



## RESEARCH ARTICLE

## Predictors of Difficult Tracheal Intubation in Adult Surgical Patients: A Prospective Observational Study

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### ABSTRACT

**Background:** Difficult tracheal intubation is an important airway-related challenge during general anaesthesia and may result in repeated intubation attempts, airway trauma and perioperative complications. Identification of patients at increased risk during preoperative assessment allows appropriate preparation and planning. The present study evaluated demographic, clinical and airway-related predictors of difficult tracheal intubation in adult surgical patients.

**Methods:** This prospective observational study included 300 adult patients aged  $\geq 18$  years scheduled for elective surgery under general anaesthesia with planned tracheal intubation. Preoperative assessment included age, sex, body mass index, comorbidities, modified Mallampati class, mouth opening, thyromental distance, neck movement and dentition. During laryngoscopy, Cormack–Lehane grade was recorded. Difficult tracheal intubation was defined as Cormack–Lehane grade III or IV. Associations between potential predictors and difficult intubation were assessed using appropriate statistical tests, followed by multivariable logistic regression to identify independent predictors.

**Results:** Difficult tracheal intubation was observed in 27 (9.0%) patients. Its incidence was significantly higher among patients aged  $\geq 60$  years, males, patients with BMI  $\geq 30$  kg/m<sup>2</sup> and those with comorbidities. Significant associations were observed with modified Mallampati class III–IV (33.9% vs. 3.3%), mouth opening  $< 3$  cm (40.9% vs. 3.5%), thyromental distance  $< 6.5$  cm (29.9% vs. 3.0%), restricted neck movement (42.1% vs. 4.2%) and abnormal dentition (62.5% vs. 6.0%) ( $p < 0.05$ ). On multivariable analysis, Mallampati class III–IV, restricted neck movement, mouth opening  $< 3$  cm, thyromental distance  $< 6.5$  cm, abnormal dentition, BMI  $\geq 30$  kg/m<sup>2</sup> and age  $\geq 60$  years remained independently associated with difficult intubation.

**Conclusion:** Difficult tracheal intubation occurred in a clinically relevant proportion of adult surgical patients. A systematic assessment incorporating demographic and multiple airway parameters may improve preoperative identification of patients at increased risk.

**Key word:** Difficult intubation, Surgical, BMI.

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### INTRODUCTION

Tracheal intubation is a fundamental component of general anaesthesia and is routinely performed to establish and maintain a secure airway during surgery. Although intubation is successful in the majority of patients, unexpected difficulty in securing the tracheal airway can result in repeated attempts, airway trauma, hypoxaemia and other serious perioperative complications. Consequently, identification of patients who may have a difficult airway before induction of anaesthesia is an important component of safe anaesthetic practice[1,2].

Difficult tracheal intubation is not uncommon in routine anaesthetic practice. The reported incidence varies considerably between studies because of differences in patient populations, definitions of difficult intubation, airway assessment methods and operator experience. The Difficult Airway Society has reported an incidence

of difficult tracheal intubation of approximately 1.9–10% in different clinical settings[1]. In an Indian prospective study involving 330 adult patients undergoing general anaesthesia, difficult laryngoscopy was observed in 9.7% and difficult intubation in 4.5% of patients[3]. These findings demonstrate that difficult intubation can occur even among patients undergoing routine elective surgery without an obvious airway abnormality.

Preoperative airway assessment therefore plays an important role in anticipating difficulty and allowing appropriate preparation before induction. The All India Difficult Airway Association recommends routine preoperative airway assessment to identify factors associated with difficult facemask ventilation, supraglottic airway insertion and tracheal intubation. However, the guideline also emphasizes that no single available bedside test can reliably exclude a difficult airway[4]. Thus,

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assessment should incorporate relevant clinical history and multiple anatomical and functional airway characteristics rather than relying on one measurement alone.

Several bedside parameters have been investigated for predicting difficult tracheal intubation. These include modified Mallampati classification, mouth opening or inter-incisor distance, thyromental distance, sternomental distance, neck mobility, mandibular protrusion, neck circumference, dentition and body habitus[3,5]. A prospective study from India involving 135 adult patients demonstrated that the modified Mallampati test, thyromental distance and sternomental distance provided useful information for predicting difficult intubation, while combining these parameters improved predictive validity

compared with the Mallampati assessment alone[5].

However, the predictive performance of individual airway tests is variable. A prospective study involving 300 adult patients found that commonly used parameters such as modified Mallampati classification, thyromental distance and upper-lip-bite test differed in their ability to predict difficult laryngoscopy, highlighting the limitations of relying on a single anatomical measurement[6]. Similarly, another Indian prospective study of 340 patients evaluated thyromental height together with modified Mallampati score, inter-incisor gap, thyromental distance, neck circumference and neck extension and demonstrated differences in their diagnostic performance[7]. These findings support the assessment of multiple routinely measurable airway characteristics during the preoperative evaluation.

Patient-related factors may also contribute to difficulty in tracheal intubation. Increasing age, higher body weight or BMI, male sex, reduced mouth opening, higher Mallampati class, shorter thyromental distance, restricted neck movement and limited mandibular protrusion have been associated with difficult laryngoscopy or intubation in different populations[3,8]. A prospective observational study of 100 adult patients further demonstrated associations between difficult intubation and variables including BMI, inter-incisor gap, Mallampati classification, neck circumference, thyromental distance and sternomental distance[8]. These observations suggest that demographic, clinical and anatomical factors may collectively influence the likelihood of difficult intubation.

Importantly, the ability of preoperative airway assessment to predict difficulty remains imperfect. The 2016 All India Difficult Airway Association guidelines

**Table 1:** Association of demographic and clinical factors with difficult tracheal intubation (n = 300)

| Variable    | Category                  | Difficult intubation n (%) | Non-difficult intubation n (%) | p-value |
|-------------|---------------------------|----------------------------|--------------------------------|---------|
| Age         | 18–39 years               | 4 (3.7)                    | 104 (96.3)                     | 0.012   |
|             | 40–59 years               | 10 (8.5)                   | 108 (91.5)                     |         |
|             | ≥60 years                 | 13 (17.3)                  | 62 (82.7)                      |         |
| Sex         | Male                      | 20 (12.1)                  | 145 (87.9)                     | 0.034   |
|             | Female                    | 7 (5.2)                    | 128 (94.8)                     |         |
| BMI         | <25 kg/m <sup>2</sup>     | 5 (3.8)                    | 126 (96.2)                     | <0.001  |
|             | 25–29.9 kg/m <sup>2</sup> | 9 (8.4)                    | 98 (91.6)                      |         |
|             | ≥30 kg/m <sup>2</sup>     | 13 (21.0)                  | 49 (79.0)                      |         |
| Comorbidity | Absent                    | 12 (6.0)                   | 188 (94.0)                     | 0.021   |
|             | Present                   | 15 (15.0)                  | 85 (85.0)                      |         |

**Table 2:** Association of preoperative airway assessment parameters with difficult tracheal intubation (n = 300)

| Airway parameter          | Category   | Difficult intubation n (%) | Non-difficult intubation n (%) | p-value |
|---------------------------|------------|----------------------------|--------------------------------|---------|
| Modified Mallampati class | I–II       | 8 (3.3)                    | 236 (96.7)                     | <0.001  |
|                           | III–IV     | 19 (33.9)                  | 37 (66.1)                      |         |
| Mouth opening             | ≥3 cm      | 9 (3.5)                    | 247 (96.5)                     | <0.001  |
|                           | <3 cm      | 18 (40.9)                  | 26 (59.1)                      |         |
| Thyromental distance      | ≥6.5 cm    | 7 (3.0)                    | 226 (97.0)                     | <0.001  |
|                           | <6.5 cm    | 20 (29.9)                  | 47 (70.1)                      |         |
| Neck movement             | Normal     | 11 (4.2)                   | 251 (95.8)                     | <0.001  |
|                           | Restricted | 16 (42.1)                  | 22 (57.9)                      |         |
| Dentition                 | Normal     | 17 (6.0)                   | 267 (94.0)                     | <0.001  |
|                           | Abnormal   | 10 (62.5)                  | 6 (37.5)                       |         |

specifically note that currently available airway assessment tests are not completely reliable, emphasizing the need for appropriate preparation even when preoperative assessment does not suggest difficulty[4]. The challenge, therefore, is not simply to identify a single test with the highest predictive value but to determine which routinely obtainable patient and airway characteristics are associated with difficult intubation in the population being studied.

A prospective evaluation of these predictors in the local surgical population can provide clinically useful information because the prevalence and strength of individual risk factors may vary according to patient characteristics and the clinical setting. Identification of readily measurable predictors such as Mallampati class, mouth opening, thyromental distance, neck movement, dentition, BMI and relevant demographic factors may facilitate better preoperative risk stratification and preparation for airway management.

Therefore, the present prospective observational study was undertaken to determine the incidence of difficult tracheal intubation among adult surgical patients undergoing general anaesthesia and to evaluate the association of demographic, clinical and routinely assessed airway characteristics with difficult tracheal intubation. The study further aims to identify independent predictors that may help in recognizing patients at increased risk before induction of anaesthesia.

## METHODOLOGY

This prospective observational study was conducted in the Department of Anaesthesiology of a private medical college and affiliated tertiary care hospital over a period of one year, after obtaining approval from the Institutional Ethics

Committee. Adult patients aged ≥18 years scheduled for elective surgical procedures under general anaesthesia with planned tracheal intubation was enrolled after obtaining written informed consent. Patients undergone emergency surgery, those with a previously documented difficult airway, patients requiring awake intubation, and patients with gross upper-airway abnormalities or incomplete airway assessment was excluded.

A total of 300 consecutive eligible patients were included. Preoperative assessment recorded age, sex, BMI and relevant comorbidities. Airway assessment was

**Table 3:** Cormack–Lehane grade and intubation-related findings among study participants (n = 300)

| Variable                           | Category  | Number (n) | Percentage (%) |
|------------------------------------|-----------|------------|----------------|
| Cormack–Lehane grade               | Grade I   | 183        | 61.0           |
|                                    | Grade II  | 90         | 30.0           |
|                                    | Grade III | 21         | 7.0            |
|                                    | Grade IV  | 6          | 2.0            |
| Number of intubation attempts      | One       | 267        | 89.0           |
|                                    | Two       | 25         | 8.3            |
|                                    | ≥3        | 8          | 2.7            |
| Alternative airway/device required | No        | 282        | 94.0           |
|                                    | Yes       | 18         | 6.0            |

Difficult intubation = Cormack–Lehane Grade III/IV = 21 + 6 = 27 (9.0%).

**Table 4:** Independent predictors of difficult tracheal intubation on multivariable logistic regression

| Predictor                       | Adjusted Odds Ratio (AOR) | 95% CI     | p-value |
|---------------------------------|---------------------------|------------|---------|
| Age $\geq 60$ years             | 2.41                      | 1.01–5.76  | 0.048   |
| Male sex                        | 1.86                      | 0.76–4.55  | 0.173   |
| BMI $\geq 30$ kg/m <sup>2</sup> | 3.27                      | 1.34–7.99  | 0.009   |
| Mallampati III–IV               | 6.42                      | 2.63–15.67 | <0.001  |
| Mouth opening <3 cm             | 5.18                      | 2.05–13.09 | <0.001  |
| Thyromental distance <6.5 cm    | 4.36                      | 1.79–10.62 | 0.001   |
| Restricted neck movement        | 5.73                      | 2.25–14.61 | <0.001  |
| Abnormal dentition              | 3.81                      | 1.36–10.67 | 0.011   |

include modified Mallampati class, mouth opening/inter-incisor distance, thyromental distance, neck movement, dentition and other clinically relevant airway findings. During anaesthesia, laryngoscopy was performed using a standardized technique by an experienced anaesthesiologist, and the Cormack–Lehane grade will be documented. Difficult tracheal intubation was defined primarily as Cormack–Lehane grade III or IV. Number of intubation attempts, need for alternative airway devices and other airway-related events also recorded. Data was analysed using appropriate statistical tests. Associations between individual predictors and difficult intubation initially assessed, followed by multivariable logistic regression to identify independent predictors. A p-value <0.05 considered statistically significant.

## RESULTS

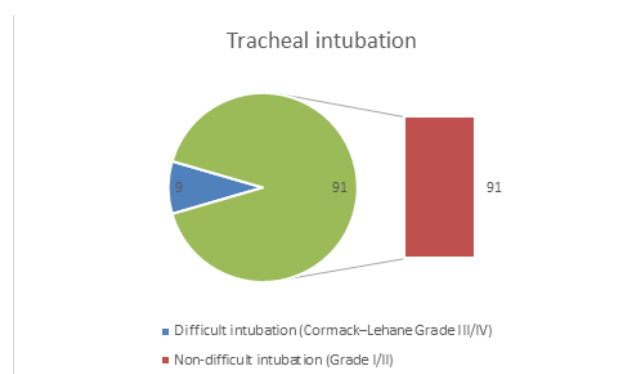
Among the 300 adult surgical patients included in the study, difficult tracheal intubation, defined as Cormack–Lehane grade III or IV, was observed in 27 (9.0%) patients, whereas 273 (91.0%) patients had non-difficult intubation. Thus, difficult tracheal intubation was encountered in approximately one out of every eleven patients.

Age showed a significant association with difficult tracheal intubation. The proportion of difficult intubation increased from 3.7% among patients aged 18–39 years to 8.5% among those aged 40–59 years and 17.3% among patients aged  $\geq 60$  years ( $p=0.012$ ). Difficult intubation was also more frequent among males than females (12.1% vs.

5.2%), with the difference being statistically significant ( $p=0.034$ ). Increasing BMI demonstrated a significant association, with difficult intubation occurring in 21.0% of patients with BMI  $\geq 30$  kg/m<sup>2</sup> compared with 3.8% among patients with BMI <25 kg/m<sup>2</sup> ( $p<0.001$ ). Presence of comorbidity was also associated with a higher proportion of difficult intubation (15.0% vs. 6.0%;  $p=0.021$ ).

Airway assessment parameters demonstrated stronger associations with difficult tracheal intubation. Patients with modified Mallampati class III–IV had a markedly higher incidence of difficult intubation than those with class I–II (33.9% vs. 3.3%;  $p<0.001$ ). Similarly, patients with mouth opening <3 cm had a substantially higher frequency of difficult intubation than those with mouth opening  $\geq 3$  cm (40.9% vs. 3.5%;  $p<0.001$ ). A thyromental distance <6.5 cm was associated with difficult intubation in 29.9% of patients compared with 3.0% among those with a distance  $\geq 6.5$  cm ( $p<0.001$ ). Restricted neck movement was also strongly associated with difficult intubation (42.1% vs. 4.2%;  $p<0.001$ ). Abnormal dentition showed the highest observed proportion of difficult intubation, with 62.5% of such patients having difficult intubation compared with 6.0% among patients with normal dentition ( $p<0.001$ ).

Regarding laryngoscopic findings, Grade I laryngoscopic view was obtained in 183 (61.0%) patients and Grade II in 90 (30.0%), while Grade III and Grade IV views were observed in 21 (7.0%) and 6 (2.0%) patients, respectively. Overall, 27 patients therefore fulfilled the predefined criterion for difficult tracheal intubation. A single intubation attempt was successful in 267 (89.0%) patients, while 25 (8.3%) required two attempts and 8 (2.7%) required three or more attempts. An alternative airway device was required in 18 (6.0%) patients. On multivariable logistic regression, several airway-related

**Chart 1:** Incidence of difficult tracheal intubation among study participants (n = 300)

parameters remained independently associated with difficult tracheal intubation. Mallampati class III–IV showed an adjusted odds ratio (AOR) of 6.42 (95% CI: 2.63–15.67;  $p < 0.001$ ). Restricted neck movement (AOR 5.73; 95% CI: 2.25–14.61;  $p < 0.001$ ), mouth opening  $< 3$  cm (AOR 5.18; 95% CI: 2.05–13.09;  $p < 0.001$ ), thyromental distance  $< 6.5$  cm (AOR 4.36; 95% CI: 1.79–10.62;  $p = 0.001$ ), and abnormal dentition (AOR 3.81; 95% CI: 1.36–10.67;  $p = 0.011$ ) were independently associated with difficult intubation. BMI  $\geq 30$  kg/m<sup>2</sup> was also independently associated with increased odds (AOR 3.27; 95% CI: 1.34–7.99;  $p = 0.009$ ), while age  $\geq 60$  years showed a more modest independent association (AOR 2.41; 95% CI: 1.01–5.76;  $p = 0.048$ ). Male sex was not independently associated after adjustment ( $p = 0.173$ ).

Overall, the proposed results indicate that routinely measurable preoperative airway characteristics—particularly higher Mallampati class, restricted neck movement, reduced mouth opening, short thyromental distance and abnormal dentition—provide important information for identifying patients at increased risk of difficult tracheal intubation.

## DISCUSSION

In the present study of 300 adult surgical patients undergoing general anaesthesia, difficult tracheal intubation, defined as Cormack–Lehane grade III or IV, was observed in 27 patients (9.0%). This finding indicates that difficult intubation remains a clinically relevant occurrence even among patients undergoing routine surgical procedures. The observed frequency is somewhat higher than the 4.5% incidence of difficult tracheal intubation reported by Prakash et al. in 330 Indian adult patients.<sup>1</sup> Differences in patient characteristics, surgical population, airway assessment methods and operational definitions of difficult intubation may account for variation between studies. In the same study, difficult laryngoscopy defined by Cormack–Lehane grade III/IV occurred in 9.7%, which is close to the 9.0% observed in the present study[1].

The present study demonstrated a significant association between increasing age and difficult intubation. Difficult intubation occurred in 17.3% of patients aged  $\geq 60$  years compared with 3.7% among those aged 18–39 years. Older age remained independently associated with difficult intubation after adjustment for other variables. This finding is consistent with observations from the Indian population, where increasing age was associated with difficult laryngoscopy. Prakash et al. suggested that age-related changes, including reduced neck mobility and poor dentition, may contribute to increasing difficulty with

laryngoscopy[1]. However, the association between age and difficult intubation should be interpreted in conjunction with anatomical airway findings rather than as an isolated predictor.

Male sex and higher BMI were also associated with difficult intubation in the present study. Although male sex showed a significant association on initial analysis, it did not remain statistically significant after multivariable adjustment. In contrast, BMI  $\geq 30$  kg/m<sup>2</sup> remained independently associated with difficult intubation. Similar associations between weight and airway difficulty have been reported in Indian patients[1]. A prospective observational study of Indian patients also identified weight among the variables associated with difficult intubation and incorporated anthropometric variables into a predictive model.<sup>2</sup> These findings support the importance of considering body habitus during routine preoperative airway assessment.

Among the airway parameters evaluated, modified Mallampati class III–IV demonstrated a strong association with difficult tracheal intubation. Difficult intubation occurred in 33.9% of patients with Mallampati class III–IV compared with only 3.3% among those with class I–II. Furthermore, Mallampati class III–IV remained an independent predictor in multivariable analysis, with an adjusted odds ratio of 6.42. This finding is consistent with previous Indian studies in which higher Mallampati class was associated with difficult laryngoscopy.<sup>1</sup> A prospective Indian study evaluating multiple bedside tests also found that commonly used airway parameters, including Mallampati classification, had predictive value, although their performance varied when used individually.<sup>3</sup>

Reduced mouth opening was another significant predictor in the present study. Patients with an inter-incisor distance  $< 3$  cm had a substantially higher frequency of difficult intubation than those with adequate mouth opening. This observation is consistent with the findings of Prakash et al., who identified an inter-incisor distance  $\leq 3.5$  cm as an independent factor associated with difficult laryngoscopy[1]. Similarly, a prospective observational study involving Indian patients identified interincisor gap as one of the significant variables associated with difficult intubation.<sup>2</sup> Restricted mouth opening may limit the ability to introduce and manipulate the laryngoscope and therefore has a plausible anatomical relationship with difficult laryngoscopy.

Thyromental distance  $< 6.5$  cm was also significantly associated with difficult intubation in the present study and remained an independent predictor after adjustment.

This finding is in agreement with the established role of thyromental distance as a routinely assessed anatomical airway parameter. Previous Indian research has evaluated thyromental distance alongside Mallampati score, inter-incisor gap, neck circumference and neck extension for prediction of difficult laryngoscopy[4]. However, the variable performance of individual bedside tests indicates that thyromental distance should preferably be interpreted as part of a broader airway assessment rather than as a stand-alone screening test.

Restricted neck movement showed a particularly strong association with difficult intubation in the present study. Difficult intubation occurred in 42.1% of patients with restricted neck movement compared with 4.2% among those with normal neck movement, and restricted neck movement remained independently associated with the outcome. This observation closely corresponds with the findings of Prakash et al., who reported decreased range of neck movement as an independent risk factor for difficult laryngoscopy. Another prospective Indian study similarly identified neck movement as one of the significant variables associated with difficult intubation and subsequently incorporated it into a predictive risk score.<sup>2</sup> These findings reinforce the importance of assessing cervical mobility during routine preoperative airway evaluation.

Abnormal dentition was also significantly associated with difficult intubation in the present study and remained independently associated after multivariable adjustment. This association may be particularly relevant in older patients and in individuals with limited oral access. The relationship between age, dentition and airway difficulty has also been described in previous Indian literature[1]. Although abnormal dentition cannot by itself establish that intubation will be difficult, its presence may provide additional information when considered alongside other anatomical predictors.

The overall findings support the concept that no single preoperative airway parameter should be relied upon in isolation. The All India Difficult Airway Association guidelines emphasize systematic airway assessment and preparedness for unexpected difficulty because currently available prediction methods cannot completely exclude a difficult airway[5]. The present findings similarly demonstrate that several easily measurable parameters—particularly Mallampati class, mouth opening, thyromental distance and neck movement—provide complementary information regarding the risk of difficult intubation.

The multivariable analysis is particularly relevant to the objective of identifying independent predictors.

Mallampati class III–IV, restricted neck movement, mouth opening <3 cm, thyromental distance <6.5 cm, abnormal dentition, BMI  $\geq 30$  kg/m<sup>2</sup> and age  $\geq 60$  years remained associated with difficult intubation after adjustment. The strongest association was observed with Mallampati class III–IV, followed by restricted neck movement and reduced mouth opening. These findings are broadly consistent with previous Indian prospective studies demonstrating that combinations of anatomical and clinical parameters can improve identification of patients at risk of difficult intubation[2,3].

An important practical implication of these findings is that the predictors identified in this study are inexpensive, non-invasive and routinely assessable during preoperative evaluation. Their assessment requires no specialized equipment beyond standard clinical examination. This makes them particularly applicable to routine surgical practice. Nevertheless, the findings should not be interpreted as indicating that patients without these risk factors can be considered free of airway risk. The AIDAA guidelines emphasize that unexpected difficult intubation may still occur and that appropriate preparation and availability of difficult-airway equipment remain essential[5].

The present study has some limitations. It is a single-centre observational study with a relatively modest sample size, and therefore the findings may not be directly generalizable to all surgical populations. The number of difficult-intubation events was relatively small, which limits the number of variables that can be reliably included in multivariable regression. In addition, airway assessment and laryngoscopy findings may be influenced by operator experience and technique. Larger multicentric studies would be useful to validate the identified predictors and determine whether a simple combined prediction model can improve preoperative risk stratification.

## CONCLUSION

In this prospective observational study, difficult tracheal intubation occurred in a clinically important proportion of adult surgical patients. Higher Mallampati class, restricted neck movement, reduced mouth opening, shorter thyromental distance, abnormal dentition, obesity and older age were associated with increased risk of difficult intubation, with several of these factors remaining independently associated after multivariable analysis. The findings support the use of a systematic, multidimensional preoperative airway assessment rather than reliance on a single bedside predictor. Early identification of patients with multiple risk factors may facilitate appropriate preparation and planning for airway management, while recognizing

that no preoperative assessment can completely exclude unexpected difficulty.[1,2,5]

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