Clinical Investigation

Diagnostic value of the upper lip bite test in predicting difficulty in intubation with head and neck landmarks obtained from lateral neck X-ray

Zahid Hussain Khan, Shahriar Arbabi[1]

Departments of Anesthesiology and Intensive Care, Imam Khomeini Medical Center, Keshavarz Blvd., [1]Farabi Eye Hospital, Tehran University of Medical Sciences, Tehran, Iran

Address for correspondence: Prof. Zahid Hussain Khan, Department of Anesthesiology and Intensive Care, Imam Khomeini Medical Center, Keshavarz Blvd., Tehran University of Medical Sciences, Tehran, Iran. E-mail: khanzh51@yahoo.com

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ABSTRACT

Background: Unanticipated difficult tracheal intubation remains a primary concern of anaesthesiologists and upper lip bite test (ULBT) is one of the assessments used in predicting difficult intubation. In this study, we aimed to check the utility of lateral neck X-ray measurements in improving the diagnostic value of the ULBT. **Methods:** In a prospective study conducted from January 2007 until December 2010, we recorded personal and demographic data of 4500 patients who entered the study and subjected them to standard lateral neck radiography. Before the induction of anaesthesia, clinical examination and ULBT results were recorded and during induction of anaesthesia laryngoscopic grading was evaluated and recorded in questionnaires. All the compiled data were analysed by SPSS 14.0 (SPSS Inc., Chicago, IL, USA) software. Diagnostic value for each test was calculated and compared. **Results:** Negative predictive values (NPVs) were high in all tests. ULBT had the highest specificity and NPV compared with the other tests. The positive predictive value for all the tests had been low, but marginally high in the ULBT. **Conclusion:** Although all the tests used had relatively acceptable predictive values, combination of tests appeared to be more predictive. Highest sensitivities were observed with ULBT, mandibulohyoid distance and thyromental distance respectively. Use of radiological parameters may not be suitable as screening tools, but may help in anticipating and preparing for a difficult scenario.

Key words: Airway assessment, difficult intubation, lateral neck radiography, predictive tests, upper lip bite test

INTRODUCTION

Unexpected difficult tracheal intubation is a major apprehension of anaesthesiologists. The incidence of a difficult laryngoscopy and endotracheal intubation varies. The incidence of failed intubation is approximately 0.05% or 1:2230 in surgical patients[1-3] and approximately 0.13-0.35%, or 1:750-1:280, in the obstetric patients.[4-6] The incidence of unsuspected difficult intubation is higher and is estimated to be 3%.[5] In an updated report by the American Society of Anaesthesiologists (ASA) task force on management of the difficult airway, a difficult airway is defined as the clinical situation in which a conventionally trained anaesthesiologist experiences difficulty with face mask ventilation of upper airway, difficult tracheal intubation or both.[7] Failure to maintain a patent airway after induction of anaesthesia leads to irrevocable catastrophic sequelae such as brain damage or death.[8,9]

Anatomical malformations such as the lower jaw anomalies, chin protrusion, excessive maxillary length, limited temporomandibular joint range of motion, decreased atlanto-occipital distance and reduction of pharyngeal space and submandibular tissue compliance have been considered as causes of difficult intubation. Because of the potentially serious consequences of failed tracheal intubation, considerable attention has been focused on attempts to

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predict patients in whom laryngoscopy and intubation will be difficult. Ever since Banister and Macbeth[10] stressed the importance of the position of the head and neck in direct laryngoscopy in order to achieve a proper alignment of the axes of the mouth, pharynx and larynx, many tests and landmarks (Mallampati test, inter-incisor gap (IIG), subluxation of the mandible, thyromental distance (TMD), length of mandibular rami, profile classification, chin protrusion, atlanto-occipital extension) have been introduced to predict an unanticipated difficult airway, but unfortunately these tests are not totally reliable.[11-25] Despite limitations, some tests or combination of tests have been of immense value in predicting unsuspected difficult cases of endotracheal intubations. In the present study, an attempt is made to compare the diagnostic value of the upper lip bite test (ULBT) along with anatomic measurements of lateral neck radiography.[26-29]

METHODS

After Institutional Ethics and Research Committee's approval and obtaining an informed consent, 4500 consecutive patients, ASA physical status I to III who required general anaesthesia and endotracheal intubation were studied prospectively over a 3-year period from January 2007 until December 2010. Exclusion criteria included inability to sit, gross anatomical abnormality or recent surgery of the head and neck and patients with pregnancy or severe cardiorespiratory disorders.

Anatomical factors predicting difficult intubation at direct laryngoscopy were noted and lateral radiographs were obtained from 265 patients in whom tracheal intubation proved particularly difficult and from 4235 patients in whom intubation was reasonably straightforward. The sample size was obtained from a pilot study performed earlier.

A group of nine anaesthesiologists with 5 years of experience were trained during several workshops to evaluate patients in a similar way.

Data collection for this study was performed in three steps.

Step 1 (primary assessment) – A group of nine Anaesthesiologists with 5 years of experience in anaesthesia carried out the primary assessment and evaluation as described in the protocol. Demographic data including age, sex, weight, height and body mass index were collected.

The following five predictive test measurements were performed on each patient:

1. Modified Mallampati test (MMT): Samsoon and Young's modification of the Mallampati test recorded oropharyngeal structures visible upon maximal mouth opening, with the patient in the upright position.[13,19,30-33]
   - Grade 1: Faucial pillars, soft palate and uvula visible
   - Grade 2: Faucial pillars, soft palate visible, but uvula masked by the base of the tongue
   - Grade 3: Soft palate only visible
   - Grade 4: Soft palate not visible.
2. TMD: Distance from the thyroid cartilage to the mental prominence with the neck fully extended
3. Sternomental distance (SMD): Distance measured in the seated position with the head fully extended on the neck and with the mouth closed (straight distance between the upper border of the manubrium-sterni and bony point of the mentum)
4. Horizontal length of mandible (HLM): Patient seated with the head in the neutral position and straight distance from the angle of the mandible to the symphysis menti measured. Tests 2-4 were measured with a rigid ruler
5. IIG: Distance between the upper and lower incisors, measured with the patient sitting in the neutral position and mouth maximally open with a pair of calipers
6. ULBT: Class I: Lower incisors biting the upper lip, making the mucosa of the upper lip totally invisible. Class II: The same biting manoeuvre revealing a partially visible mucosa. Class III: The lower incisors fail to bite the upper lip (ULBT Class II and III considered as difficult intubation).

The cut-off points for the predictors were determined *a priori* as suggested by the originators of the tests except for the SMD in which the cut-off was increased from 12.5 cm to 13.5 cm after preliminary analysis of pilot data. Values below and inclusive of each cut-off point were predicted as difficult visualisation of the larynx (DVL) for the anthropometric variables. Values above the cut-off point were predicted as easy-visualisation of the larynx (EVL). DVL was predicted with MMT III or IV, TMD $<$ 6.5 cm;

SMD < 13.5 cm; HLM < 9.0 cm; IIG < 4.0 cm and ULBT Class II and III.

This was followed by step 2 (radiologic assessment) – A routine lateral neck view taken with the patient in an upright, sitting or standing position and patient's shoulder on level with radiology film. The patient's neck was located at approximately 20-30 cm distance from the film and patient's midsagittal plane being parallel to the surface of the film. Both the shoulders were kept horizontal and the head vertical to the body. In order to maintain uniformity, all the patients were asked to look at an object located in their eye axis. The radiology beam was vertical to the film surface and the centre was located on the most prominent point of the thyroid cartilage. The films used were 21 cm × 18 cm. The radiology tube was located at 150-180 cm from the neck. For better quality of soft-tissue image, we used settings of 75-90 kV and 10-20 mA. Siemens Model 50-Polymath radiographical unit was used.

The following distances were measured in each of the radiographs:

1. Anterior depth of the mandible: Distance from the tip of the mandibular central incisors to the posterior border of the mandible
2. Effective mandibular length. Distance between tips of lower incisors to the mid-point of the temporomandibular joint
3. Posterior depth of the mandible: Perpendicular distance from the lower border of the mandible to the alveolar margin at position of the posterior border of 3rd molar tooth
4. Atlanto-occipital distance. The vertical distance between the occiput of the skull and the superior surface of the posterior tubercle of the atlas
5. Mandibulohyoid distance (MHD): Perpendicular distance from the hyoid to the mandible
6. Mandibular angle: Angle between a line intersecting the lower border of the mandible and a perpendicular line.

Step 3 (laryngoscopic assessment) consisted of anaesthesia induction and tracheal tube insertion.

After establishing standard monitoring and establishing an adequate access in the operating room and preparing the required equipment for difficult intubation management, induction of anaesthesia was performed in the supine position with 5 mg/kg of sodium thiopentone or propofol 2 mg/kg intravenously. Suxamethonium chloride 1.5 mg/kg was administered intravenously to facilitate endotracheal intubation. After the disappearance of fasciculations, the patient's head was placed in the sniffing position (10 cm pillow was kept underneath the occiput of the patients). Attending anaesthesiologists not involved in the airway assessment of the patients carried out the laryngoscopy and intubation. Laryngoscopy was performed using a Macintosh #4 blade to visualise the larynx and the view was classified using the Cormack and Lehane (CL) classification[12] (I = vocal cords visible; II = only posterior commissure or arytenoids visible; III = only epiglottis visible; IV = none of the foregoing visible). DVL was defined as CL III or IV views on direct laryngoscopy. EVL was defined as CL I or II view on direct laryngoscopy. Confirmation of successful intubation was by bilateral auscultation over the lung fields and capnography.

Statistical analysis

Distribution of demographic data were calculated and summarised based on central statistical indices and dispersion indices. For each diagnostic test, all indices of a diagnostic test were calculated in comparison with laryngoscopic view as the gold standard.

RESULTS

A total of 4500 patients enrolled in our study included 1505 women and 2995 men.

Table 1 shows the demographic data of the enrolled cases.

Diagnostic value of ULBT based on laryngoscopic view was calculated and shown in Table 2. Table 3 reveals the statistical indices of the different diagnostic tests with the highest sensitivities obtained for ULBT, TMD and MHD respectively. ULBT had the highest specificity and negative predictive value (NPV) compared with the other tests. The positive predictive value (PPV) for all the tests had been low, but marginally high in the ULBT.

DISCUSSION

This is the first study where in a large sample size was used and which used all clinical, radiologic and airway risk criteria in an attempt to identify factors affecting difficult laryngoscopy and intubation. We carefully matched control subjects for age, height and weight and oropharyngeal appearance to avoid age-related

Table 1: Demographic data of patients enrolled in study			
Variables	**Laryngoscopic view I, II**	**Laryngoscopic view III, IV**	**Total**
M/F ratio	2824/1411≈2.01/1	171/94≈1.87/1	2995/1505≈1.99/1
Mean age (year)	58.5±14.9	52.9±18.1	55.7±16.8
Mean weight (kg)	62.8±21.2	69.8±18.8	74.5±18.5
Mean height (cm)	164.8±19.9	165.4±21.6	167.8±2.3
BMI	25.2±1.9	25.5±2.3	26.9±2.4

BMI – Body mass index

Table 2: The result of different predictive tests based on laryngoscopic view			
Airway indices	**Laryngoscopic view I, II**	**Laryngoscopic view III, IV**	**Total**
ULBT I, II	3875	49	3924
ULBT III	360	216	576
Total	4235	265	4500
TMD≥65 mm	3848	56	3904
TMD<65 mm	387	209	596
Total	4235	265	4500
SMD≤135 mm	3823	100	3923
SMD≥136 mm	412	165	577
Total	4235	265	4500
Atlanto-occipital gap<4 mm	3759	91	3850
Atlanto-occipital gap≥4 mm	476	174	650
Total	4235	265	4500
Mandibular angle<75	3523	152	3675
Mandibular angle≥75	712	113	825
Total	4235	265	4500
Ramus length<60 mm	3602	118	3720
Ramus length≥60 mm	633	147	780
Total	4235	265	4500
TSD>75	3217	98	3315
TSD≤75	1018	167	1185
Total	4235	265	4500
Mandibular depth≥40 mm	2885	127	3012
Mandibular depth<40 mm	1350	138	1488
Total	4235	265	4500
Mandibular depth≥40 mm	2885	127	3012
Mandibular depth<40 mm	1350	138	1488
Total	4235	265	4500

ULBT – Upper lip bite test; TMD – Thyromental distance; SMD – Sternomental distance; TSD – Thyrosternal distance

Table 3: Sensitivity, specificity, PPV and NPV of different evaluation tests				
Airway indices	**Sensitivity**	**Specificity**	**PPV**	**NPV**
ULBT	0.815	0.914	0.375	0.987
TMD	0.788	0.908	0.35	0.98
SMD	0.622	0.902	0.285	0.974
Atlanto-occipital gap	0.655	0.887	0.267	0.976
Mandibular angle	0.426	0.831	0.13	0.95
Ramus length	0.554	0.85	0.188	0.968
TSD	0.63	0.768	0.139	0.97
Mandibular depth	0.52	0.65	0.09	0.95
Mandibulohyoid distance	0.75	0.899	0.318	0.98

PPV – Positive predictive value; NPV – Negative predictive value; ULBT – Upper lip bite test; TMD – Thyromental distance; SMD – Sternomental distance; TSD –Thyrosternal distance

anatomic differences in musculoskeletal structures. None of the patients in our study had arthritic changes of the cervical spine and all patients had a full set of teeth. White and Kander[34] studied many of the skeletal measurements included in the present investigation. They determined that an increase in the anterior and posterior depth of mandible, a decrease in the atlanto-occipital gap and C1-C2 gap and limitation of movement at the temporomandibular joint were the factors that determined whether direct laryngoscopy would be easy or difficult. They did not define 'difficult laryngoscopy' and no mention of a difficult endotracheal intubation was made. They felt that difference in effective mandibular length, arching of the palate and protrusion of the upper teeth, the factors that had been claimed to be associated with difficult endotracheal intubation by Cass *et al*.[35] did not play a significant role in their study. In a more recent study by Bellhouse and Doré[23] consistent evidence of a relationship between difficulty in endotracheal intubation and posterior and anterior depth of mandible could not be established. The difference in findings of these studies may be explained by the fact that the investigators in the study were two otolaryngologists who used different instrumentations and techniques for direct laryngoscopy than that routinely used by anaesthesiologists to accomplish endotracheal intubation. Our finding of no significant difference in the atlanto-occipital gap, which was found to be a significant parameter by White and Kander[34] is in agreement with Nichol and Zuck[36] who reported a wide variation in the atlanto-occipital distance. It would be inappropriate to speak in terms of 'normal' and 'abnormal'. And it is not possible to identify a critical measurement that could be used as a predictor of difficulty in intubation.

Several authors have given absolute values of the radiological measurements in patients with easy or with difficult intubations.[23,24] The assessments have been performed in small populations and neither the sensitivity nor specificity of the measurement as indicators of difficult intubation has been evaluated.

In most of the studied tests, the NPV was high meaning that the tests adequately eliminated patients with difficult intubation and hence, difficult laryngoscopic view or difficult intubation was not encountered.

On the other hand, a positive test result does not always indicate difficult laryngoscopy as a low value predicts intubation difficulty when there is none; it falsely predicts intubation difficulty in a certain number of patients. This may be useful in some situations, but it becomes necessary to subject the patient to many tests of predicting difficult airway and thus obviating an unanticipated difficult intubation. However, it would be at additional cost and time. Moreover, most of the tests in our study had low PPVs implying that the tests lacked the utility to forecast difficulty in intubation and these findings corroborate with other studies conducted so far.[1,11,12,14,15,20,27] Subjecting patients to risks of radiological exposure may be a consideration, but a single exposure in select cases may be worth the effort in avoiding and predicting difficult intubation, undetected with the available tests. Lateral neck X-ray may be used confined only to cases where positive findings provide us a definite clue that a difficult intubation is in the offing.

CONCLUSION

Although all the tests in this study had relatively acceptable predictive values, perhaps a combination of tests could be of value in arriving at better results.[14,15,28] It would not be practical to recommend radiological measurements in the assessment of difficulty in intubation as screening tests. They can be of value in understanding the problems encountered during laryngoscopy and thus can help assessment in some selected patients with difficulty in intubation.

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Contact: +91 99726 02727
E-mail: swamy9009@hotmail.com