Original Research Article

# OBSERVATIONAL STUDY OF DIFFICULT AIRWAY PREDICTORS AND THEIR CORRELATION WITH LARYNGOSCOPIC VIEW IN PATIENTS UNDERGOING GENERAL ANAESTHESIA

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## ABSTRACT

**Background:** Difficult airway management remains an important concern during general anaesthesia because failure to anticipate a difficult laryngoscopic view may lead to repeated intubation attempts, airway trauma, hypoxaemia, and the need for alternative airway techniques. Preoperative assessment using multiple clinical and anatomical predictors can help identify patients at increased risk of difficult laryngoscopy. **Aim:** To evaluate difficult airway predictors and determine their correlation with the laryngoscopic view in patients undergoing general anaesthesia.

**Materials and Methods:** This prospective observational study included 84 adult patients undergoing elective surgery under general anaesthesia with direct laryngoscopy and endotracheal intubation in our hospital. Preoperative airway assessment included modified Mallampati class, inter-incisor gap, thyromental distance, sternomental distance, neck circumference, upper lip bite test, and cervical mobility. Laryngoscopic view was graded using the Cormack–Lehane classification. Grades I–II were considered easy and Grades III–IV difficult laryngoscopy. Data were analysed using IBM SPSS Statistics version 27.0. A p-value <0.05 was considered statistically significant.

**Results:** Easy laryngoscopy was observed in 70 (83.33%) patients, whereas 14 (16.67%) had difficult laryngoscopy. Difficult cases had significantly higher BMI (28.10 ± 3.70 vs. 24.90 ± 3.20 kg/m²; p=0.008), greater neck circumference (41.68 ± 3.71 vs. 37.18 ± 3.54 cm; p<0.001), and reduced inter-incisor gap, thyromental distance, sternomental distance, and neck extension. Modified Mallampati Class III–IV was present in 78.57% of difficult cases (p<0.001). First-attempt intubation success was significantly lower in difficult laryngoscopy (21.43% vs. 94.29%; p<0.001). Modified Mallampati Class III–IV remained the strongest independent predictor (adjusted OR 19.19; p=0.004).

**Conclusion:** Multiple bedside airway parameters were significantly associated with difficult laryngoscopy. Combined preoperative airway assessment may improve prediction and assist in safer airway planning.

**Keywords:** Difficult airway; Laryngoscopy; Cormack–Lehane grade; Mallampati classification; General anaesthesia.

## INTRODUCTION

Airway management is one of the fundamental responsibilities of an anaesthesiologist and is essential for maintaining adequate oxygenation and ventilation during general anaesthesia. Direct laryngoscopy followed by endotracheal intubation remains a routinely used technique for securing the airway in patients undergoing a wide range of surgical procedures. Although tracheal intubation is generally accomplished without difficulty, an unexpectedly difficult laryngoscopic view can complicate airway management and increase the likelihood of repeated attempts, airway trauma, hypoxaemia, aspiration, haemodynamic disturbances, and the need for alternative airway devices. Consequently, identification of patients who may have a difficult airway before induction of anaesthesia is an important component of perioperative patient safety. Current difficult airway guidelines emphasize systematic airway evaluation, appropriate preparation, availability of alternative airway techniques, and formulation of an individualized airway management strategy when difficulty is anticipated.[1] A difficult airway may involve difficulty with facemask ventilation, supraglottic airway placement, laryngoscopy, tracheal intubation, or establishment of an invasive airway. Difficult laryngoscopy specifically refers to difficulty in obtaining an adequate view of the glottic structures during laryngoscopy. The Cormack–Lehane grading system is widely used to describe the laryngoscopic view, with higher grades representing progressively poorer visualization of the glottis. Prediction of such difficulty before induction is challenging because the laryngoscopic view depends on the interaction of several anatomical and functional characteristics rather than a single abnormality. Therefore, preoperative assessment generally incorporates multiple bedside parameters that evaluate oral access, mandibular space, cervical mobility and the relationship of external anatomical landmarks. Multivariable approaches have consequently gained importance in difficult laryngoscopy prediction.[2] The modified Mallampati classification is among the most frequently used bedside screening methods for airway assessment. It evaluates visibility of the oropharyngeal structures when the patient opens the mouth and protrudes the tongue. Other conventional measurements include inter-incisor gap, thyromental distance and sternomental distance. The inter-incisor gap provides an estimate of mouth opening and space available for introduction and manipulation of the laryngoscope. Thyromental distance reflects mandibular dimensions and the available submandibular space, whereas sternomental distance incorporates mandibular characteristics together with the ability to extend the head and neck. Neck circumference, body habitus, cervical mobility and modified Mallampati class may provide additional information regarding anatomical conditions that can interfere with alignment of the oral, pharyngeal and laryngeal axes. Clinical examination can also be supplemented with indirect or ultrasonographic assessment when appropriate.[3] Airway ultrasonography has emerged as an additional non-invasive approach to preoperative airway evaluation. Sonographic examination can assess structures and dimensions that cannot be adequately quantified by routine external examination, including anterior neck soft-tissue thickness, tongue-related measurements and hyomental relationships. However, conventional bedside tests continue to have considerable practical importance because they are rapid, inexpensive, reproducible, and require minimal equipment. The relationship between bedside airway characteristics and the laryngoscopic view therefore remains clinically relevant even with the increasing availability of newer imaging-based techniques. Evaluation of these parameters against direct laryngoscopic grading provides an objective method of determining their usefulness for routine preoperative screening.[4] Functional characteristics of the mandible and cervical spine are also important during laryngoscopy. The upper lip bite test assesses mandibular protrusion and the ability of the lower incisors to advance in relation to the upper lip, providing information about temporomandibular mobility and mandibular movement. Similarly, adequate head and neck extension facilitates positioning and improves alignment during conventional direct laryngoscopy. Restricted cervical movement may prevent optimal positioning even when mouth opening and other anatomical measurements appear satisfactory. Accordingly, contemporary airway research has continued to evaluate established clinical tests alongside newer anatomical measurements and combinations of predictors to improve the recognition of potentially difficult direct laryngoscopy.[5] Patient-related characteristics can further influence airway difficulty. Increased body mass index and greater neck circumference may be accompanied by altered upper airway anatomy and increased soft-tissue volume, while snoring and obstructive sleep apnoea may indicate anatomical or functional narrowing of the upper airway. Previous difficult intubation, abnormalities of the head and neck, limited mouth opening, restricted mandibular protrusion and reduced cervical mobility are therefore important elements of the pre-anaesthetic history and examination. Neck circumference considered together with thyromental distance has also been investigated as a composite anatomical assessment because the relationship between different airway dimensions may provide more clinically useful information than an isolated measurement.[6]

## MATERIALS AND METHODS

This hospital-based prospective observational study was conducted in the department of anesthesiology at our tertiary care hospital among patients scheduled to undergo elective surgical procedures under general anaesthesia requiring direct laryngoscopy and endotracheal intubation. The study was designed to assess commonly used preoperative difficult airway predictors and determine their correlation with the laryngoscopic view obtained during direct laryngoscopy. A total of 84 adult patients fulfilling the predefined eligibility criteria were included in the study. Patients were enrolled consecutively from the elective operative list after obtaining written informed consent. Each patient underwent a standardized pre-anaesthetic airway assessment before surgery, followed by documentation of the laryngoscopic view during induction of general anaesthesia.

**Inclusion Criteria:** Patients aged 18–65 years, belonging to American Society of Anesthesiologists (ASA) physical status I–III, scheduled for elective surgery under general anaesthesia with oral endotracheal intubation, and willing to provide informed consent were included in the study.

**Exclusion Criteria:** Patients requiring emergency surgery, patients with an already secured airway or planned awake intubation, known major craniofacial abnormalities, maxillofacial trauma, cervical spine instability, restricted mouth opening due to local pathology, upper airway tumours, previous major surgery or radiotherapy involving the head and neck, pregnancy, and patients in whom direct laryngoscopy was contraindicated were excluded. Patients with incomplete airway assessment data were also excluded.

**Methodology**

**Pre-Anaesthetic Assessment:** A detailed pre-anaesthetic evaluation was performed and included age, sex, height, weight, body mass index (BMI), ASA physical status, relevant medical history, history of previous difficult intubation, snoring or obstructive sleep apnoea, and history of head and neck surgery. Routine systemic examination and investigations required according to the patient's clinical condition and planned surgical procedure were performed.

**Assessment of Difficult Airway Predictors:** Airway examination was performed with the patient sitting comfortably and included the modified Mallampati classification, inter-incisor gap, thyromental distance, sternomental distance, neck circumference, upper lip bite test, mandibular protrusion, and cervical spine mobility. Modified Mallampati class III or IV was considered suggestive of a potentially difficult airway. An inter-incisor gap of <3.5 cm, thyromental distance <6.5 cm, sternomental distance <12.5 cm, and increased neck circumference were considered potentially unfavourable airway features. Neck circumference was measured at the level of the thyroid cartilage. Cervical spine mobility was assessed by estimating the range of head and neck extension. The upper lip bite test was classified into Classes I–III, with Class III indicating restricted mandibular movement and a potentially difficult airway.

**Anaesthetic Technique:** Standard fasting guidelines were followed. On arrival in the operating room, routine monitoring including electrocardiography, non-invasive blood pressure, pulse oximetry, and capnography was instituted. After adequate preoxygenation, general anaesthesia was induced using standard intravenous induction agents and an appropriate neuromuscular blocking agent. After adequate muscle relaxation, direct laryngoscopy was performed with the patient in an appropriate sniffing position using a Macintosh laryngoscope blade of suitable size. Laryngoscopy was performed by an anaesthesiologist experienced in airway management to minimize operator-related variability.

**Assessment of Laryngoscopic View:** The best laryngoscopic view obtained without external laryngeal manipulation was graded according to the Cormack–Lehane classification. Grade I represented a complete view of the glottis, Grade II a partial view of the glottis, Grade III visualization of only the epiglottis without visualization of the glottis, and Grade IV inability to visualize either the glottis or epiglottis. Cormack–Lehane Grades I and II were categorized as an easy laryngoscopic view, whereas Grades III and IV were considered a difficult laryngoscopic view. The number of laryngoscopy and intubation attempts, requirement for external laryngeal manipulation, use of an alternative airway device or technique, and any airway-related complications were also recorded.

**Statistical Analysis**

Data were entered into Microsoft Excel and analysed using IBM SPSS Statistics for Windows, version 27.0**.** Continuous variables were expressed as mean ± standard deviation or median with interquartile range, while categorical variables were presented as frequencies and percentages. Normality was assessed using the Shapiro–Wilk test, and comparisons were performed using the independent-samples t-test/Mann–Whitney U test and chi-square/Fisher’s exact test, as appropriate. Correlation analysis, ROC curve analysis with AUC, and multivariable binary logistic regression were performed to evaluate difficult airway predictors. A p-value <0.05 was considered statistically significant.

## RESULTS

A total of 84 patients undergoing elective surgical procedures under general anaesthesia were included in the study. Based on the Cormack–Lehane classification, 70 (83.33%) patients had an easy laryngoscopic view corresponding to Grades I–II, while 14 (16.67%) patients had a difficult laryngoscopic view corresponding to Grades III–IV.

**Table 1: Demographic and Clinical Characteristics According to Laryngoscopic View**

The mean age of the overall study population was 44.82 ± 11.69 years. Patients with easy laryngoscopy had a mean age of 43.80 ± 11.70 years, whereas those with difficult laryngoscopy had a higher mean age of 49.90 ± 10.60 years; however, the difference was not statistically significant (p=0.068). The overall mean BMI was 25.43 ± 3.48 kg/m². The mean BMI was significantly higher among patients with difficult laryngoscopy compared with those with easy laryngoscopy (28.10 ± 3.70 vs. 24.90 ± 3.20 kg/m²; p=0.008). Of the 84 patients, 46 (54.76%) were males and 38 (45.24%) were females. Among patients with easy laryngoscopy, 36 (51.43%) were males and 34 (48.57%) were females, whereas the difficult laryngoscopy group included 10 (71.43%) males and 4 (28.57%) females. The difference in sex distribution was not statistically significant (p=0.242).

Regarding ASA physical status, 35 (41.67%) patients belonged to ASA I, 38 (45.24%) to ASA II, and 11 (13.10%) to ASA III. Among patients with easy laryngoscopy, 32 (45.71%) were ASA I, 31 (44.29%) were ASA II, and 7 (10.00%) were ASA III. In the difficult laryngoscopy group, 3 (21.43%) were ASA I, 7 (50.00%) were ASA II, and 4 (28.57%) were ASA III. The difference in ASA physical status distribution between the groups was not statistically significant (p=0.090). A history of snoring or obstructive sleep apnoea was present in 15 (17.86%) patients overall, including 9 (12.86%) patients with easy laryngoscopy and 6 (42.86%) patients with difficult laryngoscopy, and this difference was statistically significant (p=0.016). Previous difficult intubation was reported in 3 (3.57%) patients, comprising 1 (1.43%) patient in the easy group and 2 (14.29%) patients in the difficult group; the difference did not reach statistical significance (p=0.071).

**Table 2: Comparison of Preoperative Airway Predictors Between Easy and Difficult Laryngoscopy**

The mean inter-incisor gap in the overall study population was 4.26 ± 0.70 cm. It was 4.42 ± 0.61 cm among patients with easy laryngoscopy and 3.46 ± 0.58 cm among those with difficult laryngoscopy, with a statistically significant difference (p<0.001). The overall mean thyromental distance was 7.03 ± 0.82 cm, being 7.21 ± 0.72 cm in the easy group and 6.12 ± 0.70 cm in the difficult group (p<0.001). Similarly, the mean sternomental distance was 13.97 ± 1.67 cm overall, 14.32 ± 1.48 cm in patients with easy laryngoscopy, and 12.19 ± 1.43 cm in patients with difficult laryngoscopy, with the difference being statistically significant (p<0.001).

The mean neck circumference was 37.93 ± 3.93 cm in the total population. Patients with difficult laryngoscopy had a mean neck circumference of 41.68 ± 3.71 cm compared with 37.18 ± 3.54 cm among patients with easy laryngoscopy, and the difference was statistically significant (p<0.001). Mean neck extension was 85.93 ± 10.13° overall, with a mean of 88.40 ± 8.20° in the easy group and 73.60 ± 10.10° in the difficult group (p<0.001).

Modified Mallampati Class III–IV was present in 23 (27.38%) patients overall. It was observed in 12 (17.14%) patients with easy laryngoscopy and 11 (78.57%) patients with difficult laryngoscopy (p<0.001). An inter-incisor gap <3.5 cm was present in 16 (19.05%) patients, including 8 (11.43%) in the easy group and 8 (57.14%) in the difficult group (p<0.001). Thyromental distance <6.5 cm was recorded in 20 (23.81%) patients, comprising 10 (14.29%) patients with easy laryngoscopy and 10 (71.43%) with difficult laryngoscopy (p<0.001). Sternomental distance <12.5 cm was observed in 22 (26.19%) patients, including 13 (18.57%) patients in the easy group and 9 (64.29%) patients in the difficult group (p=0.001).

A neck circumference >40 cm was noted in 24 (28.57%) patients overall, including 15 (21.43%) with easy laryngoscopy and 9 (64.29%) with difficult laryngoscopy, with a statistically significant difference (p=0.003). Upper lip bite test Class III was present in 12 (14.29%) patients, of whom 5 (7.14%) belonged to the easy laryngoscopy group and 7 (50.00%) to the difficult laryngoscopy group (p<0.001). Restricted cervical mobility was present in 14 (16.67%) patients, including 7 (10.00%) in the easy group and 7 (50.00%) in the difficult group (p=0.001).

**Table 3: Cormack–Lehane Grade and Airway Management Characteristics**

Among the 84 patients, Cormack–Lehane Grade I was recorded in 41 (48.81%) patients and Grade II in 29 (34.52%) patients. These 70 patients constituted the easy laryngoscopy group. Grade III was observed in 12 (14.29%) patients and Grade IV in 2 (2.38%) patients, together accounting for 14 (16.67%) patients with difficult laryngoscopy. Within the difficult laryngoscopy group, 12 (85.71%) patients had Grade III and 2 (14.29%) had Grade IV views.

Successful endotracheal intubation on the first attempt was achieved in 69 (82.14%) patients overall. First-attempt success was recorded in 66 (94.29%) patients with easy laryngoscopy compared with only 3 (21.43%) patients with difficult laryngoscopy, and the difference was statistically significant (p<0.001). Two or more intubation attempts were required in 15 (17.86%) patients overall, including 4 (5.71%) patients in the easy group and 11 (78.57%) in the difficult group (p<0.001).

External laryngeal manipulation was required in 21 (25.00%) patients, comprising 11 (15.71%) patients with easy laryngoscopy and 10 (71.43%) patients with difficult laryngoscopy (p<0.001). A bougie was required in 10 (11.90%) patients overall, including 3 (4.29%) patients in the easy group and 7 (50.00%) patients in the difficult group (p<0.001). Video laryngoscopy was required in 3 (3.57%) patients, all belonging to the difficult laryngoscopy group, representing 21.43% of this group (p=0.004). Mucosal trauma occurred in 4 (4.76%) patients, including 1 (1.43%) patient with easy laryngoscopy and 3 (21.43%) patients with difficult laryngoscopy (p=0.014). Transient oxygen desaturation occurred in 2 (2.38%) patients, both of whom belonged to the difficult laryngoscopy group, accounting for 14.29% of that group (p=0.026).

**Table 4: Diagnostic Performance of Preoperative Difficult Airway Predictors**

Modified Mallampati Class III–IV showed a sensitivity of 78.57%, specificity of 82.86%, positive predictive value of 47.83%, negative predictive value of 95.08%, and overall diagnostic accuracy of 82.14% for identifying difficult laryngoscopy. An inter-incisor gap <3.5 cm demonstrated a sensitivity of 57.14%, specificity of 88.57%, positive predictive value of 50.00%, negative predictive value of 91.18%, and diagnostic accuracy of 83.33%. Thyromental distance <6.5 cm showed a sensitivity of 71.43%, specificity of 85.71%, positive predictive value of 50.00%, negative predictive value of 93.75%, and diagnostic accuracy of 83.33%.

Sternomental distance <12.5 cm demonstrated a sensitivity of 64.29%, specificity of 81.43%, positive predictive value of 40.91%, negative predictive value of 91.94%, and diagnostic accuracy of 78.57%. Neck circumference >40 cm had a sensitivity of 64.29%, specificity of 78.57%, positive predictive value of 37.50%, negative predictive value of 91.67%, and diagnostic accuracy of 76.19%. Upper lip bite test Class III showed a sensitivity of 50.00% and specificity of 92.86%, with a positive predictive value of 58.33%, negative predictive value of 90.28%, and the highest diagnostic accuracy of 85.71%. Restricted cervical mobility demonstrated a sensitivity of 50.00%, specificity of 90.00%, positive predictive value of 50.00%, negative predictive value of 90.00%, and overall diagnostic accuracy of 83.33%.

**Table 5: ROC Curve and Multivariable Logistic Regression Analysis of Difficult Airway Predictors**

Receiver operating characteristic curve analysis was performed for continuous airway parameters. The inter-incisor gap at a cut-off of ≤3.5 cm had an area under the curve of 0.873 with a 95% confidence interval of 0.750–0.996, and the result was statistically significant ($p<0.001$). Thyromental distance at a cut-off of <6.5 cm showed an AUC of 0.861 (95% CI: 0.734–0.988; $p<0.001$). Sternomental distance at a cut-off of <12.5 cm had an AUC of 0.850 (95% CI: 0.719–0.981; $p<0.001$). Neck circumference at a cut-off of >40 cm demonstrated an AUC of 0.810 (95% CI: 0.667–0.953; $p<0.001$), whereas neck extension at a cut-off of ≤80° showed an AUC of 0.872 (95% CI: 0.749–0.995; $p<0.001$).

On multivariable binary logistic regression analysis, Modified Mallampati Class III–IV had an adjusted odds ratio of 19.19 (95% CI: 2.63–139.90) and remained statistically significant ($p=0.004$). Neck circumference >40 cm showed an adjusted odds ratio of 12.66 (95% CI: 1.66–96.41; $p=0.014$). Thyromental distance <6.5 cm had an adjusted odds ratio of 8.69 (95% CI: 1.33–57.04; $p=0.024$), while upper lip bite test Class III had an adjusted odds ratio of 7.97 (95% CI: 1.04–60.99; $p=0.045$). These four variables remained statistically significant in the multivariable model.

**Table 1: Demographic and clinical characteristics according to laryngoscopic view**

| Parameter | Total (n=84) | Easy laryngoscopy (n=70) | Difficult laryngoscopy (n=14) | p-value |
|---|---|---|---|---|
| Age (years), mean ± SD | 44.82 ± 11.69 | 43.80 ± 11.70 | 49.90 ± 10.60 | 0.068 |
| BMI (kg/m²), mean ± SD | 25.43 ± 3.48 | 24.90 ± 3.20 | 28.10 ± 3.70 | **0.008** |
| Male | 46 (54.76%) | 36 (51.43%) | 10 (71.43%) | 0.242 |
| Female | 38 (45.24%) | 34 (48.57%) | 4 (28.57%) | |
| ASA physical status I | 35 (41.67%) | 32 (45.71%) | 3 (21.43%) | 0.090 |
| ASA physical status II | 38 (45.24%) | 31 (44.29%) | 7 (50.00%) | |
| ASA physical status III | 11 (13.10%) | 7 (10.00%) | 4 (28.57%) | |
| History of snoring/OSA | 15 (17.86%) | 9 (12.86%) | 6 (42.86%) | **0.016** |
| Previous difficult intubation | 3 (3.57%) | 1 (1.43%) | 2 (14.29%) | 0.071 |

**Table 2: Comparison of preoperative airway predictors between easy and difficult laryngoscopy**

| Airway parameter | Total (n=84) | Easy laryngoscopy (n=70) | Difficult laryngoscopy (n=14) | p-value |
|---|---|---|---|---|
| Inter-incisor gap (cm), mean ± SD | 4.26 ± 0.70 | 4.42 ± 0.61 | 3.46 ± 0.58 | **<0.001** |
| Thyromental distance (cm), mean ± SD | 7.03 ± 0.82 | 7.21 ± 0.72 | 6.12 ± 0.70 | **<0.001** |
| Sternomental distance (cm), mean ± SD | 13.97 ± 1.67 | 14.32 ± 1.48 | 12.19 ± 1.43 | **<0.001** |
| Neck circumference (cm), mean ± SD | 37.93 ± 3.93 | 37.18 ± 3.54 | 41.68 ± 3.71 | **<0.001** |
| Neck extension (degrees), mean ± SD | 85.93 ± 10.13 | 88.40 ± 8.20 | 73.60 ± 10.10 | **<0.001** |
| Modified Mallampati Class III–IV | 23 (27.38%) | 12 (17.14%) | 11 (78.57%) | **<0.001** |
| Inter-incisor gap <3.5 cm | 16 (19.05%) | 8 (11.43%) | 8 (57.14%) | **<0.001** |
| Thyromental distance <6.5 cm | 20 (23.81%) | 10 (14.29%) | 10 (71.43%) | **<0.001** |
| Sternomental distance <12.5 cm | 22 (26.19%) | 13 (18.57%) | 9 (64.29%) | **0.001** |
| Neck circumference >40 cm | 24 (28.57%) | 15 (21.43%) | 9 (64.29%) | **0.003** |
| Upper lip bite test Class III | 12 (14.29%) | 5 (7.14%) | 7 (50.00%) | **<0.001** |
| Restricted cervical mobility | 14 (16.67%) | 7 (10.00%) | 7 (50.00%) | **0.001** |

Table 3: Cormack–Lehane grade and airway management characteristics

| Parameter | Total (n=84) | Easy laryngoscopy (n=70) | Difficult laryngoscopy (n=14) | p-value |
|---|---|---|---|---|
| Cormack–Lehane Grade I | 41 (48.81%) | 41 (58.57%) | 0 (0.00%) | — |
| Cormack–Lehane Grade II | 29 (34.52%) | 29 (41.43%) | 0 (0.00%) | — |
| Cormack–Lehane Grade III | 12 (14.29%) | 0 (0.00%) | 12 (85.71%) | — |
| Cormack–Lehane Grade IV | 2 (2.38%) | 0 (0.00%) | 2 (14.29%) | — |
| Successful intubation at first attempt | 69 (82.14%) | 66 (94.29%) | 3 (21.43%) | **<0.001** |
| ≥2 intubation attempts | 15 (17.86%) | 4 (5.71%) | 11 (78.57%) | **<0.001** |
| External laryngeal manipulation required | 21 (25.00%) | 11 (15.71%) | 10 (71.43%) | **<0.001** |
| Bougie required | 10 (11.90%) | 3 (4.29%) | 7 (50.00%) | **<0.001** |
| Video laryngoscope required | 3 (3.57%) | 0 (0.00%) | 3 (21.43%) | **0.004** |
| Mucosal trauma | 4 (4.76%) | 1 (1.43%) | 3 (21.43%) | **0.014** |
| Transient oxygen desaturation | 2 (2.38%) | 0 (0.00%) | 2 (14.29%) | **0.026** |

Table 4: Diagnostic performance of preoperative difficult airway predictors

| Predictor | Sensitivity (%) | Specificity (%) | PPV (%) | NPV (%) | Diagnostic accuracy (%) |
|---|---|---|---|---|---|
| **Modified Mallampati Class III–IV** | 78.57 | 82.86 | 47.83 | 95.08 | 82.14 |
| **Inter-incisor gap <3.5 cm** | 57.14 | 88.57 | 50.00 | 91.18 | 83.33 |
| **Thyromental distance <6.5 cm** | 71.43 | 85.71 | 50.00 | 93.75 | 83.33 |
| **Sternomental distance <12.5 cm** | 64.29 | 81.43 | 40.91 | 91.94 | 78.57 |
| **Neck circumference >40 cm** | 64.29 | 78.57 | 37.50 | 91.67 | 76.19 |
| **Upper lip bite test Class III** | 50.00 | 92.86 | 58.33 | 90.28 | 85.71 |
| **Restricted cervical mobility** | 50.00 | 90.00 | 50.00 | 90.00 | 83.33 |

Table 5: ROC curve and multivariable logistic regression analysis of difficult airway predictors

| Predictor | Cut-off | AUC (95% CI) | ROC p-value | Adjusted OR (95% CI) | Regression p-value |
|---|---|---|---|---|---|
| Inter-incisor gap | ≤3.5 cm | 0.873 (0.750–0.996) | **<0.001** | — | — |
| Thyromental distance | <6.5 cm | 0.861 (0.734–0.988) | **<0.001** | 8.69 (1.33–57.04) | **0.024** |
| Sternomental distance | <12.5 cm | 0.850 (0.719–0.981) | **<0.001** | — | — |
| Neck circumference | >40 cm | 0.810 (0.667–0.953) | **<0.001** | 12.66 (1.66–96.41) | **0.014** |
| Neck extension | ≤80° | 0.872 (0.749–0.995) | **<0.001** | — | — |
| Modified Mallampati Class III–IV | — | — | — | 19.19 (2.63–139.90) | **0.004** |
| Upper lip bite test Class III | — | — | — | 7.97 (1.04–60.99) | **0.045** |

## DISCUSSION

In the present study, difficult laryngoscopy, defined as Cormack–Lehane Grades III–IV, was observed in 14 of 84 patients (16.67%), while 70 (83.33%) had an easy laryngoscopic view. Grade III accounted for 12 (14.29%) cases and Grade IV for 2 (2.38%) cases. The observed incidence was moderately higher than that reported by Panjiar et al. (2019), who prospectively evaluated 550 patients undergoing elective surgery and found difficult laryngoscopy in 55 patients (10.00%). Their study also used Cormack–Lehane grading and identified Grade III–IV views as difficult laryngoscopy. Thus, although the incidence differed numerically, both studies demonstrated that a clinically relevant proportion of apparently routine elective patients could exhibit a difficult laryngoscopic view.[7] In the present study, the mean age was higher in patients with difficult laryngoscopy than in those with easy laryngoscopy (49.90 ± 10.60 vs. 43.80 ± 11.70 years), although this difference did not reach statistical significance (p=0.068). Male sex was also more frequent in the difficult group (71.43% vs. 51.43%; p=0.242). In contrast, BMI was significantly higher in the difficult group (28.10 ± 3.70 vs. 24.90 ± 3.20 kg/m²; p=0.008), while a history of snoring/OSA was present in 42.86% of difficult cases compared with 12.86% of easy cases (p=0.016). Prakash et al. (2013) evaluated 330 Indian adults and reported difficult laryngoscopy in 9.7% and difficult intubation in 4.5%. Increasing age and weight, male sex and history of snoring were significantly associated with difficult laryngoscopy on univariate analysis, while snoring remained an independent predictor on multivariable analysis. Their findings regarding weight and snoring were therefore comparable with the significant BMI and snoring associations observed in the present study.[8] Several anatomical airway measurements differed significantly between the two groups in the present study. The mean inter-incisor gap was 3.46 ± 0.58 cm in patients with difficult laryngoscopy compared with 4.42 ± 0.61 cm in those with easy laryngoscopy (p<0.001).

Similarly, the mean thyromental distance was 6.12 ± 0.70 versus 7.21 ± 0.72 cm ($p<0.001$), and the sternomental distance was 12.19 ± 1.43 versus 14.32 ± 1.48 cm ($p<0.001$). An inter-incisor gap <3.5 cm and thyromental distance <6.5 cm were present in 57.14% and 71.43% of difficult cases, respectively. Merah et al. (2005) studied 380 patients and found difficult laryngeal visualization in 13 (3.4%). They reported sensitivity/specificity values of 61.5%/98.4% for the modified Mallampati test, 15.4%/98.1% for thyromental distance and 30.8%/97.3% for inter-incisor gap. A combination of modified Mallampati test, thyromental distance and inter-incisor gap increased sensitivity to 84.6% while maintaining a specificity of 94.6%, demonstrating the importance of considering several anatomical measurements together.[9] Neck-related measurements also showed marked differences in the present study. Mean neck circumference was significantly greater in patients with difficult laryngoscopy (41.68 ± 3.71 cm) than in those with easy laryngoscopy (37.18 ± 3.54 cm; $p<0.001$), while neck circumference >40 cm was present in 64.29% versus 21.43% of patients, respectively ($p=0.003$). Modified Mallampati Class III–IV was similarly much more frequent in difficult than easy laryngoscopy (78.57% vs. 17.14%; $p<0.001$). Brodsky et al. (2002) evaluated 100 morbidly obese patients with BMI >40 kg/m² and found that large neck circumference and high Mallampati score were the principal predictors of potential intubation difficulty, whereas absolute obesity and BMI alone were not significantly associated with intubation difficulty. Direct laryngoscopy successfully achieved tracheal intubation in all but one of their 100 patients. These findings correspond with the strong associations of increased neck circumference and higher Mallampati class observed in the present study, although BMI itself was also significantly associated with difficult laryngoscopy in our patients.[10] The upper lip bite test also showed a significant relationship with laryngoscopic difficulty in the present study. ULBT Class III was observed in 7 of 14 patients (50.00%) with difficult laryngoscopy compared with only 5 of 70 (7.14%) patients with easy laryngoscopy ($p<0.001$). As a diagnostic test, ULBT Class III demonstrated 50.00% sensitivity, 92.86% specificity, 58.33% positive predictive value, 90.28% negative predictive value and 85.71% overall accuracy. Khan et al. (2003), in their prospective blinded study of 300 patients, reported difficult laryngoscopy in 17 patients (5.7%). For the ULBT, they reported an accuracy of 88.0%, sensitivity of 76.5%, specificity of 88.7%, PPV of 28.9% and NPV of 98.4%. Compared with their findings, the present study showed lower sensitivity (50.00% vs. 76.5%) but slightly higher specificity (92.86% vs. 88.7%) and PPV (58.33% vs. 28.9%), while overall accuracy was relatively comparable (85.71% vs. 88.0%).[11] The difficulty in obtaining an adequate laryngoscopic view was also reflected in the intubation characteristics. In the present study, first-attempt intubation was successful in 82.14% of all patients, but the rate was markedly lower in difficult than easy laryngoscopy (21.43% vs. 94.29%; $p<0.001$). Two or more attempts were required in 78.57% of difficult cases compared with 5.71% of easy cases ($p<0.001$). External laryngeal manipulation was required in 71.43% of difficult cases, while a bougie was needed in 50.00%. Rao et al. (2018) analysed 316 patients and recorded difficult laryngoscopy in 26 (8.2%) using Cormack–Lehane Grade IIb or higher as their definition. Single-attempt intubation was achieved in 303 of 316 patients (95.89%), while 13 (4.11%) required a second attempt. A bougie or stylet was required in 23 of the 26 difficult laryngoscopies (88.46%), and external BURP manipulation improved the laryngoscopic view in 8 of 26 (30.77%). Thus, both studies showed increased requirements for adjuncts and manoeuvres when the laryngoscopic view was difficult.[12] Regarding the diagnostic performance of bedside airway tests, modified Mallampati Class III–IV in the present study demonstrated a sensitivity of 78.57%, specificity of 82.86%, PPV of 47.83%, NPV of 95.08% and diagnostic accuracy of 82.14%. Thyromental distance <6.5 cm demonstrated sensitivity and specificity of 71.43% and 85.71%, respectively, whereas the ULBT had lower sensitivity (50.00%) but higher specificity (92.86%). Shah et al. (2013) prospectively evaluated 480 adults and reported that ULBT had a sensitivity of 74.63%, specificity of 91.53%, PPV of 58.82% and NPV of 95.70%. In the same study, the ratio of height to thyromental distance demonstrated sensitivity of 71.64%, specificity of 92.01%, PPV of 59.26% and NPV of 95.24%. The specificity and PPV reported for ULBT by Shah et al. were close to the present values of 92.86% and 58.33%, respectively, although their sensitivity and NPV were higher than the corresponding values of 50.00% and 90.28% observed in the present study.[13] ROC analysis in the present study demonstrated good discriminatory ability for several continuous airway measurements. The AUC was 0.873 for inter-incisor gap ≤3.5 cm, 0.872 for neck extension ≤80°, 0.861 for thyromental distance <6.5 cm, 0.850 for sternomental distance <12.5 cm and 0.810 for neck circumference >40 cm, with all ROC analyses showing $p<0.001$. On multivariable analysis, modified Mallampati Class III–IV showed the highest adjusted odds ratio of 19.19 (95% CI: 2.63–139.90; $p=0.004$), followed by neck circumference >40 cm with an adjusted OR of 12.66 (95% CI: 1.66–96.41; $p=0.014$), thyromental distance <6.5 cm with an OR of 8.69 (95% CI: 1.33–57.04; $p=0.024$), and ULBT Class III with an OR of 7.97 (95% CI: 1.04–60.99; $p=0.045$). Krobbuaban et al. (2005) studied 550 patients and found difficult laryngoscopy in 69 (12.5%). Their multivariable analysis identified RHTMD ≥23.5, Mallampati Class III–IV and neck movement ≤80° as independent predictors, with odds ratios of 6.72

(95% CI: 3.29–13.72), 2.96 (95% CI: 1.63–5.35) and 2.73 (95% CI: 1.14–6.51), respectively. Their multivariable findings, particularly for Mallampati grade and restricted neck movement, were consistent with the significant contribution of multiple preoperative airway characteristics demonstrated in the present analysis.[14]

## CONCLUSION

Difficult laryngoscopy was observed in a notable proportion of patients undergoing general anaesthesia. Modified Mallampati Class III–IV, reduced thyromental distance, increased neck circumference, upper lip bite test Class III, and restricted neck mobility were significantly associated with a difficult laryngoscopic view. Among these, modified Mallampati class showed the strongest independent association. A combined preoperative airway assessment using multiple predictors may improve identification of patients at risk of difficult laryngoscopy and facilitate safer airway planning.

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