthesiologist. Difficulty in endotracheal intubation constitutes an essential predisposing factor for morbidity and mortality especially when it is not anticipated preoperatively (Cattano *et al.,* 2004). Over recent year several clinical methods have been proposed for preoperatively identifying the difficult intubation. These include Mallampati grading, Thyromental distance and Sternomental distance. A test to predict difficult intubation should have high sensitivity so that it will identify most patients in whom intubation will be difficult. It should also have a high positive predictive value so that patients with easy intubation are not subjected to difficult airway management protocol (Rose and Cohen, 1994). The study was therefore undertaken in an attempt to devise a method of predicting difficult intubation which is more comprehensive and accurate as well as simple and clinically applicable on a day to day basis. Our study was conducted in 100 patients of either sex from 18-55 years of age scheduled to undergo surgery under general anesthesia. Pre-operatively the airway of these patients were assessed for the following parameters namely Modified Mallampati test (MMT), Thyromental (TMD) and Sternomental distance (SMD). Each discriminate value of the above variable was assigned points. The intubation difficulty score (IDS) was then calculated for each patient by adding points. We predefined difficult intubation as Cormack–Lehane laryngoscopic grade III or IV or use of a gum elastic bougie after failing twice with direct placement of endotracheal tube. There were 28 patients in whom intubation was difficult out of which 25 were laryngoscopic III and IV. There were no case of failed intubation. The modified Mallampati test is one of the commonest clinical methods used to predict difficult intubation. It is an assessment of relative size of the tongue to

the oral cavity. The Mallampati classification (Bellhouse, 1988) had a sensitivity of 100% and a specificity of 80% in the original paper but it was found to be only 42.44% sensitive in two large prospective series with specificity and PPV of 84% and 4.4% respectively (Oates *et al.,* 1991; Cohen *et al.,* 1998). This was probably due to various factors on which Mallampati classification depends. Limitation of this predictive test includes failure to consider neck mobility, size of mandibular space and significant inter-observer variability in classification. Also certain physiological factors like phonation, pregnancy and labour alter its assessment value (Farcon *et al.,* 1994). Also the MMT may not discriminate those patients in whom difficult laryngoscopy is caused by limited head and neck mobility. TMD alone has been advocated as a screening test for predicting difficult intubation since several factors such as restricted head extension, receding mandible or a high anterior larynx may contribute to its shortening. As per the original study by Patil *et al.* (1983) a TMD less than 6 cm was associated with difficult intubation. Using a TMD less than 6cm and mentomandibular distance of less than 9cm Mathew *et al.* (1989) observed sensitivity, specificity and positive predictive value of 100 %. In a subsequent study by Butler *et al.* (1992) who also considered the cut off value for anticipated difficult intubation as a TMD of less than 6cm observed a sensitivity of 62% specificity of 25% and PPV of 16%. However Koay *et al.* (1998) concluded that a TMD of 6cm or less as a predictor of difficult intubation has a poor specificity and a low Positive Predictive value. A number of recent studies defined TMD less than 7cm to predict difficult intubation (Rose and Cohen, 1994; Nath and Sekar, 1997; Yamamoto, 1907). In spite of higher cut off these studies had a low sensitivity, specificity and PPV. We also considered a TMD of $\leq$ 7cm to predict difficult intubation. The mean TMD in the easy intubation group was 8.74 ± 1.72 whereas in the difficult intubation group it was 7.91 ± 1.46 ($p>0.05$). Our study had total of 29 patients with TMD $\leq$7cm out of which 11 had difficult intubation (8 of them had Cormack-Lehane grade III and 3 had grade IV) resulting in a PPV of only 37.9%. The test falsely predicted 18 cases to have difficult intubation out of FP=25.0%.

Summary and conclusion

Evaluation of difficult endotracheal intubation is mandatory for safe anesthetic care. Together the history and focused physical examination may provide clues about a number of congenital, developmental and acquired conditions that are associated with difficult intubation. All association between different variable and difficulty in intubation was evaluated using the Chi-square test for qualitative data and the Student's test for the quantitative data. P value <0.05 was considered as significant. The sensitivity, specificity, positive (PPV) and negative predictive values (NPV) were calculated for each test according to standard formulae. No method either individual or in combination had 100% sensitivity. In any individual test the most common problem was not "missed diagnosis" but rather predicting many to be difficult when in fact they were not. Amongst the individual tests MMT had the greatest ability to predict difficult intubation i.e. sensitivity of 67.85% followed by TMD with 39.2%.For correct identification of easy intubation specificity for MMT was 81.90%.

From this study the following conclusions were drawn:-

1) No methods either individual or in combination identifies all the cases of difficult intubation and so the "difficult intubation drill" should always be ready.
2) Amongst the individual tests the best balance of sensitivity and specificity was that of Modified Mallampati Test followed by Thyromental distance and Sternomental distance.
3) It was observed that the sensitivity progressively decreases while the specificity improves as the combinations are expanded for two test.
4) The "intubation difficult score" used in this study is an easy and reliable method of predicting difficult intubation as it involves assessment of most of the common variable and has an optimal balance of sensitivity and specificity and a high positive predictive value and a low false positive.

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