COMPARATIVE EVALUATION OF AIRWAY ASSESSMENT TESTS AND THEIR CORRELATION WITH LARYNGOSCOPY

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ABSTRACT

Background: *It is an established fact that endotracheal intubation allows the best control of airway and ventilation. Any difficulty in intubation which has not been anticipated and evaluated can lead to adverse outcomes such as hypoxia, aspiration of vomitus etc. The preoperative assessment for recognition of difficult airway in advance is the best method of avoiding any disaster caused by the inability to maintain the airway.*
Objectives: *The main objective of this study was to assess the airway by various tests and then grade the view obtained at laryngoscopy, in all patients undergoing elective surgery requiring general anaesthesia and endotracheal intubation. Then to compare and correlate the laryngoscopic view obtained with the findings of airway assessment tests.*
Material and Methods: *A total 150 adult patients of either sex of ASA class I and II , undergoing elective surgery for various procedures requiring general anaesthesia with endotracheal intubation were included in our study. Assessment of the airway was made by viewing the patient from lateral and anterolateral positions; viewing and palpating the neck anteriorly and laterally; extending and flexing the head and neck maximally; examining the mouth opening, teeth & oral cavity; and determining patency of nostrils. The following measurements were undertaken and recorded: a) Modified Mallampati Test, b) Thyromental Distance, c) Upper lip Bite Test, d) Head Extension, e) Wilson's criteria. After induction of anaesthesia, laryngoscopy was performed in classical intubating position with McIntosh blade and the laryngoscopic grade was recorded as described by Cormack and Lehane. Statistical analysis was done for the usefulness of various tests (alone or in combination) for identifying difficult intubation.*
Conclusion: *No method either individual or in combination with other, identifies all cases of difficult intubation. Wilson score and neck extension were most accurate individual methods. Combination of 3 tests is not required when 2 tests combined together can give better results.*

Keywords: *Airway, airway assessment tests, laryngoscopy, Cormack Lehane, tracheal intubation.*

BACKGROUND

The nature has bestowed on humans a biologically complex and highly efficient respiratory apparatus. One need only a moment's reflection to realise the potential risk this life sustaining respiratory apparatus is subjected to during the process of anaesthetising the individual.With the advent of muscle relaxants the technique of direct laryngoscopy for facilitating endotracheal intubation became an easy procedure. Inspite of this there are a few patients in who direct laryngoscopic examination and endotracheal intubation may be difficult. A difficult airway has been defined as one which due to anatomic disproportion or pre-existing pathology is likely to offer a moderate or severe degree of difficulty to bag mask ventilation, direct laryngoscopy for orotracheal intubation or both. A difficult laryngoscopy has been defined as an inability to visualize any portion of the vocal cords with conventional laryngoscopy[1]. Any difficulty in intubation which has not been anticipated and evaluated can lead to respiration related adverse outcome such as varying degrees of hypoxia, hypercarbia and aspiration of vomitus[2], in addition to rising level of consciousness in a paralysed patient[3]. Publishing morbidity and mortality data demonstrate that airway difficulties and mismanagement are responsible for a significant proportion of adverse events in clinical practice. The preoperative airway assessment for the recognition of difficult airway in advance is the best method of avoiding the disaster and it calls for adequate understanding of the anatomy and physiology of the airway and a thorough

knowledge of anatomic landmarks and methods of their evaluation.

Certain pathological disorders which make intubation difficult like facial or upper airway deformities, maxillofacial and airway trauma, airway tumours and abscess, cervical spine immobility, fibrosis of face and neck and other systemic diseases are typically recognised before anaesthetic induction and have not been usually responsible for airway catastrophes[4].

A number of bedside tests and measurements of head and neck and other anatomical factors were suggested by different authors. Some of them are: Posterior mandibular depth[5]; Atlanto-occipital distance[6]; Thyromental distance[7]; Modified Mallampati classification of airway; Wilson's Criteria[8]; Sternomental distance[9] and Upper Lip bite test[10]. Most of the causes of difficult intubation can be discovered during careful preoperative examination of the patients by simple clinical bedside tests as predictors of difficult laryngoscopy and intubation, thus enabling the anaesthesiologist to plan alternative methods of securing the airway and obtaining experienced help. However, most of the tests used do not always predict difficult intubation and are useful in only a variable proportion of patients.

The present study was undertaken to identify and evaluate precisely the effectiveness of some of the commonly used tests and correlate them with laryngoscopic findings.

MATERIAL AND METHODS

150 patients of either sex between 15-65 years of age and ASA class I & II, undergoing elective surgery for various procedures requiring general anaesthesia with endotracheal intubation were included in our study after obtaining approval from the hospital ethics committee. Informed consent was obtained from all patients. Following exclusion criteria were used: a) patients below 16 years of age; b) Obstetric patients; c) patients with cervical spine injury; d) patients with obvious airway pathology e.g. upper airway malignancy, abscess, temporomandibular ankylosis etc; and e) edentulous patients or those with artificial dentures.

Preoperative evaluation: - After taking a detailed history a thorough physical and systemic examination was carried out. The necessary investigations were reviewed. The further assessment of airway was made by viewing the patient from lateral and anterolateral positions, viewing the neck anteriorly and laterally, extending and flexing the head and neck maximally, and examining the mouth opening, teeth and oral cavity. The following measurements were undertaken and recorded:-

1) **Modified Mallampati Class (MMC):** Mallampati classification as modified by Samsoon and Young with patient in sitting position, mouth maximally opened and tongue protruded as much as possible. Phonation was avoided during the examination and oropharyngeal structures were examined. The view was graded as: Class I where hard palate, soft palate, uvula and pillars viewed.; Class II where Hard palate, soft palate and uvula viewed; Class III where hard palate and soft palate are viewed; Class IV where only hard palate is viewed (Figure 1.1).

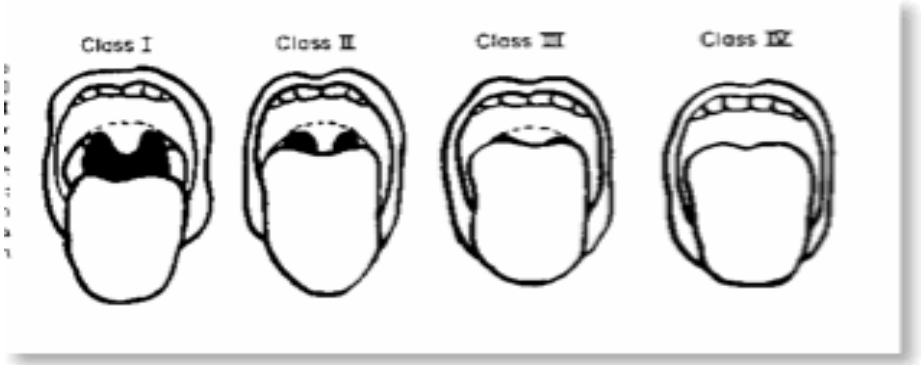

Figure 1.1: Modified Mallampati Classification.

2) **Thyromental Distance (TMD):** It is described as a straight line distance from hyoid notch to the lower border of the mentum with head extended and mouth closed. The distance was measured using a straight ruler in centimeters (cms). Patients having TMD≤6.5cm were considered to have difficult intubation (Figure 1.2)

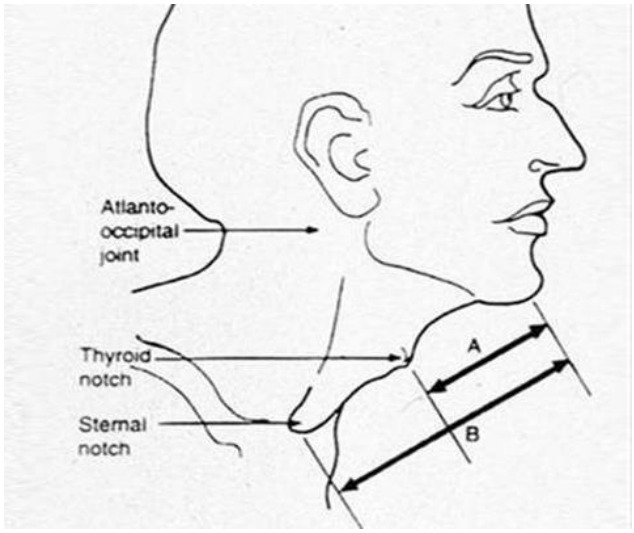

Figure 1.2: Thyromental distance.

3) **Upper Lip Bite Test (ULBT):** As described as: Class I where lower incisors can bite the upper lip above the vermilion line; Class II where lower incisors can bite the upper lip below the vermilion line; Class III where the lower incisors cannot bite the upper lip. Class III patients were considered having difficult intubation (Figure 1.3)

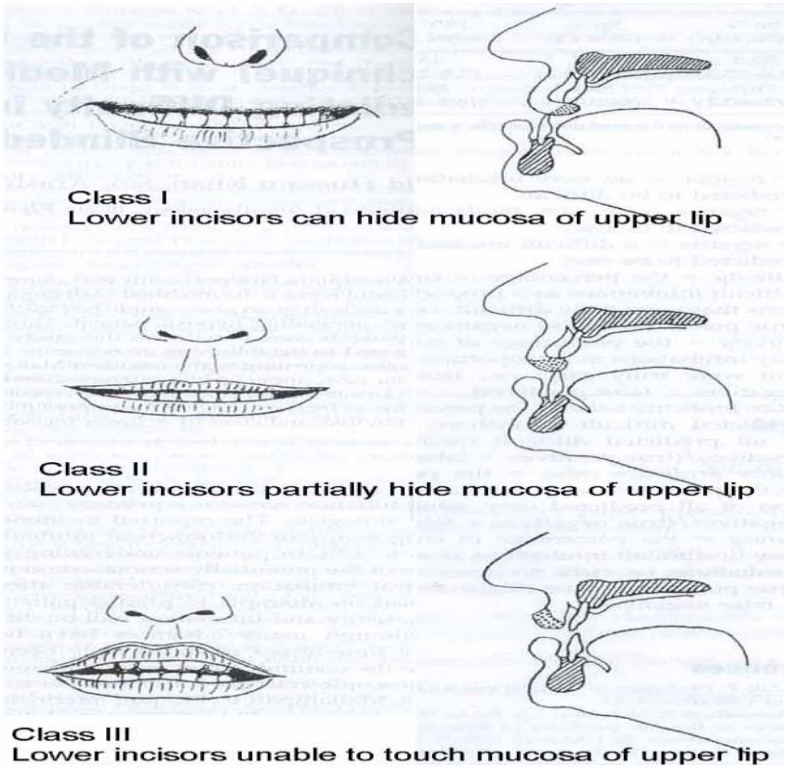

Figure 1.3: Upper Lip Bite test.

4) **Head Extension (HE):** The patients were asked to be in sitting position facing the examiner with their mouth widely open. The patients were then asked to extend the head without any movement at the cervical spine. The angle traversed by the occlusal surface of upper teeth was recorded using a Gonimeter. One arm of the goniometer was fixed securely by the side of the patients' teeth and the change in the pendant arm was recorded. Head extension $\leq 20^0$ in patients was considered to have difficult intubation.

5) **Wilson's Score:** This included Body weight; Extent of head and neck movement; Jaw movement; receding mandible; and Buck teeth. These risk criteria were scored from 0-2 (Table1).

Table 1: Wilson's Score. *IG- Interincisor gap;* SL- Subluxation

Criteria	***Points***		
	0		**1** **2**
Weight (kg)	<90	90-110	>110
Head extension and neck movement	>90	90	<90
Jaw Movement	IG* ≥ 5cm; SL*=0	IG<5cm; SL=0	IG< 5cm; SL<0
Receding Mandible	None	moderate	severe
Buck Teeth	None	moderate	severe

Patients having total risk sum of ≥4 were considered to have difficult intubation.

Induction of anaesthesia:- General Anaesthesia was induced using injection Propofol 2-2.5 mg kg^{-1} and before giving muscle relaxant mask ventilation was checked. Laryngoscopy was performed in classical intubating position[11] (Sniff position). The laryngoscopic grade was recorded as described by Cormack and Lehane[12] as follows:

Grade I- Full view of glottis; Grade II- only posterior commisure visible (IIa- parts of cords available, IIb- only arytenoids or very posterior origin of cords visible); Grade III- Only tip of epiglottis visible; Grade IV- No epiglottis visible (figure 1.4).

Figure 1.4: Cormack and Lehane grading.

Statistical analysis was done using Fisher 't' Test and usefulness of various tests for identifying difficult intubation were evaluated by Bayesian method in terms of Specificity, Sensitivity, Positive predictive value and Negative predictive Value. A high Sensitivity is desirable as it will identify most patients in whom intubation will truly be difficult. Specificity indicates number of patients in whom intubations will be correctly predicted as easy. Positive predictive value identifies the number of patients predicted to have difficult intubation and a negative predictive value signifies the number of patients correctly predicted not to have difficult intubation.

RESULTS

Data from 150 patients revealed that there were 94.66% patients in easy intubation group and 5.33% patients in difficult intubation group.

Demographic data: Mean age of patients in difficult intubation group was 45.37±5.7 years and mean age in easy intubation group was 41.07±12.64 years in this study. The difference of age between two groups was statistically insignificant (p=0.34). The average weight of patients in difficult intubation group was statistically higher than those in the easy intubation group with a p value <0.00001. Sensitivity, specificity, positive predictive value, negative predictive value and accuracy were calculated of all tests individually and in combination (Tables 2 & 3)

Table 2: Sensitivity, specificity, positive predictive value, negative predictive value, accuracy of all individual tests.

Name of test	Sensitivity	Specificity	Positive predictive value (PPV)	Negative predictive value (NPV)	Accuracy
MMC	62.5%	93.0%	33.3%	97.8%	91.33%
TMD	50.0%	95.7%	40.0%	97.14%	93.3%
ULBT	25.0%	98.6%	50.0%	95.9%	94.66%
HE	87.5%	92.3%	38.9%	99.2%	92.0%
Wilson's score	87.5%	98.6%	77.5%	99.3%	98.0%

Table 3: sensitivity, specificity, positive predictive value, negative predictive value, accuracy of combination of various tests.

Name of the test	Sensitivity	Sensitivity	PPV	NPV	Accuracy
MMC+ ULBT	12.5%	99.3%	50.0%	95.3%	94.66%
MMC+ Wilson's	50.0%	98.6%	66.7%	97.2%	96.0%
MMC +TMD	37.5%	96.5%	37.5%	96.5%	93.33%
MMC+ HE	50.0%	96.5%	44.4%	97.2%	94.0%
MMC+ULBT+TMD	12.5%	100%	100%	95.3%	95.33%
MMC+ULBT+TMD+HE+Wilson's	12.5%	100%	100%	95.3%	95.33%
MMC+ ULBT+HE	25.0%	100%	100%	95.9%	96.0%
MMC+ULBT+Wilson's	12.5%	99.3%	50.0%	95.3%	94.66%
ULBT+TMD	0.0%	99.3%	0.0%	94.6%	94.0%
ULBT+Wilson's	25.0%	99.3%	66.7%	95.9%	95.33%
ULBT+HE	25.0%	99.3%	66.7%	95.9%	95.33%

DISCUSSION

Various tests have been used to predict difficult intubation. An ideal predictive test of difficult intubation should be able to distinguish potentially difficult intubation from the easy ones. Statistically speaking, it should be simple enough to allow routine clinical use during preoperative visit. It should be versatile to be applicable to difficult ethnic groups, gender and age. No single test available till today satisfies all the above criteria and no single anatomic factor determines the ease or difficulty during laryngoscopy and intubation with the exception of patients with obvious pathology. Sometimes even with no pathology, the difficulty at intubation may occur due to variation in the normal anatomy of the individuals.

Modified Mallampati classification (MMC) is one of the most widely employed methods of airway evaluation. Mallampati hypothesised that the size of the base of the tongue, as assessed by visualization of oropharyngeal structures could be used as a

clinical test to predict subsequent difficulty at laryngoscopy and intubation. When tongue is maximally protruded in seated patient, there is concealment of faucial pillars and uvula by the base of the tongue and if the base of tongue is disproportionately large, it overshadows the larynx, rendering the exposure of the larynx by direct laryngoscopy poor and difficult[13]. The original study had a sensitivity of 100% and a specificity of 80%, but the sensitivity dropped to 40-50% in subsequent prospective studies[14, 15, 16]. The most important factor which has an influence on MMC is the inter observer variability[17]. Physical factors like phonation, pregnancy and labour do alter this airway assessment[18]. We in our study tried to eliminate all these factors as much as possible. All the observations were done by a single person and phonation was strictly avoided and all the obstetrics patients were also excluded from this study. Despite all this we obtained a sensitivity of 62.7%. MMC has a high false positive rate i.e. low predictive value, which makes the anaesthesiologist overcautious in most of the patients who do not have a difficult intubation. But at the same time because of its low false negative rate i.e. a very high negative predictive value it rules out chances of unanticipated difficult intubation.

The next most widely used method to predict difficult airway is Thyromental distance (TMD). In our study a TMD of≤6.5cm was considered to predict a difficult laryngoscopy and obtained a sensitivity of 50% and specificity of 95.7%. This distance reflects the ease of displacement of the tongue by the laryngoscope blade by giving an estimate of mandibular space. After the original study multiple methods of measuring the distance were tried and it was concluded that the best predictive value is achieved with the patient sitting with the head fully extended[19]. A positive predictive value of 100% was obtained when a TMD less than 6 cm was used. The subsequent studies defined TMD of <7 cm to predict difficult intubation. Inspite of the higher values these studies increased neither the sensitivity nor the specificity of this test high enough to justify the employment of the TMD as the only predictor of a difficult laryngoscopy. A simple new technique, Upper lip bite test (ULBT) was described by Khan et al[20] which can assess a combination of jaw subluxation and the presence of buck teeth simultaneously. They conducted many studies subsequently in various set of patients with different conditionsand comparing with other tests and found that the inclusion of these factor sincreased the accuracy and specificity of ULBT as compared to MMC (76.5%)[21, 22]. Contrary to their findings our study showed a very low sensitivity of ULBT (25%).

The normal range of head and neck movement is one of the basic requisites for endotracheal intubation. Exposure of the larynx requires some degree of flexion, about 35 degrees in the lower cervical spine and extension about 80 degree in upper cervical spine, especially at the atlanto-occipital joint. This manoeuvre helps in the alignment of laryngeal, pharyngeal and oral axes[23]. Extension of the head can be quantitated by determining the angle of head extension, with the lower neck flexed about 30-40 degrees in the sniffing position. The normal range of this movement is 35 degrees[24, 25]. Head extension from neutral to full extension can be easily measured by a goniometer[26]. We measured head extension using a goniometer and considered a head extension of ≤20 degrees to be associated with difficult intubation. A high sensitivity of 87.5% and a high accuracy of 92% were obtained in our study which indicate that measurement of head extension can be used as an individual predictive measure of difficult intubation.

Wilson studied different patient factors in his study and found only five factors to correlate with difficult intubation which were: weight, head and neck movement, jaw movement, receding mandible and buck teeth. It was also concluded that these subjective assessments were not sensitive enough to be employed alone. In many subsequent studies Wilson's score was combined with short neck and Mallampati and a slight increase in sensitivity was observed[27]. In our study we took risk sum ≥4 as predictor of difficult intubation. Overall accuracy of the test was 98% and high positive predictive value and specificity (77.5% & 87.5%) which makes it an accurate individual method to predict difficult intubation.

To screen and improve the prediction of a difficult laryngoscopy precisely various combinations of tests were also evaluated. Firstly Mallampati classification was combined with all the tests. Only its combination with Wilson's score had a high accuracy of 96% and sensitivity of 50%. MMC in combination with other tests gave low sensitivities like with ULBT 12.5%, TMD 37.5%, HE 50% (low accuracy of 94%). ULBT was combined with other tests and it was found that it gave 0% sensitivity with TMD, 25% with Wilson's Score and 25% with HE. On combining more than two tests i.e. MMC, ULBT and HE, a high positive predictive value was obtained of 100% i.e. it could predict all difficult intubation cases correctly and a sensitivity of 25% with accuracy of 96%. Specificity was also 100% i.e. it could predict all easy intubations correctly. Combining all the five tests together neither increased the sensitivity nor the positive predictive value.

CONCLUSION

No method whether individual or in combination with others identifies all the cases of difficult intubation. In our study both Wilson's score and Head extension were the most accurate individual methods to predict difficult intubation. Also, combination of Modified Mallampati test and Wilson's Score could identify most of the cases of difficult intubation correctly. When one more test i.e. Upper lip bite test was added, there was no increase in the accuracy, which indicates that combination of three tests is not required when two tests combined can give better results.

ABBREVIATIONS

MMC: Modified Mallampati Classification; TMD: Thyromental Distance; ULBT: Upper lip bite test; HE: Head extension; cms: centimeters.

COMPETING INTERESTS: None declared.

REFERENCES

1. Samsoon GLT, Young TRB. Difficult tracheal intubation: a retrospective study. Anaesthesia 1987:42:487–490.
2. Vasava JC, Swadia VN. Difficult endotracheal intubation. Indian Journal of Anaesthesia. 1994; 42(4): 257-61.
3. Mckenne T, Wilton TNP. Awareness in anaesthesia: Incidence, consequences and prevention. Acta Anasthesiol Scand *1973*: 39: 23-36.
4. Benumof and Jonathan L. Management of difficult adult airway. Anaesthesiology 1991:75:1087-1110.
5. White A, Kander PL . Anatomical factors in difficult laryngoscopy. Br J Anaesth 1975:47:468–74.
6. Nichol HC, Zuch D. Difficult laryngoscopy- the anterior larynx and the atlanto-occipital gap. Br J Anaesth 1983:55:141-143.
7. Patil UV, Stehling LC, Zander HL. Fibreoptic endoscopy in Anaesthesia. Chicago: year book 1983:79.
8. Wilson ME, Speigelhalter D, Robertson JA, Lesser P. Predicting difficult intubation. Br J Anaesth 1988:61:211-216.
9. Sava D. Prediction of difficult tracheal intubation. Br J Anaesth 1994: 73:149–153.
10. Khan ZH, Kashfi A, Ebrahim Khani E. A comparison of Upper lip bite test (a simple new technique) with modified Mallampati classification in predicting difficulty in endotracheal intubation a prospective blind study. Anaesth Analg 2003:96:595-599.
11. BannisterFB, Macbeth RG. Direct laryngoscopy and tracheal intubation. Lancet. 1944:2:651.
12. Cormack RS, Lehane J. Difficult intubation in obstetrics. Anaesthesia 1984:39:1105–1111.
13. Mallampati SR, Gatt SP, Gugino LD, Waraksa B, Frieberger D, Liu PL. A clinical sign to predict difficult tracheal intubation: a prospective study. Can Anaesth Soc J 1985:32:429-434.
14. Frerk CM. Predicting difficult intubation. Br J Anaesth 1991:46:1005-1008.
15. Butler BJ, Dhara SS. Prediction of difficult laryngoscopy and Mallampati predictive tests. Anesth Int Care 1992: 20: 139-142.
16. Oates JDL, Macleod AD, Oates PD, Pearsall FJ, Howie JC, Murray GD. Comparison of two methods for predicting difficult intubation. Br J Anaesth 1991:66:305-309.
17. Khan ZH, Khorassani AM, Yekaninejad MS. Mallampati airway assessment test in upright and supine positions with or without noisy exhalation in the prediction of difficult mask ventilation. Intern Med 3: 2013 Doi:10.4172/265-8048.1000122.
18. Lewis M, Keramati S, Benumof JL, Berry CC. What is the best way to determine oropharyngeal classification and mandibular space length to predict difficult laryngoscopy? Anaesthesiology 1994:81:69-75.
19. Mathew M, Hanna LS, AldretenJA. Preoperative indices to anticipated difficult tracheal intubation. Anes Analg 1989:5187.

20. Khan ZH, Mufrad MK, Arbabi S, Javid MH, Makarem J. Upper lip bite test as a predictor of difficult mask ventilation:a prospective study. MEJ Anesth 2009:20:377–382.
21. Khan ZH, Maleki N, Makarem J, et al. A comparison of the upper lip bite test with hyomental /thyrosternal distances and mandible length in predicting difficulty in intubation: a prospective study. Ind J Anaesthesia 2011;55:43-46.
22. Khan ZH, Mohammadi M, Rasouli MR, Frrokhnia F, Khan RH (2009) The diagnostic value of the upper lip bite test combined with sternomental distance, thyromental distance, and interincisor distance for prediction of easy laryngoscopy and intubation:a prospective study. Anesth Analg 109:822–824.
23. Stone DJ, Gal JJ. Airway management. Anaesthesia, Miller RD, New York, Churchill Livingstone 1994:1408.
24. Nath G, Sehar M. Predicting difficult intubation- A comprehensive scoring system. Anaesth Inten Care 1997:25:482-486.
25. El Ganzouri AR, Mc Carthy RJ, Juman KJ, Tanck EN, Inankovich AD. Preoperative airway assessment:predictive value of multivariate risk index. Anaesth Analg 1996:82:1197-1204.
26. Bellhouse CP, Dore C. Criteria for estimating likelihood of difficult endotracheal intubation with the Macintosh laryngoscope. Anesth Inten Care 1988:16:329–337.
27. Rocke DA, Murray WB, Rout CC, Gouws E. Relative risk analysis of factors associated with difficult intubation in obstetric anaesthesia. Anaesthesiology 1992:77:67-73.