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Evaluation of Intubation Prediction Score for assessment of Difficult Intubation: A Prospective Observational Study

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ABSTRACT

Introduction: Endotracheal intubation is an airway management technique indicated in various clinical situations which can be challenging at times. Proper planning is paramount in these situations. An unanticipated difficult airway can lead to improper management which may potentially cause severe complications including irreversible brain damage or death. Prediction of difficult airways, thus, has great importance. The study was conducted to assess the intubation prediction score (IPS) as an airway assessment tool for the prediction of difficult visualization of the larynx.

Methods: Eighty-eight American Society of Anaesthesiologists Physical Status I and II patients undergoing elective surgery requiring general anaesthesia with endotracheal intubation were enrolled in this prospective, observational study. Airway assessment of the patients was done preoperatively with different tests included in Intubation prediction score. After induction of anaesthesia and achieving adequate muscle relaxation, laryngoscopy was done by consultant anaesthesiologist unaware of the score. Modified Cormack-Lehane grading (MCLG) after optimal external laryngeal manipulation during laryngoscopy was recorded as the standard test for difficult intubation prediction. The sensitivity, specificity, positive predictive value, negative predictive value, and likelihood ratios were calculated.

Results: The prevalence of difficult intubation was 17.1%. The sensitivity, specificity, PPV, NPV, positive and negative LR of IPS were 78.6%, 63.2%, 30.6%, 93.5%, 2.14, and 0.34 respectively.

Conclusions: Intubation prediction score which is combination of commonly used test for airway assessment has a sensitivity of 78.6% and a specificity of 63.2% for the prediction of difficult intubation.

Keywords: *Airway management; Endotracheal intubation; Laryngoscopy; Nepal.*

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INTRODUCTION

Airway management to ensure optimal oxygenation and ventilation is a fundamental part of the practice of anaesthesia. Endotracheal intubation is commonly performed for the maintenance of the airway, upper airway protection or positive pressure ventilation.

Difficult intubation is defined as tracheal intubation requiring multiple attempts or tracheal intubation failing after multiple attempts.[1] The prevalence of difficult intubation in the general adult population undergoing surgery ranges from 1.7% to 20.2%.[2] Inability to intubate a patient can lead to airway trauma, aspiration pneumonitis, and hypoxia.[3]

Prediction of difficult intubation would allow us to plan, prepare, and prevent complications. Single bedside tests like Interincisior gap, Modified Mallampati Test, Thyromental Distance, Upper Lip Bite Test are used to predict difficult tracheal intubation. However, no single method that is totally reliable. [4] This has prompted the use combination of tests and develop scoring system to predict difficult intubation. Intubation Prediction Score (IPS) is a scoring system which uses combination of objective tests. [5] This study aims to evaluate Intubation Prediction Score as a predictor of difficult intubations.

METHODS

This was a prospective observational study conducted in Tribhuvan University Teaching Hospital (TUTH) from May 2022 to August 2023. The approval for the study was taken from the Institutional Review Committee, Institute of Medicine (IOM) and reference number is 271(6-11) E2. Written informed consent was taken from all the patients. ASA-PS I and II patients, aged 16-65 years, undergoing elective surgery under general anaesthesia with endotracheal intubation were included in the study. Patients with distorted head and neck anatomy, cervical spine pathology, need for rapid sequence intubation, midline neck swellings, and history of previous difficult airway were excluded from the study.

The sample size was calculated based on the sensitivity and specificity of Intubation Prediction Score (IPS) using following formula $n_{Se} = \frac{z^2 Se(100-Se)}{d^2 X\ Prev}$ and $n_{Sp} = \frac{z^2 Sp(100-Sp)}{d^2 X\ (1-Prev)}$. With the value for z being 1.96 for a 95% confidence interval, a sensitivity (se) of 77.8% and specificity (sp) of 92.4% was used from a past study. [6] A standard error (d) of 3% was taken for both sensitivity and specificity. The prevalence of difficult airway (prev) of 16.52% was considered as per a past study done in the same institute.[6] So, $n_{Se} = \frac{1.96^2 x 77.8(100-77.8)}{(0.03x77.8)^2 X\ 16.52}$ and $n_{Sp} = \frac{1.96^2 x 92.4(100-92.4)}{(0.03x92.4)^2 X\ (100-16.52)}$ giving n_{Se} to be 74 and n_{Sp} to be 5. So, the needed sample size was 79 according to these calculations. Considering the 10% dropout, the final sample size of 88 was considered.

The non-probability convenience sampling method was used. The patients sent to pre-operative Assessment Clinic in the hospital were assessed for eligibility. Airway evaluation of eligible patients was done using Modified Mallampati test (MMT), Thyromental distance (TMD), Interincisor gap (IIG), Length of Mandible (LM) and Atlanto-occipital joint extension preoperatively by the principal investigator. The following variables were recorded for each patient.

For the assessment of MMT, each patient was seated with the head in the neutral position. They were then asked to open their mouth maximally and to protrude the tongue without any phonation. Based on the view of oropharyngeal structures, MMT was recorded as class I if soft palate, uvula, and tonsillar pillars visible; class II if soft palate and uvula visible; class III if soft palate and base of uvula visible; and class IV if soft palate not visible.

While seated, each patient was asked to fully extend their neck with their mouth closed. The distance between the thyroid notch and the tip of the mentum was measured using a rigid ruler and recorded as thyromental distance (TMD). The length of the mandible (LM) was measured as the length from the angle of the mandible to the tip of the mentum using a rigid ruler. Interincisior gap (IIG) was measured as the distance between the maxillary and mandibular occlusal surfaces with the mouth maximally open using a rigid ruler. MMT of class III and IV, TMD < 6 cm, and IIG < 4 cm were labelled as predicted difficult visualization of the larynx.

Atlanto-occipital joint extension (AOJE) is the angle traversed by the occlusal surface of the maxilla as the atlanto-occipital joint is extended from complete flexion to complete extension. The patient was asked to face directly to the front with the head held erect with the maxillary occlusal surface parallel to the ground. The stationary arm of a goniometer was placed in line with the occlusal surface of the maxilla. The patient was then asked to fully extend at the atlanto-occipital joint. The moving arm of the goniometer was then placed at the new position of the occlusal surface of the maxilla. The angle traversed was then measured. AOJE was graded as grade 1 if AOJE ≥ 35°, grade 2 if AOJE ≥ 22° and < 35°, grade 3 if AOJE ≥ 13° and < 22°, and grade 4 if AOJE < 13°.

Mandibular space (MS) consists of two variables, Thyromental distance and Length of mandible. It was graded as shown in Table 1.

Table 1: Grading of mandibular space [5]

Grade of Mandibular Space	Thyromental distance	Length of Mandible
1	≥6 cm	≥9 cm
2	≥6 cm	<9 cm
3	<6 cm	≥9 cm
4	<6 cm	<9 cm

Intubation Prediction Score consists of combination of tests and the score is calculated as shown in Table 2. A score of 5 or more is predictive of difficult intubation and a score of 9 or more suggests very difficult intubation. [5]

Table 2. Intubation prediction score [5]

Parameter	Grade/Class	Score
MMT	Class I	1
	Class II	2
	Class III	3
	Class IV	4
MS	Grade 1	1
	Grade 2	2
	Grade 3	3

	Grade 4	4
AOJE	Grade 1	1
	Grade 2	2
	Grade 3	3
	Grade 4	4

On the day of surgery, anaesthesia was provided as per the protocol of Department of Anaesthesiology. Direct laryngoscopy was done by a consultant anaesthesiologist unaware of the score. Modified Cormack-Lehane Grade (MCLG) was noted as grade 1 if entire glottis was visible, grade 2a if posterior laryngeal aperture visible but the anterior portion was not, grade 2b: Arytenoids visible but not the glottis opening, grade 3 if Epiglottis visible, and grade 4 if epiglottis not visible.

In cases with MCLG higher than 2a, optimal external laryngeal manipulation (OELM) was done and MCLG was noted again. The patient was then intubated with an appropriately sized endotracheal tube. Whenever intubation was not possible with conventional laryngoscopy, ASA guidelines for difficult airway was followed as per the decision of the attending consultant anesthesiologist. Modified Cormack-Lehane Grade 2b, 3, or 4 even after OELM was defined as difficult visualization of the larynx and thus rated as difficult intubation.

The data were entered in Excel sheet and data was analyzed using SPSS software. The demographic variables were represented in frequency or mean with standard deviation where appropriate. The relation between actual difficult intubation, as determined by MCLG during laryngoscopy (gold standard test) and the results of screening test (intubation prediction score) is determined by 2x2 table. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), likelihood ratio (LR), and accuracy of IPS, MMP, TMD, and IIG were calculated and analyzed.

RESULTS

A total of 134 patients were assessed. After checking for inclusion and exclusion criteria, 88 patients were enrolled in the study. Four cases were cancelled on the day of surgery and two had their anaesthetic plans changed. So, a total of 82 patients were analyzed.

The demographic profile of study population is shown in Table 3.

Table 3: Summary of demographic variables (n=82)

Patient characteristics	Mean/Number	Standard deviation/percentage
Age (years)	40.83	12.67
Female	57	69.5 %
Male	25	30.5%
Weight (kg)	61.77	11.19
Height (cm)	157.87	7.58
BMI (kg/m^2)	24.72	4.05

In our study,46 (56.1%) patients had IPS of 4 or less and 36 (43.9%) had IPS of 5 or more. The maximum IPS in this study was eight. Fourteen patients (17.1%) had Modified Cormack-Lehane Grading of 2b or higher even with OELM. So, the prevalence of difficult visualization of larynx in our study is 17.1%. There were no failed intubations in the study. The maximum IPS in our study was eight. IPS of 9 or more is suggestive of very difficult intubation. None of the patients in this study have IPS of 9 or more. The distribution of difficult and easy visualization of the larynx (DVL and EVL) with IPS is given in Table 4.

Table 4: Distribution of difficult and easy visualization of the larynx with an intubation prediction score (n=82)

Intubation Prediction Score	Difficult visualization of the larynx	Easy visualization of the larynx	Total
≥5	11	25	36
3-4	3	43	46
Total	14	68	82

The sensitivity, specificity, PPV, NPV, LR of different single tests and Intubation Prediction Score is shown in Table 5.

Table 5: Comparative table of various tests for prediction of difficult visualization of larynx (n=82)

Tests	Sensitivity	Specificity	PPV	NPV	+LR	-LR
IPS	78.6%	63.2%	30.6%	93.5%	2.14	0.34
MMT	50%	85.3%	41.2%	89.2%	3.4	0.58
TMD	7.1%	97.1%	33.3%	83.5%	2.45	0.96
IIG	21.4%	91.2%	33.3%	84.9%	3.78	0.73

DISCUSSION

This study was designed to assess intubation prediction score (IPS) as a tool for an airway assessment tool to predict difficult visualization of the larynx (DVL) on direct laryngoscopy and hence difficult intubation. A total of eighty-two American Society of Anaesthesiologists – Physical Status (ASA-PS) I and II patients planned for elective surgery under general anaesthesia with endotracheal intubation were analyzed. Airway assessment was done with intubation prediction score (IPS) and other individual tests before surgery. Difficult visualization of the larynx (DVL) was defined using modified Cormack-Lehane grading (MCLG) of 2b or more with optimal external laryngeal manipulation. Difficult visualization of the larynx is a surrogate to difficult intubation.

The prevalence of difficult intubation in this study was 17.1%. The prevalence in different studies ranges from 1.7% to 20.2% worldwide.[2] Even in study done in our country itself, the prevalence varies in different studies ranging from 3.8% to 17.7%. [6-9] These variations are probably due to the different definitions used for difficult intubation.

An ideal preoperative assessment tool for difficult laryngoscopy and hence intubation, should be able to identify all the cases with difficult intubation while also ruling out ones without difficult intubation. Identifying difficult intubation is the more important goal than ruling out ones without difficulty as unanticipated difficulties can be catastrophic.

Looking at all these findings, we can say that none of these single tests are accurate enough to be used as a sole predictor difficult intubation. Similar results with low specificity and positive predictive values have been shown in other studies as well.[7,10-12] Most individual tests have high specificity and PPV but low sensitivity and NPV. In airway assessment, a test with a low false negative rate would be preferred as we would like to avoid unanticipated difficult intubation as much as possible. Therefore, a test with higher sensitivity and NPV would be desirable. As most individual tests were found to have low sensitivity, they are not ideal for airway assessment.

Sensitivity can be increased with the use of a multivariate test like IPS. This increase in sensitivity means a decrease in false negative cases and hence a decrease in the proportion of cases with unanticipated difficult intubation. This was shown to have occurred at the expense of decreased specificity which meant an increase in the number of false positive cases. However, a false negative prediction is more dangerous to the patient than a false positive prediction.

In our study, the sensitivity and specificity of the IPS were 78.6% and 63.2% respectively. This implies that IPS would be able to detect 78.6% of cases with difficult intubation as difficult. Likewise, 63.2% of cases with easy visualization of the larynx (EVL) would be labeled easy with IPS according to our study. A past study showed IPS to have a sensitivity and specificity of 77.8% and 92.4% respectively.[5] The sensitivity of IPS was comparable (78.6% vs. 77.8%). However, the specificity was discrepant (63.2% vs. 92.4%). A reason for the discrepancy could be the different definitions of difficult intubation used. We used MCLG to define difficult intubation while they used intubation difficulty score (IDS) to define difficult intubation. IPS was divided into three groups (easy intubation, moderately difficult intubation, and difficult intubation) based on the IDS. However, Cormack-Lehane (CL) grade and MCLG are the more commonly used definitions for difficult intubation.

The discrepancies could also have been caused by limitations of MMT which is included in the IPS. Variations in the diagnostic capabilities of MMT may be due to involuntary phonation during the assessment which may considerably alter the MMT. Low prediction value of MMT can be due to involuntary phonation.[13] One critical factor in doing a reliable MMT was the maximal opening of the mouth and extrusion of the tongue.[14] Failure to employ these maneuvers strictly is a chief drawback when performing the test. We encouraged the patients to have their mouths maximally open and tongues maximally protruded. We also discouraged any phonation. Most past studies do not mention maximal mouth opening and tongue protrusion. [15]

Similarly, TMD which also another component of the IPS may have discrepancies due to different anthropological measurements in people of different geographical regions, ethnicities, and races.

Our study reported the positive predictive value (PPV) and negative predictive value (NPV) of

IPS to be 30.6% and 93.5%. This implies that in patients with a predicted difficult intubation with IPS, only 30.6% actually had difficulty. In our study, 93.5% of the patients were labeled as easy intubation by IPS is actually easy. A past study found the positive and negative predictive values of IPS to be 58.6% and 96.8% respectively.[6] The difference in positive predictive values could be due to the difference in the prevalence of difficult intubation itself (17.1% vs. 12%).

None of the patients had AOJE less than 13° and only one patient had AOJE less than 22° in our study. This may have been due to the exclusion of elderly patients with age greater than 65 years and patients in whom neck mobility would be decreased to a greater extent. There were no failed intubations, or major complications such as airway trauma and hypoxia.

Our study has used modified Cormack-Lehane grading (MCLG) as the definition of difficult visualization of the larynx (DVL) as MCLG is the most commonly used surrogate of difficult intubation. However, the intubation prediction score (IPS) has only been validated with Intubation Difficulty Score and not with MCLG in previous studies.

CONCLUSIONS

Intubation prediction score (IPS) has a sensitivity of 78.6% and a specificity of 63.2% for the prediction of difficult intubation. It is combination of commonly used tests in clinical practice with scoring system. It can be incorporated in clinical practice to better prediction of difficult intubation.

Further studies are recommended with larger sample size to test the predictively of IPS for difficult intubation. This score has objective parameters also which is added advantage for reliability of data in different studies.

CONFLICT OF INTEREST

None

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None

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