A prospective observational study of predictors of difficult intubation in Indian patients

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Abstract

Background and Aims: During routine preoperative assessment of patients one of the commonest practices is predicting difficulty of intubation. The present study was undertaken to evaluate parameters associated with difficult intubation and to test on new set of patients. At the end, to form simple predictive rule to decreased the number of false alarms.
Material and Methods: In initial series of 483 Indian population patients we measured age, sex, weight, height, interincisor gap, mandibular length, neck movement, neck circumference, subluxation of mandible, sternocricoid distance, and identified factors associated with difficult intubation. These were applied on next 480 patients of prospective series and simple predictive rule in form of risk sum score was developed.
Results: After analyzing initial series data we found that weight ($P = 0.033$), height ($P = 0.034$), interincisor gap ($P = 0.005$), subluxation ($P < 0.001$), neck movement ($P < 0.001$), and sternocricoid distance ($P = 0.020$) were significantly associated with difficult intubation. These six factors were applied on next set of 480 patients to found accuracy of predicting difficult intubation of weight (51.7%), height (83.8%), interincisor gap (80.2%), subluxation (77.7%), neck movement (82.7%), and sternocricoid distance (79.2). Total score greater than 2 predicted 92.8% of difficult laryngoscopies correctly as against 33.9% would be falsely labeled as difficult.
Conclusion: Interincisor gap and sternocricoid distance are the two most sensitive factors predicting difficult intubation in Indian patients. However, risk sum score of more than 6 may lead to better anticipation of truly difficult intubations.

Keywords: Difficult intubation, intratracheal, laryngoscopy, larynx, sensitivity, specificity

Introduction

The failure to maintain unobstructed airway following the induction of general anesthesia is major concern of anesthesiologist. Difficult airway has been defined as "the clinical situation in which a conventionally trained anesthesiologist experiences difficulty with face mask ventilation of the upper airway, difficulty with tracheal intubation, or both.[1] Difficult tracheal intubation accounts for 17% of respiratory related injuries and 28% of all anesthesia related deaths are secondary to the inability to mask ventilate or intubate.[2]

Tracheal intubation remains the method of choice in most cases, however direct laryngoscopic intubation is difficult in 1.5–13% of patients who have seemingly normal airway.[2] Several predictors like Mallampati score, thyromental distance (TMD), sternomental (SM) distance, and Wilson's risk sum score are widely recognized as tools for predicting difficult intubation,[3-5] but none is gold standard.

The primary purpose of the present study was to evaluate the predictors significantly associated with difficult intubations in an Indian population. In initial series, patients were divided into two groups, easy intubation group (A) and difficult intubation group (B). The six significant predictors associated with difficult intubations were identified in initial series.

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Secondary objective of present study was to test validity of these significant predictors in next set of patients so as form a risk sum score that effectively predicts difficult endotracheal intubation.

Material and Methods

This prospective study was conducted after obtaining Institutional Ethical Committee approval, CTRI registration (CTRI/2017/11/010571), and patient's written informed consent. We enrolled 963 ASA grades I and II adult patients of either sex. Patients with facial maxillary trauma, post-burns neck contracture, intraoral pathology/infections, bleeding tendencies, rheumatoid disease, degenerative spinal disease and edentulous patient were excluded from the study.

Sample size was calculated by applying Z TEST: n = Z2 PQ/d2, where at 95% confidence level, Z = 1.96 and assuming 1.1% of study error (P = proportion of difficult intubation, Q = proportion of not having difficult intubation). Difficulty of intubation was seen in 1.5% of patients as found in previous study.[5] So, P = 1.5. Q =100 – P = 100–1.5 = 98.5. Therefore, sample size came to 478, for simplification 480 patients in both series and additional number of patient reported as "difficult to intubate" by other colleague were include in initial series.

In initial series, Laryngeal grade as described by Wilson and colleagues[5] at intubation was assessed prospectively in 480 adult patients undergoing surgeries and three patients reported as "difficult to intubate" by other colleague was also included in initial series. In the operation theatre, standard monitoring devices such as cardioscope, pulse oximeter, and non-invasive blood pressure were applied to the patient and baseline parameters were noted and an intravenous line was secured. Patients requiring general anesthesia with endotracheal intubation were studied by anesthesiologist having 2 years of experience to eliminate subjective variability. All the patients were preoxygenated with 100% oxygen for 3 min. General anesthesia was induced with either thiopentone sodium 5 mg/kg or propofol 2 mg/kg. Level of seniority or experience of the anesthesiologist performing laryngoscopy and intubation were kept same to rule out bias associated with inexperience in mask holding and laryngoscopy and intubation. After confirming adequate depth of anesthesia mask ventilation was attempted. After confirming ventilation, injection succinylcholine 1.5 mg/kg or vecuronium 0.1mg/kg was given and patient was ventilated with bag and mask till adequate muscle relaxation was achieved. Direct laryngoscopy was done using Macintosh laryngoscope. Patients were intubated with appropriate sized endotracheal tube. Confirmation of correct placement of tube was done by chest movements, visualization of tidal movement of expired moisture, auscultation, and capnography and pulse oximeter. Before intubation parameters like age, sex, weight, height, intericisor gap, mandibular length, neck length and subluxation of mandible, neck movement in degree, neck circumference, sternocricoid distance (in intubation position) were noted. Laryngeal grade as described by Wilson and colleagues[5] (Grade I-almost all vocal cord seen ,Grade II-half of vocal cord seen, Grade III-Only arytenoid seen, Grade IV-only epiglottis seen, Grade V-not even epiglottis seen) and external laryngeal pressure applied was also noted.

The data obtained from initial series were divided in two groups: Group A: Easy intubation (grade I -III) and Group B: Difficult intubation (grade IV). Analyzing above data we identified factors significantly associated with difficult intubation according to P value of each parameter and labeled significant if P value was <0.05. Each risk factor was divided into 0 (normal), 1 (moderate), and 2 (severe) levels. Accordingly, all patients were analyzed by this risk levels.

All the six significant factors were applied on next set of 480 patients of prospective series and calculated risk level. Also, the sensitivity, specificity, positive, negative predictive values of these factors and simple predictive rule in form of risk sum score was developed.

Results

In the present study, data were collected prospectively from 483 patients included in initial series and 480 from new patients in prospective series. There was no protocol violation so all the data were analyzed and results were divided into stage-1 (initial series), stage-2 (identification of risk factors), and stage-3 (prospective series).

In initial series, patients in both the groups A and B did not differ significantly in terms of age, sex, mandibular length, neck length, neck circumference, external laryngeal pressure ($P > 0.05$) whereas in terms of weight, height, interincisor gap, neck movement, subluxation, sternocricoid distance were significantly different in both the groups [Table 1]. This association was evaluated using Chi-square test for qualitative data and two sample t test for quantitative data and $P < 0.05$ was considered as significant. Distribution of patients as per Wilson grading with laryngeal pressure, showed maximum 72% of patient in grade I and minimum 0.6% of patient in grade V. Maneuver of laryngeal pressure was significantly required in difficult group.

From the analysis of initial series data, weight, height, interincisor gap, subluxation, neck movement, and sternocricoid distance were found to be significantly associated with difficult intubation. So, these six factors can predict difficult intubation in advance and each factor was divided into level of risk for difficult intubation as 0, 1, and 2 according to mean value in difficult group [Table 2].

In prospective series of next set of patients, all the above six factors were applied on 480 patients to calculate sensitivity, specificity, positive, and negative predictive values by using statistical test of each of these factors [Table 3].

Simpler method to allocate a risk score to new patients was to add up the observed risk level as 0, 1, and 2. The percentage of true positive and false positive predictions for each risk sum score was also calculated [Table 4].

Table 1: Distribution of risk factors in intubation groups A and B (initial series)

Factors assessed (*n*=483)		Group A (*n*=470)		Group B (*n*=13)		*P*
		Mean or no	SD or %	Mean or no	SD or %	
Weight (kg)		55.9	8.2	60.9	10.6	0.033
Height (cm)		154.5	7.0	150.3	7.3	0.034
Interincisor gap (cm)		4.2	0.9	3.5	1.3	0.005* (S)
Subluxation	>0 mm	465	(98.9%)	4	(30.8%)	<0.001*
	0 mm	5	(1.1%)	4	(30.8%)	
	<0 mm	0	(0.0%)	5	(38.5%)	
Neck movement	>90°	469	(99.8%)	3	(23.1%)	<0.001*
	90°	0	(0.0%)	0	(0.0%)	
	<90°	1	(0.2%)	10	(76.9%)	

*By Chi-square test and two sample t-test; *P<0.05 significant*

Table 2: Level of risk for difficult intubation

Risk factor	Level	Criteria
Weight	0	<60 kg
	1	60-65 kg
	2	>65 kg
Height	0	>150 cm
	1	150 cm
	2	<150 cm
Interincisor gap	0	>3.5 cm
	1	=3.5 cm
	2	<3.5 cm
Subluxation	0	>0 mm
	1	0 mm
	2	<0 mm
Neck movement	0	>90°
	1	=90°
	2	<90°
Sternocricoid distance	0	>4.9 cm
	1	=4.9 cm
	2	<4.9 cm

Discussion

In present study, we studied 11 factors to predict difficult intubation out of which only six factors such as weight, height, interincisor gap, neck movement, subluxation, sternocricoid distance were found to be significantly predicting difficult intubation. The incidence of difficult intubation in initial series was 2.6% that was similar to report by Aftab *et al.*[6] There is a possibility of higher incidence of difficult intubation on similar patients according to varies previous studies.[7] The incidence of difficult intubation in prospective series was 2.9%, this was compared with study of Wilson *et al.*[5] Wilson required maneuvers such as external laryngeal pressure maximum times in grade I but in our study we used it in difficult intubation group. Probably this difference was due to different expertise of the person who is intubating, however, in difficult to intubate group it is advisable to give external laryngeal pressure and it definitely improves the vision.

In easy group (A) the mean weight was 55.9 ± 8.2 kg and in difficult group (B) it was 60.9 ± 10.6 kg, (*P* value <0.05, statistically significant) whereas height in easy group was 154.5 cm and 150.3 cm in difficult group. The difference in height was statistically significant with *P* value of 0.03; this may be due to racial difference in height and was comparable with Wilson's study.[5] The mean interincisor gap in easy group was 4.2 ± 0.9 cm and in difficult group it was 3.5 ± 1.3 cm with *P* value of 0.005, this was compared with the other studies.[5,8] Wilson *et al.*[5] and El-Ganzouri *et al.*[9] reported that receding mandible as a good predictor of difficult intubation with *P* value of 0.0004 and 0.001, respectively. Subluxation <0 was the significant factor for prediction of difficult intubation with *P* value of 0.001. Thus, receding mandible indicates that the tongue is positioned posteriorly than usual, blocking the laryngoscopic view and causing difficult intubation. Similarly, the neck movement as significant factor for prediction of difficult intubation with *P* value of 0.001 and the result was agreement with the study of Wilson *et al.*[5] and Vasudevan *et al.*[10] The mean sternocricoid distance was 4.92 ± 0.09 cm in difficult intubation group and 5.54 ± 1.7 cm in easy intubation group, *P* value was 0.023, which was statistically significant. So, accordingly weight, height, interincisor gap, neck movement, subluxation, sternocricoid distance were labeled as predictors of difficult intubation in prospective series.

Risk sum score can be obtained by classifying each of six factors into 0, 1, and 2. If we consider >2 risk sum score as predictor of difficulty 92.8% of difficult laryngoscopies were correctly identified as against 33.9% was falsely labeled as difficult. If we consider >1 risk sum score as predictor of

Table 3: Sensitivity, specificity, and positive and negative predictive values by using statistical test of each of risk factors

Factors	Sensitivity (%)	Specificity (%)	Positive predictive value (%)	Negative predictive value (%)	Accuracy (%)
Prediction by weight	78.6	50.9	4.6	98.8	51.7
Prediction by height	57.1	84.5	10	98.5	83.8
Prediction by interincisor gap	85.7	80.0	11.4	99.5	80.2
Prediction by subluxation	71.4	77.9	8.8	98.9	77.7
Prediction by neck movement	78.6	82.8	12.1	99.2	82.7
Prediction by sternocricoid distance	85.7	79.0	10.9	99.5	79.2

Table 4: Percentage of true positive and false positive predictions for each risk cum score

Risk cum criteria	True positive		False positive	
	Initial series *n* (%)	Prospective series *n* (%)	Initial series *n* (%)	Prospective series *n* (%)
>6	7 (53.8)	12 (85.7)	3 (0.6)	24 (5.1)
>5	8 (61.5)	13 (92.8)	12 (2.5)	58 (12.4)
>4	9 (69.2)	13 (92.8)	22 (4.6)	72 (15.4)
>3	9 (69.2)	13 (92.8)	75 (15.9)	122 (26.1)
>2	10 (76.9)	13 (92.8)	123 (26.1)	158 (33.9)
>1	13 (100)	14 (100)	470 (100)	466 (100)

difficulty 14 of difficult laryngoscopies were correctly identified as against 466 was falsely labeled as difficult. Compared with Wilson study[5] example of 10,000 patients, with 2.9% incidence of difficult intubation in our study 290 cases of difficult laryngoscopies and 9,710 cases of nondifficult would be seen. By risk sum score >2, 269 patients would be correctly identified. As shown in Table 4 false positive rate of 33.9%, 3,291 patients would be falsely classified as at risk. In other words, 274 times a month a skilled assistance would be called unnecessary, so that assistance could be at hand for 22 of 24 difficult laryngoscopies expected in each month (the other 2 being missed, i.e., 92.8% true positivity). Thus, only 7% (22 true difficult of 298 of all call) of alarms would turn out to be necessary. Similar sensitivity and specificity results found by Shiga *et al*.[11] Whether this helpful or not will depend on the geography and staffing arrangement of individual hospitals. Increasing the threshold to a risk sum score >6 would reduce the rate of false alarms to 41 per month at a cost of lowering the number of detected difficult laryngoscopies to 20 of 24: thus 85% of alarms would turn out to be positive.

In general, interincisor gap can correctly predict 80% of easy or difficult intubations. Comparison with El-Ganzouri *et al*. study,[9] in the present study the sensitivity was high, it was appealing, but it also accompanies large false positive values that could result in extra time to overcome difficulties of anticipated difficult intubation by provision of alternative measures such as awake intubation. Our specificity was low as compare with El-Ganzouri *et al*. study.[9] Comparing weight with El-Ganzouri *et al*.[9] study higher number of true difficult intubations were present but at the cost of false positive intubations. Comparing mandibular subluxation with the Savva *et al*.[12] study and neck movement values with Arne *et al*.[13] study higher sensitivity, less specificity, and positive predictive values were present in our study, those may be less important factors for difficult intubation in comparison with the above study.[12,13] Factor with highest sensitivity (few false negative) was interincisor gap and sternocricoid distance and one with low sensitivity (many false positive) was height and subluxation in comparison with others factors. Similarly, factor with highest specificity (few false positive) in comparison with others were height and neck movement. From the above discussion, we come to the conclusion that not a single factor can itself predict only true difficult intubations. We should always use the combinations of the factors and it will help to predict difficult intubation in advance.

There are some limitations of the study. The clinical value of these bedside screening tests for predicting difficult intubation remains limited as single factor may not be predictive of difficult intubation at all the time but combination of these might be helpful. Ultimately, it was clinical study so there can be inter-observer variations in the measurement of all factors. There will always be a bias due to subjective findings. Also, one of the limitations of bed side test is incorrect evaluation and many time patients do not understand the instructions. Variations may be due to different expertise of the person and different conditions when someone is intubations such as inadequate muscle relaxation, improper head position.

Conclusion

We conclude that combination of factors will help predict difficult intubation more efficiently than any single factor.

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Conflicts of interest

There are no conflicts of interest.

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