

Difficult Intubation: Prospective observational study to evaluate it's key predictors

Urvi H. Desai^{1,*}, Devendra W. Thakare², Amala G. Kudalkar³

¹Associate Professor, ²Assistant Professor, ³Professor, Dept. of Anaesthesia, LTMMC & LTMGH

***Corresponding Author:**

Email: urvi_desai@hotmail.com

Abstract

Introduction: Airway assessment to identify the predictors of difficult intubation (DI) during general anaesthesia is very important to maintain patient safety and prevent untoward events like hypoxia and brain damage. The aim of our study is to evaluate the occurrence of difficult tracheal intubation during general anaesthesia in elective surgeries and to find out the key predictors of difficult intubation.

Materials and Method: A prospective study was conducted in 450 patients posted for elective general surgeries requiring general anaesthesia over a one year period. The screening tests for difficult intubation included the following: Mallampati classification (MPC), inter-incisor gap (IG), thyromental distance (TMD), subluxation of mandible (slux) and restricted neck movements (RNM). Risk factors assessed included obesity, neck circumference, short neck, buck teeth and poor dentition (loose / missing). Difficult intubation was defined when any one or more of these criteria were present: > 2 attempts at intubation; > 5-minutes duration of laryngoscopy; Cormack Lehane grade 3 or 4; use of intubating aids like McCoy laryngoscope and Frova (tracheal introducer). Multivariate analysis using a binary logistic regression was performed for the ten predictors. Predictive accuracy was assessed using sensitivity, specificity and positive predictive values.

Result: Incidence of DI was 20.8%. It had strong correlation with MPC, RNM, TMD and poor dentition with an odds ratio of 9.2, 5.2, 4.8, and 2.58 respectively. TMD is most sensitive predictor (55.32%) and RNM is most specific predictor (97.2%). MPC, RNM, TMD are the key independent predictors of difficult intubation.

Keywords: Predictor, Difficult intubation, Laryngoscopic view

Received: 9th December, 2016

Accepted: 15th March, 2017

Introduction

Difficult intubation under general anaesthesia can lead to multiple laryngoscopy attempts, intubation delay or failure resulting in hypoxia and brain damage. This sequence can get exaggerated if the difficult intubation is not predicted. Identifying the key predictors for difficult intubation is an important step for safety of the patient. Difficult intubation (DI) can be predicted by simple or complex mathematical scoring methods. If multiple positive predictors are present, then difficult intubation can be anticipated easily. The issue arises when one has to predict difficult intubation with single independent predictors. There are multitude screening methods to evaluate difficult intubation, however different populations will have variations in the nature of the predictors positive for difficult intubation.

The incidence of difficult intubation in elective surgeries ranges from 2%-15% (1). Cormack Lehane (CL) grade 3 and 4 is associated with poor view of larynx and difficult intubation. CL grade 2 may also be associated with difficult intubation especially if only posterior arytenoids or chink of glottis visualised. In such cases, depending on the experience of anaesthesiologist, an aid to intubation may be required. Wide variations in the incidence of difficult intubation is mainly due to varied criteria of defining DI.

The purpose of our study was to know the occurrence of difficult tracheal intubation during general an-

aesthesia in elective cases and to evaluate the key (independent) predictors of difficult intubation. We have used ten bedside predictors as screening tests for difficult intubation. These have been used routinely as preoperative evaluation for our patients in our institute. This would help us ensure proper airway strategies, decrease failure of tracheal intubations and their complications.

Materials and Method

This was a prospective, observational study which included 450 consenting adult patients, undergoing elective surgeries, requiring general anaesthesia and tracheal intubation over one year period. The study has been approved by the institutional ethics committee and review board. The surgeries included were head and neck, breast, thoracic, abdominal and plastic surgery for burns. We excluded patients with previous history of difficult intubation, obstetric patients, patients with laryngeal lesions like tumors, polyps, congenital airway anomalies, unstable cervical spine and awake intubations.

Demographic data collected included age, sex, weight, height and body mass index (BMI). An objective and detailed airway examination was carried out pre-operatively for each patient, using five bedside tests and five risk factors as predictors of difficult intubation. All tests were completed with patient in sitting position. The tests were clearly defined and measurements were made using measuring tape or goniometer. The positive predictors were Mallampati classification (MPC) 3 and 4,

inter-incisor gap (IG) < 4cm, thyromental distance < 6.5cm, restricted neck movement (RNM) or atlanto-occipital joint extension < 25 degrees, lux or subluxation of mandible 0 or -1, obesity (BMI more than or equal to 30), neck circumference (more than or equal to 16 inches), short neck, buck teeth and poor dentition (missing or loose).^(2,3)

We anticipated difficult intubation if any one or more predictors were present. We used the standard routine protocol for general anaesthesia and tracheal intubation followed in our hospital. We induced anaesthesia with either inhalational or intravenous agents. Mask ventilation was assessed. All patients were administered succinylcholine as the neuromuscular blocking agent to facilitate direct laryngoscopy except where it was contraindicated. All patients were given sniffing position. Direct laryngoscopy was performed using appropriate sized Macintosh laryngoscope by anaesthesiologist with minimum two years of experience under the supervision of consultant. Glottis was visualised with external laryngeal manipulation (ELM), if required. Cormack Lehane (CL) classification was used to assess difficult intubation.⁽⁴⁾ In CL grade 1, most of the glottic opening can be seen. In CL grade 2, only posterior portion of glottis or only arytenoid cartilages are seen. In CL grade 3, only the epiglottis and no portion of the glottis is seen. In CL grade 4, neither the glottis nor the epiglottis can be seen. Intubating aids like McCoy laryngoscope or Frova (tracheal introducer) or both were used when best glottic view after ELM was CL grading 2 and above. Difficult intubation was defined as one or all of the following; poor laryngeal view with CL grading 3-4, laryngoscopy attempts more than two, laryngoscopy time more than five minutes, use of intubating aids and use of alternative intubation devices if any.^(5,6)

Complications like soft tissue trauma, dental trauma, oesophageal intubations, oxygen desaturation and aspiration were recorded. Any failed intubation was noted. All notifications were done in pro forma sheet by tick method or minimal objective method.

Univariate analysis was performed using Chi square test and Fishers exact test to know the association of each airway predictor with difficult intubation. Sensitivity, specificity, and positive predictive values were obtained to compare the predictive accuracy amongst the predictors. Data was analysed using IBM SPSS version 2015. Binary logistic regression by forward stepwise method was carried out with difficult intubation as dependent variable for the ten predictors. This multivariate analysis was done to find out the main independent predictors for difficult intubation. Odds ratio, 95% confidence interval and *P* values were obtained for independent predictors

derived. A *P* value less than 0.05 was considered statistically significant. Sample size was calculated taking into consideration incidence of difficult intubation as 10%.⁽¹⁾ During study period total general anaesthesia cases conducted were around 600, thus minimum sample size at 5% alpha error and 80% power of study was found to be 113. We assessed total 450 cases.

Result

A total of 450 patients were taken in this trial over a one year period. There were 252 females and 198 males. Difficult intubation was reported in 94 patients. Our incidence of difficult intubation was 20.8 %. We anticipated difficult intubation in 183 patients. 101 patients were found out to be false positive cases. We were not able not anticipate difficult intubation in 12 out of 94 patients (false negative). There were 94 patients in whom we had to use aids for tracheal intubation. CL grade 3 was seen in 15 patients, and CL grade 4 was seen in one patient. Among the 94 patients who required aids there were six patients with more than two attempts of laryngoscopy, and three patients required more than five minutes of total laryngoscopy time. During our study period there was one failed intubation who had CL grade 4 on direct laryngoscopy. After multiple attempts of laryngoscopy with intubating aids, patient was awakened and surgery was postponed.

In the univariate analysis we derived that among the ten predictors all except buck teeth had significant association with DI (**Table 1**). Coming to the predictive accuracy, the highest sensitivity value was seen with TMD (55.32 %). Rest all the predictors had low to borderline sensitivities. All predictors had high specificities, with maximum specificity seen with RNM (97.19 %). Positive predictive value was also low to borderline with highest value seen with RNM (66.67%) and MPC (65.67%) (**Table 2**).

All the predictors were included in the multivariate analysis which identified that MPC, RNM, TMD and poor dentition are the key predictors of difficult intubation, with the greatest association with MPC having a odds ratio (ODR) of 9.2, and least with poor dentition (ODR 2.58) (**Table 3**).

When we combined the three key bedside predictors (MPC, RNM, TMD), we observed that presence of any one increased the sensitivity to 62.5% and presence of all three only made it a 100 % specific test. (**Table 4**).

We encountered complications in 22 patients which included oesophageal intubations (n=3), dental trauma (n= 6), soft tissue trauma (n=10), and oxygen desaturation (n=3).

Table 1: Positive predictive tests and its association with difficult intubation

Positive predictors	Patients with predictor present	Patients with difficult intubation	P
Mallampati classification 3-4	67	44	0.000*
Inter-incisor gap < 4cm	38	20	0.000*
Thyromental distance < 6.5cm	90	52	0.000*
Restricted neck movement	30	20	0.000*
Slux 0 or -1	82	32	0.000*
Obesity BMI > 30	45	19	0.001*
Neck circumference > 16 inches	54	18	0.021*
Short neck	92	41	0.000*
Buck teeth	59	17	0.122
Poor dentition	85	28	0.004*

* $P < 0.05$ is statistically significant; BMI – Body mass index

Table 2: Sensitivity, specificity and positive predictive value of ten single predictors

Predictive Tests	Sensitivity (%)	Specificity (%)	Positive predictive value (%)
Mallampati classification	46.8	93.4	65.67
Inter-incisor gap	21.2	94.9	52.6
Thyromental Distance	55.32	89.33	57.78
Restricted neck movement	21.2	97.19	66.67
Slux	34	85.96	39
Obesity	20.21	92.7	42.22
Neck circumference	19.1	89.9	33.33
Short neck	43.62	85.67	44.57
Buck teeth	18.09	88.2	28.81
Poor dentition	29.79	83.99	32.94

Table 3: Logistic regression showing independent predictors of difficult intubation

Predictors	Odds Ratio	95% confidence interval	P
MPC	9.19	4.54 - 18.67	0.000*
RNM	5.20	1.99 - 13.67	0.001*
TMD	4.79	2.51 - 9.15	0.000*
Poor Dentition	2.58	1.33 - 5.04	0.005*

* $P < 0.05$ is statistically significant; MPC – Mallampati classification; RNM – Restricted neck movement; TMD – Thyromental distance

Table 4: Sensitivity, specificity, positive predictive value of key predictor combinations (MPC, RNM, TMD)

Predictor combinations	Sensitivity (%)	Specificity (%)	Positive predictive value (%)
Any One	62.5	85.8	41.67
Any two	37	96.9	75
All three	5.32	100	100

MPC – Mallampati classification; RNM – Restricted neck movement; TMD – Thyromental distance

Discussion

The incidence of difficult intubation in our study is 20.8%. Our incidence is much higher than observed in the other studies, which ranges from 3-13%.⁽⁷⁻¹²⁾ Wide variations in the incidence of difficult intubation were observed mainly due to the different criteria for defining difficult intubation. Laryngeal view with CL grade 3 and 4 is definitely difficult intubation criteria. But sometimes there may be conditions where a part of glottis or arytenoids is seen during laryngoscopy, yet intubation would require another adjunct for easier insertion. It may be that factors like lack of uniformity in grading, positioning, degree of muscle relaxation, cause this disparity.⁽¹³⁾ We have chosen use of adjuncts like McCoy laryngoscope and Frova, Cormack and Lehane grading 3 and 4, laryngoscopy time and number of attempts as criteria for defining difficult intubation.⁽⁶⁾ We applied ELM in 225 patients. This helped us in improving the glottic view. We encountered CL grade 3 in only 15 patients and CL grade 4 in only one patient after applying ELM. In case we had applied only Cormack Lehane classification as our criteria for DI then our incidence of difficult intubation would have been in 3.5%. CL laryngoscopy grading alone is not particularly effective at discriminating easy, awkward and genuinely DI.⁽¹⁴⁾ Thus we used a broader definition of difficult intubation in our study. The addition of adjuncts and alternative techniques as definition for DI can be criticised, as the threshold for the use of each can be variable.⁽⁸⁾

Meta analysis by Shiga et al showed the incidence of difficult intubation in normal patients without pathologic airway to be 5.8%.⁽¹⁾ Even though we excluded laryngeal lesions and congenital airway deformity, we did include cases like thyroid swelling (n=21), carcinoma head and neck (n=11) and neck contractures post burns (n=6). We encountered difficult intubation in 94 of 450 patients. We had to use Frova and, or McCoy blade in all 94 difficult intubation cases. Out of these, 78 had CL grade 2 and still required an aid to intubate while only 15 patients had CL grade 3. We had only one failed intubation with CL grade 4. Our patient was obese, short neck with MPC 3.

Ideally, any preoperative assessment test of difficult tracheal intubation should have high sensitivity and specificity and result in minimum false positive and false negative cases. Coming to the predictive accuracy of our ten predictors, all had significant association with DI except buck teeth, unlike the study group by Wilson et al.⁽⁷⁾

According to him long upper incisors may affect the position of the upper end of the line of sight. However according to us this can be compensated by other airway elements like mandibular movement, mandibular space, neck mobility and oropharyngeal space. Arne et al also did not find buck teeth as a significant finding, in the univariate analysis.⁽¹⁵⁾

In our study, all predictors had low to borderline sensitivities with TMD and MPC having 55.32 % and 46.8% sensitivity respectively, similar to observation by Jimson et al.⁽⁹⁾ All predictors had high specificity with RNM, IG and MPC having 97.19 %, 94.9 % and 93.4% respectively. All had borderline positive predictive values (PPV) with RNM and MPC having 66.67% and 65.67% respectively. Thus this study tells us that there is a high probability that the intubation will not be difficult if the predictors are negative. With RNM and MPC as positive predictors there are less chances of encountering false positive cases.

Merah et al had similar observations for MPC (61.5%, 98.4%, and 57.1%) for sensitivity, specificity and PPV respectively. However TMD differed in its sensitivity (15.4%) and PPV (22.2%).⁽¹⁰⁾ This is because it was a study of West African population, so there would be anthropometric peculiarities seen. He also observed that IG had a higher sensitivity 30% compared to ours 21%. Mouth opening is an important predictor of DI, however higher cut off value decreases the sensitivity.

When we performed logistic regression analysis our strongest independent predictors were MPC, RNM and TMD. Similarly, Merah found MPC, TMD and IG as his key predictors. When he combined these three main key predictors, he had the best prediction for difficult intubation with sensitivity, specificity and PPV of 84.6%, 94.6%, 35.5% respectively. However when we combined our three main predictors (MPC, RNM, TMD), we got sensitivity, specificity and PPV of 5.3%, 100% and 100% respectively. Our sensitivity increased to 62.5%, when any one of the three key predictors was present. This difference in the outcome may be due to different ethnicity and total number of predictors included in the study.

By the logistic regression method, we derived that poor dentition is also a key independent predictor of difficult intubation. However the strength of association is weak, with odds ratio of 2.586 compared to the other key predictors MPC, RNM, TMD with odds ratio 9.2, 5.2, and 4.8 respectively. This highlights the problem of bad

oral hygiene and tobacco chewing habit of the Indian population. This is a significant finding not seen with other studies. We had 19% of patients who came with poor dentition.

In our study, in the univariate analysis obesity was associated with DI, however as observed by Brodsky et al, it was not found to be independent predictor.⁽¹⁶⁾ They had taken 100 morbidly obese patients with BMI more than 40. They however found that neck circumference ranging from 42–49 cm was significantly associated with DI. In our trial neck circumference more than 40cm was having association with DI, but not a key predictor. Gonzales observed that neck circumference is an independent risk factor for difficult intubation in 70 obese patients.⁽¹⁷⁾ Perna Shah et al did a similar study, but her key predictors for DI were obesity (BMI>26) and RNM.⁽¹¹⁾ When she combined both the predictors, the sensitivity for difficult intubation was 43%. When we combined any two of the key predictors, the sensitivity was 37% and positive predictive value was 75%.

In a study done in the Korean population by Suk Hwan Seo, out of seven predictors for difficult intubation only ULBT (upper lip bite test) with odds ratio of 12.48 and Total Airway Score (TAS) > 6 with odds ratio (13.57) were independent predictors for difficult intubation.⁽¹²⁾ In our study even though slux had a significant association with DI, it was not observed to be independent predictor by logistic regression. Possibility of this airway element to be compensated by large mouth opening and its association with possibility of buck teeth could have resulted in actual subluxation of mandible not being a key predictor. A high ULBT could be due to receding mandible, poor mouth opening as well as presence of buck teeth.

In spite of applying ten predictors to assess difficult intubation, we encountered 12 cases in whom we could not predict difficult intubation. The consequences of false negative result may be detrimental and life threatening. Thus a multivariate risk index scoring system as done by Arne and El Gounzari, may be required.^(15,18) However these methods are quite complicated, involving numerous variables. As one study suggested, perhaps indirect laryngoscopy could be included as a screening test. However this is not a bedside test and also it is quite invasive.⁽¹⁹⁾

We anticipated difficult intubations in 183 cases, but only 82 were difficult to intubate. Total false positive cases were 101(40.7%). There were 12 patients whom we could not anticipate difficult intubation. Thus our assumption that the presence any one or more of the 10 predictors of difficult intubation has not helped us to accurately judge the occurrence of difficult intubation. High anticipation of DI only prepared us to keep our patients safe with decreased rate of complications. Our study is one of the very few studies conducted in Indian population where patients were preoperatively assessed with ten predictors for the risk of difficult intubation to find the key ones. The ten predictors are not new, they

are routinely used for preoperative evaluation of airway in our institute. Negative result is of immense benefit because it directs us towards easy intubation. Teeth play an important role in association with difficult intubation. Surprisingly more than buck teeth, it is the presence of loose and missing teeth that we must pay more attention to guide us to prepare for difficult intubation.

Conclusion

In our study after performing simple screening tests we concluded that Mallampati classification (MPC), restricted neck movement (RNM), thyromental distance (TMD) are the independent key predictors of difficult intubation. At the end of the study, we now know that the presence of any one of the key predictors (MPC, RNM, TMD) independently would make intubation difficult in 65 % of the patients.

Acknowledgements

We have registered our trial with the Clinical trials registry India (CTRI) and number is CTRI/2016/03/006711.

Competing interests

No external funding and no competing interests declared.

References

1. Shiga T, Wajima Z, Inoue T, Sakamoto A. Predicting difficult intubation in apparently normal patients. A meta-analysis of bedside screening test performance. *Anesthesiology* 2005;103:429–37.
2. Gupta S, Sharma R, Jain D. Airway assessment: predictors of difficult airway. *Indian J. Anaesth.* 2005;49(4):257–262.
3. Karkouti K, Rose DK, Wigglesworth D, Cohen MM. Predicting difficult intubation: a multivariable analysis. *Can J Anaesth* 2000;47(8):730–739.
4. Cormack RS and Lehane J. Difficult tracheal intubation in obstetrics. *Anaesthesia* 1984;39:1105–1111.
5. Crosby ET, Richard M, Cooper, Douglas MJ. The unanticipated difficult airway with recommendations for management. *Can J Anaesth* 1998;45(8):757.
6. Law JA, Broemling N, Cooper RM, et al. The difficult airway with recommendations for management – Part 1 – Difficult tracheal intubation encountered in an unconscious/induced patient. *Can J Anaesth* 2013;60:1089–118.
7. Wilson ME, Spiegelhalter D, Robertson JA and lesser P. Predicting difficult intubation. *Br J Anaesth.* 1988;61:211–216.
8. Savva D. Prediction of difficult tracheal intubation. *Br. J. Anaesth* 1994;73(2):149–153.
9. Tse JC, Rimm EB, Hussain A. Predicting Difficult Endotracheal Intubation in Surgical Patients Scheduled for General Anesthesia: A Prospective Blind Study. *Anesth & Analg* 1995;81(2):254–258.
10. Merah NA, Wong DT, Ffoulkes-Crabbe DJ, Kushimo OT, Bode CO. Modified Mallampati test, thyromental distance and inter-incisor gap are the best predictors of difficult laryngoscopy in West Africans. *Can J Anaesth* 2005;52:291–6.

11. Shah PN, Sundaram V. Incidence and predictors of difficult mask ventilation and intubation. *J Anaesthesiol Clin Pharmacol* 2012;28:451-5.
12. Seo SH, Lee JG, Yu SB, Kim DS, Ryu SJ, Kim KH. Predictors of difficult intubation defined by the intubation difficulty scale (IDS): Predictive value of 7 airway assessment factors. *Korean J Anesthesiol* 2012;63:491-7.
13. Karkouti K, Rose DK, Ferris LE. Inter-observer reliability of ten tests used for predicting difficult tracheal intubation. *Can J Anaesth* 1996;43(6):554.
14. Cook TM. A new practical classification of laryngeal view. *Anaesthesia* 2000;55:274-9.
15. Arne J, Descoins P, Fusciardi J, Ingrand P, Ferrier B, Boudigues D, Aries J. Preoperative assessment for difficult intubation in general and ENT surgery: predictive value of a clinical multivariate risk index. *Br J Anaesth* 1998;80(2):140-6.
16. Brodsky JB, Lemmens HJ, Brock-Utne JG, Vierra M, Saidman LJ. Morbid obesity and tracheal intubation. *Anesth Analg* 2002;94:732-6.
17. Gonzalez H, Minville V, Delanoue K, Mazerolles M, Concina D, Fourcade O. The importance of increased neck circumference to intubation difficulties in obese patients. *Anesth Analg* 2008;106:1132-6.
18. El-Ganzouri AR, McCarthy RJ, Tuman KJ, et al. Preoperative airway assessment: predictive value of a multivariate risk index. *Anesth Analg* 1996;82:1197-204.
19. Yamamoto K, Tsubokawa T, Shibata K, Ohmura S, Nitta S, Kobayashi T. Predicting difficult intubation with indirect laryngoscopy. *Anesthesiology* 1997;86:316-21.