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Original article

A Prospective clinical study of difficult intubation predictors in Tertiary Care Hospital

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Abstract

Background: *Airway management is of prime importance to an Anaesthesiologist. Unanticipated difficult laryngoscopy and endotracheal intubation remains a primary concern of anaesthesiologists. The reported incidence of a difficult laryngoscopy or endotracheal intubation varies from 1.5% to 13% in patients undergoing surgery. Failure to intubate is detected in 0.05 - 0.35% of the patients. Thus preoperative airway assessment is of pivotal importance for the anaesthesiologist to predict difficult intubation. Thus we aimed to study the usefulness of six different airway assessment predictors as a clinical tool to predict difficult intubation.*

Methods: *100 patients between 18-50 years of age and either sex were included in our study. We assessed a combined head and neck movements, modified Mallampati classification, Mouth opening, Upper Lip Bite Test and Body Mass Index in all the patients. A Cormack lehane grade of I & II were considered easy intubation and III & IV were considered to be difficult.*

Results: *7 patients had difficulty during intubation. Mean age, weight, and Body Mass Index of Group E (Easy Intubation, n = 93) and Group D (Difficult Intubation, n = 7) were 34.2 yrs, 63.2 kg and 24.2 kg/m2, and 42.6 yrs, 67.71 kg and 27.2 kg/m2 respectively. Mean age and BMI were statistically significant (P < 0.05) in both the groups. A combined head and neck movement had highest sensitivity (57.1%), Positive Predictive Value (44.44%). Mouth opening, Thyromental distance and Upper Lip Bite Test had least sensitivity. All predictors had high Specificity and Negative Predictive Values.*

Conclusion: *From our study we conclude that: Head extension is the single important predictor of difficult intubation among the other predictors and other predictors are of value when they are combined with Head extension, but not as single predictor. All the six predictors are good at identifying most of the easy intubations.*

Key words: *Body Mass Index, Upper Lip Bite Test, Intubation.*

Introduction

Indirect visualization of the larynx had started in the year 1854, when a Spanish vocal pedagogist Manuel Garcia, became the first man to view the functioning glottis in a living human. After that many persons developed various techniques for indirect visualization of glottis. In the year 1878, Sir William McEwan passed a tube from the mouth into the trachea of a conscious patient using fingers as a guide and gave chloroform and air mixture for the removal of carcinoma from base of the tongue[1]. His technique was an attempt to describe endotracheal intubation for providing anaesthesia. In 1913, Chevalier Jackson was the first to report a high rate of success for the use of direct laryngoscopy as a means to intubate the trachea. Further advances were made by Sir Ivan Whiteside Magill. He developed the technique of awake blind nasotracheal intubation. Magill also devised a new type of angulated forceps (the Magil forceps) that is still used today especially to facilitate nasotracheal intubation. Other devices invented by

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Magill include the Magill laryngoscope blade[2,3] Failure to intubate is detected in 0.05 - 0.35% of the patients. Difficult laryngoscopy and intubation cause increased risk of complications to the patient ranging from sore throat to airway Trauma[4]. In some cases, if Anaesthesiologist is not able to maintain a patent airway, the dreaded nightmare for any Anaesthesiologist so called 'Cannot intubate - Cannot Ventilate' situation , ma y lead to serious complications like hypoxic brain damage or death[5]. Of all the anaesthesia related deaths 30% to 40% are attributed to the inability to manage a difficult airway . Of the overall claims against anaesthetist in closed claims project, 17% involved difficult or impossible intubation . Most of the dire consequences of unanticipated and failed tracheal intubations can be prevented and hence comes under preventable factors in anaesthetic mishaps. Although predict ion and forecasting is a tough business and because of the potentially serious consequences of failed tracheal intubation, considerable at tent ion has been focused on at tempts to predict patients in whom laryngoscopy and intubation will be difficult[6].

The difficulty of achieving a patent airway varies with anatomic and acquired individual patient factors. Thus per forming an airway assessment preoperatively in identifying a patient for a potentially difficult intubation is of pivotal importance for the anaesthesiologist . Difficulty in intubation is usually associated with difficulty in exposing the glottis by direct laryngoscopy. This involves a series of manoeuvres like extending the head, flexion at lower cervical joints, adequate opening of the mouth, displacing and compressing the tongue to the left side on the floor of the mouth and lifting the mandible forward. The ease or difficulty in performing each of these manoeuvres can be assessed by one or more parameters. Initially the airway assessment was carried out by single factors like Head extension and neck flexion, Mallampati's Oropharyngeal classification, Thyromental distance, Interincisor gap, protrusion of the mandible etc. and the Upper lip bite test[7]. But when it was realized that the visualization of larynx during intubation is affected by many factors, the concept of multivariate factors came into existence[8]. These include modified Head and neck movement Mallampati test , thyromental distance, inter -incisor gap, Body mass index etc. to create a scoring system. By adapting these multivariate factors one can overcome the deficiency occur ring with individual factors and anticipate difficult intubation with much better accuracy. Even with the use of multivariate factors there have been instances when a patient predicted to have difficult intubation had an easy intubation and vice versa. So predicting a difficult intubation employing a myriad of measurements and observations has not demonstrated itself to be practicable or even reliable. Thus we proposed to study the usefulness of six different airway assessment predictors as a clinical tool to predict difficult intubation with regards to their sensitivity, specificity, positive and negative predictive values.

Materials and Methods

This study was conducted at Meenakshi Medical College Hospital and Research Institute, Kanchipuram. One hundred adult patients aged 18 – 50 years of age requiring surgery under General anaesthesia with endotracheal intubation were enrolled in our current study. Institutional ethical committee clearance and written informed consent from the patients were obtained prior to the proposed surgery. All the patients were selected based on the inclusion and Exclusion criteria. The enrolled patients were subjected to the following assessments preoperatively: 1. Head extension and neck f lexion. 2. Oropharyngeal class according to the Modified Mallampati classification. 3. Mouth Opening and Thyromental distance were measured by using Rigid Ruler method. Upper Lip Bite Test and obesity measurements were measured by sing standard methods.

All the enrolled patients were given Tab Alprazolam 0.5mg and Tab Ranitidine 150mg and fasted overnight. On the day of surgery, a resident Anaesthesiologist checked for whether consent to provide anaesthesia was obtained. An IV line was secured in the pre-operative room. The patient was then shifted to the Opera ion Theatre and connected to multipara monitors

including Electrocardiogram, Non-invasive blood pressure and Pulse Oximetry.

All the enrolled patients were anaesthetized using a standardized anaesthesia technique comprising of premedication with Inj . Glycopyrrolate 0.005 mg/kg, Inj . Midazolam 0.05 mg/kg

and Inj . Fentanyl 2 mcg/kg intravenously. After pre oxygenation with 100% oxygen for 3 minutes, patients were induced with Inj . Propofol 2 mg/kg and Inj. Vecuronium 0.1 mg/kg intravenously.

After all four twitch loss on neuromuscular monitor in train of four response, laryngoscopy and endotracheal intubation was at tempted with the patient's head and neck in optimal intubating position with a pillow under the occiput during intubation (sniffing position), using an appropriate size
Macintosh curved blade for all patients by an Anaesthesiologist having minimum three years of experience in clinical anaesthesia. The anaesthesiologist who per formed the laryngoscopy and
intubation was blinded to the study. The glottic view was graded according to the Cormack and
Lehane grading as given below.

Grade I - Full view of the glottis
Grade II - Only posterior commissure visible
Grade III - Only tip of epiglott is visible
Grade IV - No glottic structure visible

The patient was then intubated. If the intubation was found to be difficult, the anaesthesiologist would first perform an optimal external laryngeal manipulation to improve the glottic exposure. If this failed to improve the glottic view, a change of blade size or use of a McCoy Blade or use of a gum elastic bougie was employed as preferred by the anaesthesiologist. The time taken to successful intubation was noted. Failure to intubate the trachea was also noted.

Statistical Analysis

Data analysis was done by entering the observations in SPSS software version 20 for windows. The age, gender, height, weight an d BMI were calculated and means were compared using ' t ' test. Wherever applicable to find any statistical significance between patients with easy intubation and those with difficult intubation. The preoperative airway assessment data and the findings during intubation were used to determine the Sensitivity, Specificity, Positive and Negative predictive value for each test. Crosstabs procedure was employed for association between the airway predictors and difficulty in intubation. One sample 't' test was used to calculate statistically significant difference in Sensitivity, Specificity, Positive and Negative predictive value between these tests respectively.

Results

The present study was undertaken to assess the reliability and to compare the commonly used preoperative difficult airway assessment criteria. One hundred patients of either sex between the
ages of 18 and 50 requiring surgeries under general anaesthesia with endotracheal intubation were assessed.

Demographic Profile

The Mean Age of Easy intubation group was 34.17 ± 9.34 yrs and that of difficult intubation group was 42.57 ± 6.80 yrs. This was found to be statistically significant. The mean Body Mass Index of Easy intubation group was 24.203 ± 2.96 kg/m2 and that of difficult intubation group was 27.157 ± 5.58 kg/m2 . This was also found to be statistically significant. Means of Height and weight were not statistically significant.

Group		Mean	Std. Deviation	Standard Error	P Value
Age	Group E	34.17	9.344	0.969	0.022*
	Group D	42.57	6.803	2.571	
Height	Group E	161.26	6.481	0.672	0.139
	Group D	157.43	7.435	2.810	
Weight	Group E	63.16	9.781	1.014	0.262
	Group D	67.71	16.173	6.113	
BMI	Group E	24.203	2.9601	0.3069	0.020*
	Group D	27.157	5.5842	2.1106	

* Statistically significant
Group E- Easy Intubation (n=93 Patients)
Group D – Difficult Intubation (n =07 Patients)

Comparison between Head and Neck Movements vs Difficult Intubation

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In our study, among the hundred patients, preoperative assessment showed 91 patients with Head and Neck Movements of > 900 and 9 patients with restrict ion in Head and Neck Movements (<
900), among whom 7 patients had an abnormal Delilkan' s test (Abnormal Head extension). Only 3 had limitation in flexion of the neck. 5 out of 9 of these patients had Diabetes Mellitus.
4 patients with Head and neck movements of < 90 0 and 3patients with a Head and neck movements of > 900 had a Cormack Lehane grade III. Three out of the four patients with Head and neck movements of < 900 had an abnormal Delilkan ' s Test[10] (Abnormal
Head extension). The distribution has been given in Table 2a and 2b. Head and neck movements showed a sensitivity of 57.1% (25 – 84.2, 95% CI) and a Positive predictive value of 44.4 % (18.9 – 73.3, 95% CI).

2a. Head and Neck Movements vs Difficult Intubation based on the Cormack Lehane Grade

	Cormack Lehane Grade				Total
	I	II	III	IV	
HNM <90˚	4	1	4	0	9
Group >90˚	76	12	3	0	91
Total	80	13	7	0	100

2b. Head and Neck Movements vs Difficult Intubation

Parameter	Value	95% Confidence Interval
True Positive	4	
False Positive	5	
True Negative	88	
False negative	3	
Sensitivity	57.1%	25-84.2
Specificity	94.6%	88-97.7
PPV	44.4%	18.9-73.3
NPV	96.7%	90.8-98.9

Modified Mallampati Classification Vs Difficult Intubation

In our study, among the hundred patients, preoperative assessment showed that 58 patients had a Modified Mallampati Classification I and 30 patients had a MMC II & 12 had a MMC II I.
Among these, 4 patients with MMC I and II & 3 patients with MMC II I had a Cormack Lehane grade III. There were no patients with a MMC IV in our study. The details have been given in Table 3a and 3b. Modified Mallampati Classification showed a sensitivity of 42.9% (15.8 – 75, 95% CI) and a Positive predictive value of 25 % (8.9 – 53.2, 95% CI) .

3a. Modified Mallampati Classification group vs Difficult Intubation based on the Cormack Lehane Grade

		Cormack Lehane Grade				Total
		I	II	III	IV	
MMC Group	I	50	6	2	0	58
	II	23	5	2	0	30
	III	7	2	3	0	12
	IV	0	0	0	0	0
Total		80	13	7	0	100

3b. Modified Mallampati Classification vs Difficult Intubation

Parameter	Value	95% Confidence Interval
True Positive	3	
False Positive	9	
True Negative	84	
False negative	4	
Sensitivity	42.9%	15.8-75
Specificity	90.3%	82.6-94.8
PPV	25%	8.9-53.2
NPV	95.5%	88.9-98.2

Mouth Opening Vs Difficult Intubation

In our study, among the hundred patients, preoperative assessment showed 96 patients without restriction of Mouth Opening and 4 patients with restriction of Mouth Opening. Among these, during laryngoscopy 1 patient with restriction of Mouth Opening & 6 patients without restriction of Mouth Opening had a Cormack lehane Grade III. The details have been given in Table 4a and 4b. Mouth Opening showed a sensitivity of 14.1% (2.6 – 51.3, 95% CI) and a Positive predictive value of 25 % (4.6 – 69.9,95% CI).

4a. Mouth Opening vs Difficult Intubation based on the Cormack Lehane Grade

	Cormack Lehane Grade				Total
	I	II	III	IV	
MO <4cm	3	0	1	0	4
Distribution >4cm	77	13	6	0	96
Total	80	13	7	0	100

4b. Mouth Opening vs Difficult Intubation

Parameter	Value	95% Confidence Interval
True Positive	1	
False Positive	3	
True Negative	90	
False negative	6	
Sensitivity	14.1%	2.6-51.3
Specificity	96.8%	90.9-98.9
PPV	25%	4.6-69.9
NPV	93.8%	87-97.1

Upper Lip Bite Test Vs Difficult Intubation

In our study, among the hundred patients, preoperative assessment showed that 82 patients had a ULBT grade I, 15 patients had ULBT grade II and 3 patients with ULBT grade III. Among these patients, 5 with ULBT grade I, 1 patient each with ULBT grade II and III had a Cormack lehane Grade III. The details have been given in Table 5a and 5b. Upper Lip Bite Test showed a sensitivity of 14.3% (2.6 –51.3, 95% CI) and a Positive predictive value of 33.3 % (6.1 – 79.2,
95% CI) .

5a. ULBT Group Vs Difficult Intubation based on the Cormack Lehane Grade

		Cormack Lehane Grade				Total
		I	II	III	IV	
ULBT Group	1	65	12	5	0	82
	2	13	1	1	0	15
	3	2	0	1	0	3
Total		80	13	7	0	100

5b. Mouth Opening vs Difficult Intubation

Parameter	Value	95% Confidence Interval
True Positive	1	
False Positive	2	
True Negative	91	
False negative	6	
Sensitivity	14.3%	2.6-51.3
Specificity	97.8%	92.5-99.4
PPV	33.3%	6.1-69.9
NPV	93.8%	87-97.1

BMI Group vs Difficult Intubation

In our study, among the hundred patients, preoperative assessment showed that 94 patients had a BMI of < 30 kg/m2 and 6 with a BMI of > 30 kg/m2 . Among these, 5 patients with BMI of < 30 kg/m2 and 2 patients with BMI of > 30 kg/m2 had a Cormack lehane Grade III. The details have been given in Table 6a and 6b.. Body Mass Index showed a sensitivity of 28.6% (8.2 – 64.1, 95% CI) and a Positive predictive value of 33.3 % (9.7 – 70, 95% CI).

6a. BMI Group vs Difficult Intubation based on the Cormack Lehane Grade

		Cormack Lehane Grade				Total
		I	II	III	IV	
BMI Group	<30 kg/m2	77	12	5	0	94
	>30kg/m2	3	1	2	0	6
Total		80	13	7	0	100

6b. BMI vs Difficult Intubation

Parameter	Value	95% Confidence Interval
True Positive	2	
False Positive	4	
True Negative	89	
False negative	5	
Sensitivity	28.6%	8.2-64.1
Specificity	95.7%	89.5-98.3
PPV	33.3%	9.7-70
NPV	94.7%	88.1-97.7

All the predictors of difficult intubation

Table.7. indicated that among the airway assessment predictors, Head and neck movements especially the Head extension was the most sensitive and had the highest Positive Predictive Value and Negative Predictive Value. ULBT was most specific.

Predictor	Sensitivity	Specificity	PPV	NPV
HNM	57.1%	94.6%	44.4%	96.7%
MMC	42.9%	90.3%	25%	95.5%
MO	14.1%	96.8%	25%	93.8%
ULBT	14.3%	97.8%	33.3%	93.8
BMI	28.6%	95.7%	33.3%	94.7%

Discussion

Airway management remains an important challenge in the contemporary practice of anaesthesia and preoperative airway assessment facilitates appropriate preparation when difficulty with intubation or ventilation is anticipated prior to induction of anaesthesia. Direct laryngoscopy is the gold standard for tracheal intubation. There is no single definition of difficult intubation. Difficult glottic view on direct laryngoscopy is the most common cause of difficult intubation. According to the definition provided by American society of Anaesthesiologists[11], a Difficult Airway is the clinical situation in which a conventionally t rained anaesthesiologist experiences
difficulty with face mask ventilation of the upper airway, difficulty with tracheal intubation or both. Difficult Mask Ventilation is the inability of a trained anaesthetist to maintain a patient 's oxygen saturation above 90% by using face mask ventilation (assuming a normal saturation at baseline). Difficult laryngoscopy where in it is not possible to visualize any port ion of the vocal cords after multiple at tempts at conventional laryngoscopy. Difficult tracheal intubation where in it requires multiple at tempts, in the presence or absence of tracheal pathology.

We proposed to conduct this study to compare six airway assessment factors in patients undergoing surgery requiring general anaesthesia and endotracheal intubation in Meenakshi Medical College Hospital and Research Institute with regards to their Sensitivity, Specificity, Positive predictive value and Negative predictive value.

One hundred patients between the ages of 18 and 50 were included in our study. The incidence of difficult intubation in our study was 7%, which is comparable to the results obtained by Frerk[12] and Savva[13]. However the reported incidence of difficult laryngoscopy or intubation is 1% to 18% . This wide variation in incidence is due to the criteria that are used to define the difficult intubation and different anthropometric features among populations.

There were no failed intubations in our study. There were no patients with difficult mask ventilation during our study.

In our study we observed a statistical significance in patients having easy intubation compared with patients having difficult intubation with respect to their Age and BMI. This is in occurrence with the study conducted by Hyoung-Yong Moon and his colleagues where risk factors in elderly were cervical joint rigidity and Rose and Cohen who reported that risk factors for difficult endotracheal intubation included being aged 40 -59 yrs, male, and obese. In addition, Ezri et al[14] reported that laryngoscopy grades and airway classes increase with age, most likely owing to changes in bone joints and poor dental condition.

We noted no statistical significance between weight and difficult intubation in our study. Of the 7 patients with difficult intubation, 4 patients were intubated in the first laryngoscopic attempt. These 4 patients were successfully intubated with an optimal external laryngeal manipulation54 (OELM), which improved the glottic view by at least one grade.

Of the remaining three, two patients required one and two laryngoscopic at tempts respectively, where in there was no improvement of glottic view on OLEM. One patient required a change of blade size. Both required a gum elastic bougie for facilitating intubation and were subsequently intubated without any significant events or difficulty. The remaining one patient required a total of three laryngoscopic at tempts. He had 2 failed intubation at tempts both

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with a gum elastic bougie and a change of an operator. He was later successfully intubated with a gum elastic bougie by a senior anaesthesiologist . There was neither any significant airway trauma nor episode of desaturation noted in this patient . He had no difficulty in mask ventilation. This patent had a Mallampati grade III and a restriction in head and neck movements.

In our study we observed that the predictor with highest Sensitivity, Positive and Negative Predictive Value was Head and Neck Movements, highest specificity was observed in ULBT. In our study the Sensitivity, Specificity, PPV and NPV of Head and Neck movements were found to be 57.1%, 94.6%, 44.4% and 96.7% respectively. These were comparable with the study done by Karkouti and colleagues[15], Rudin Domi[16] and Basunia SR et al[17]. Many studies have reported lower sensitivity and PPV. This discrepancy may be due to more number of patients with limitations of Head and neck movements in our study out of the hundred cases compared to other studies. Of the 9 patients predicted as difficult in our study, 7patients had an abnormal Delilkan "stest[10]. Only 3 had limitation in flexion of the neck. 5 out of 9 of these patients had Diabetes Mellitus.

The importance of head and neck movements has been explained as early as 1944 by Bannister and colleagues[18]. They stressed the importance of position of the head and neck in direct laryngoscopy for endotracheal intubation in order to achieve proper alignment of the axis of the mouth, pharynx and larynx. This was further emphasized by Gillespie in 1950[19] and by John McIntyre in 1987[20].

Nichole and Zuck24 suggested that the Atlanto-occipital distance is a major anatomical factor that determines the ability to extend the head on the neck and exposure of larynx. Wilson and his colleagues14 added Head and neck movements of < 90^0 as a predictor of difficult intubation in their multivariate scoring system for difficult airway assessment predictors. The usefulness of Head and Neck movements have been studied in various studies[21]later and validated. Diabetes is another factor which has been implicated in difficult laryngoscopy and intubation5. In our study three patients with diabetes had difficulty in intubation. Of these two had restriction in head and neck movements and one had restriction in mouth opening. These observations are almost comparable to studies done by Vani et al[22].

In our study the Sensitivity, Specificity, PPV and NPV of MMC were found to be 42.9%, 90.3%, 25% and 95.5% respectively. These were comparable to El -Ganzouri et al[23] Oates et al[24], and Shiga et al43. Tse et al16 reported a Mallampati score of 3, thyromental distance < 7 cm, head and neck movemen t ≤ 80^0 , or a combination of these factors as predictive factors for difficult endotracheal intubation. After its first proposal by Mallampati and colleagues[25] in 1985, Mallampati classification has been one of the most commonly used clinical airway assessment used till date. His classification was modified by Samsoon and Young11 in 1987 where in a class 4 was added. Modified Mallampati Classification has been in use for more than two decades and over the years many limitations have been pointed out by various authors. Many studies have clearly mentioned about the marked inter observer variabilities effects of phonation and posture of the patient with modified Mallampati classification. In our study the pre -operative assessment of all patients were per formed by a single anaesthesia resident which may have contributed to the less false positives and high positive predictive value[26].

In our study the Sensitivity, Specificity, PPV and NPV of Mouth opening were found to be 14.1%, 96.8%, 25% and 93.8% respectively. These were comparable to El -Ganzouri et al [23]. The low sensitivity can be attributed to less number of patients with restricted Mouth opening in our study. Lloyd F. Redick 1987[27] stated that forward sliding motion of the joint is very important to obtain an opening of the mandible wide enough to permit laryngoscopy and tracheal intubation. This criteria is one of the essential component of temporo mandibular joint integrity which affects Mouth Opening and Upper Lip Bite Test. Karkouti and colleagues[15] developed a multivariate model to predict difficult intubation which identified three airway tests that were highly significant for predicting difficult tracheal intubation. They were: 1 "Mouth opening ", 2 "Chin protrusion " , and 3)"Atlanto-occipital extension " . Of these test s Mouth opening and chin protrusion checked the integrity of TMJ which is essential for proper assessment of Modified Mallampati classification and Upper Lip Bite Test and Atlanto-occipital extension for head extension for the sniffing position. Few studies have implicated an increase in BMI as a predictor for difficult intubation[28]. Other studies have mentioned that an increased BMI is not associated difficult intubation [29] but it can

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be combined with other predictors like Modified Mallampati classification for a better sensitivity and positive likelihood ratio.

On comparing all the six criteria in our study, Head and neck movements has the highest sensitivity and positive predictive value. Its sensitivity was found to be statistically significant with mouth opening, Thyromental distance, Upper Lip Bite Test and Body mass index. Modified Mallampati classification showed a statistical significance in sensitivity compared to mouth opening, Thyromental distance and Upper Lip Bite Test . There was no statistical significance between any tests with respect to Specificities observed in our study.

We observed a statistical significance between positive predictive values of Head and neck movements and mouth opening, Thyromental distance and Upper Lip Bite Test . There was no statistical significance with respect to Modified Mallampati classification and BMI in positive predictive values. In other words, patients with decreased head extension have much higher probability of having a difficult intubation compared to those with abnormality in other parameters.

There was no statistical significance between any tests with respect to negative predictive values observed in our study. The specificities and negative predictive values as explained before are high owing mostly to the low incidence of predictive factors respectively and possibly due to the Difficult Intubation Criteria (Clause 2) used by us in this study. It may also be due to the low false positive rates observed in our study, which may partly be due to a negated inter observer variability as the pre –operative assessments of all patients were done by a single anaesthesia resident. Thus all the predictors can retrospectively predict difficult intubation by actually predicting the easy intubations.

Conclusion

In the present study we conclude that Head extension was a better test at predicting difficult endotracheal intubation with a higher sensitivity and positive predictive value, when compared to other airway assessment factors. All the six airway assessment factors are better predictors of easy intubations than of difficult intubations.

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