

# AIRWAY ASSESSMENT : PREDICTORS OF DIFFICULT AIRWAY

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## Introduction

Expertise in airway management is essential in every medical speciality. Maintaining a patent airway is essential for adequate oxygenation and ventilation and failure to do so, even for a brief period of time, can be life threatening.

Respiratory events are the most common anaesthetic related injuries, following dental damage. The three main causes of respiratory related injuries are inadequate ventilation, oesophageal intubation and difficult tracheal intubation. Difficult tracheal intubation accounts for 17% of the respiratory related injuries and results in significant morbidity and mortality. In fact up to 28% of all anaesthesia related deaths are secondary to the inability to mask ventilate or intubate.<sup>1</sup>

The term 'airway' in its day-to-day usage refers to the upper airway which may be defined as the extrapulmonary air passage, consisting of the nasal and oral cavities, pharynx, larynx, trachea and large bronchi. 'Difficult airway' is one in which there is a problem in establishing or maintaining gas exchange via a mask, an artificial airway or both. Recognizing before anaesthesia, the potential for a difficult airway (DA) in designated 'Difficult airway clinics' allows time for optimal preparation, proper selection of equipment and technique and participation of personnel experienced in DA management.

## Assessment

Assessment of difficult airway in patients begins with a comprehensive history and physical examination.

I. **History** : Medical, surgical or anaesthetic factors may be indicative of a difficult airway (DA). Some of the airway compromising conditions are given in table 1. Anaesthetic factors which could predispose to a DA are oedema, burns, bleeding, tracheal/oesophageal stenosis, compression or perforation, pneumothorax or aspiration of gastric contents.

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**Table - 1 : Airway-compromising conditions**

<b>Congenital :</b>	
Pierre-Robin syndrome	Micrognathia, macroglossia, cleft soft palate
Treacher-Collins syndrome	Auricular and ocular defects, malar and mandibular hypoplasia
Goldenhar's syndrome	Auricular and ocular defects, malar and mandibular hypoplasia
Down's syndrome	Poorly developed or absent bridge of the nose, macroglossia
Kippel-Feil syndrome	Congenital fusion of a variable number of cervical vertebrae, restriction of neck movement
Goiter	Compression of trachea, deviation of larynx/trachea
<b>Acquired :</b>	
<b>Infections:</b>	
Supraglottis	Laryngeal oedema
Croup	Laryngeal oedema
Abscess (intraoral, retropharyngeal)	Distortion of the airway and trismus
Ludwig's angina	Distortion of the airway and trismus
<b>Arthritis:</b>	
Rheumatoid arthritis	Temporomandibular joint ankylosis, cricoarytenoid arthritis, deviation of larynx, restricted mobility of cervical spine
Ankylosing spondylitis	Ankylosis of cervical spine, less commonly ankylosis of temporomandibular joints, lack of mobility of cervical spine
<b>Benign tumors:</b>	
Cystic hygroma, lipoma, adenoma, goiter	Stenosis or distortion of the airway, fixation of larynx or adjacent tissues secondary to infiltration or fibrosis from irradiation
Malignant tumor, Facial injury, cervical spine injury, laryngeal/tracheal trauma	Edema of the airway, hematoma, unstable fraction(s) of the maxillae, mandible and cervical vertebrae.
<b>Obesity</b>	Short thick neck, redundant tissue in the oropharynx, sleep apnea
<b>Acromegaly</b>	Macroglossia, prognathism
<b>Acute burns</b>	Oedema of airway

## II. General, physical and regional examination :

A global assessment should include the following:

- i. Patency of nares : look for masses inside nasal cavity (e.g. polyps) deviated nasal septum, etc.
- ii. Mouth opening of at least 2 large finger breadths between upper and lower incisors in adults is desirable.

- iii. Teeth : Prominent upper incisors, or canines with or without overbite, can impose a limitation on alignment of oral or pharyngeal axes during laryngoscopy and especially in association with a large base of tongue, they can compound the difficulty during the direct laryngoscopy or bag-mask ventilation. An edentulous state, on the other hand, can render axis alignment easier but hypopharyngeal obstruction by the tongue can occur.
- iv. Palate : A high arched palate or a long, narrow mouth may present difficulty.
- v. Assess patient's ability to protrude the lower jaw beyond the upper incisors (Prognathism).
- vi. Temporomandibular joint movement : It can be restricted ankylosis/fibrosis, tumors, etc.
- vii. Measurement of submental space (hyomental/thyromental length should ideally be > 6 cm).
- viii. Observation of patient's neck : A short, thick neck is often associated with difficult intubation. Any masses in neck, extension of neck, neck mobility and ability to assume 'sniffing' position should be observed.
- ix. Presence of hoarse voice/stridor or previous tracheostomy may suggest stenosis.
- x. Any systemic or congenital disease requiring special attention during airway management (e.g. respiratory failure, significant coronary artery disease, acromegaly, etc.).
- xi. General assessment of body habitus can yield important information.
- xii. Infections of airway (e.g. epiglottitis, abscess, croup, bronchitis, pneumonia).
- xiii. Physiologic conditions : Pregnancy and obesity.

It is also important to recognize the 'difficult-to-mask ventilate' patient as mask ventilation is of paramount importance. Several specific factors are – (i) Presence of beard : Difficulty in creating proper seal with a mask/possibly some underlying abnormality e.g. disfiguring malignancy of jaw, (ii) Body mass index : Patients with BMI > 26 kgm<sup>-2</sup> may be difficult to mask ventilate, (iii) Lack of teeth: Difficult to establish effective seal, (iv) Age and snoring : Patients older than 55 years with history of snoring are probably associated with varying degrees of obstructive sleep apnea and are difficult to mask ventilate, (v) Jewellery worn by piercing of lips, tongue, cheek, chin, eye brows and ear may also create difficulty in mask ventilation.

### III. Specific tests for assessment

#### A. Anatomical criteria

##### 1. Relative to tongue/pharyngeal size

**Mallampatti test<sup>2</sup>** : The Mallampati classification correlates tongue size to pharyngeal size. This test is performed with the patient in the sitting position, head in a neutral position, the mouth wide open and the tongue protruding to its maximum. Patient should not be actively encouraged to phonate as it can result in contraction and elevation of the soft palate leading to a spurious picture. Classification is assigned according to the extent the base of tongue is able to mask the visibility of pharyngeal structures into three classes: (fig. 1)

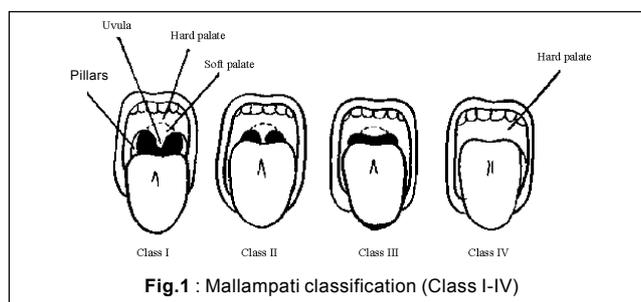


Fig.1 : Mallampati classification (Class I-IV)

**Class I** : Visualization of the soft palate, fauces; uvula, anterior and the posterior pillars.

**Class II** : Visualization of the soft palate, fauces and uvula.

**Class III** : Visualization of soft palate and base of uvula.

In Samssoon and Young's modification (1987)<sup>3</sup> of the Mallampati classification, a IV class was added.

**Class IV**: Only hard palate is visible. Soft palate is not visible at all.

To avoid false positive or false negative, this test should be repeated twice. Since its not possible to measure the size of the posterior part of the tongue relative to the capacity of the oropharynx, this method of assessment gives an indirect means of evaluating their relative proportionality. If the base of the tongue is proportional to the oropharynx then provided there are no other disturbing factors, the exposure of the glottic inlet will not be difficult. On the other hand, a disproportionately large base of the tongue overshadows the larynx and perhaps makes the angle between the two more acute, preventing easy exposure of the larynx.<sup>4</sup>

##### 2. Atlanto occipital joint (AO) extension :

It assesses feasibility to make sniffing or Magill position for intubation i.e. alignment of oral, pharyngeal

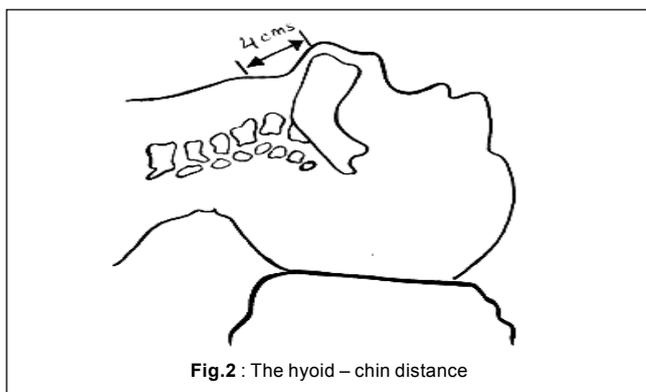
and laryngeal axes into an arbitrary straight line. The patient is asked to hold head erect, facing directly to the front, then he is asked to extend the head maximally and the examiner estimates the angle traversed by the occlusal surface of upper teeth. Measurement can be by simple visual estimate or more accurately with a goniometer. Any reduction in extension is expressed in grades:

- Grade I : >35°
- Grade II : 22°-34°
- Grade III : 12°-21°
- Grade IV : < 12°

Normal angle of extension is 35° or more<sup>5,6</sup>

**3. Mandibular space**

- i. **Thyromental (T-M) distance (Patil's test)<sup>7</sup>:** It is defined as the distance from the mentum to the thyroid notch while the patient's neck is fully extended. This measurement helps in determining how readily the laryngeal axis will fall in line with the pharyngeal axis when the atlanto-occipital joint is extended. Alignment of these two axes is difficult if the T-M distance is < 3 finger breadths or < 6 cm in adults; 6-6.5 cm is less difficult, while > 6.5 cm is normal.
- ii. **Sterno-mental distance :** Savva (1948)<sup>8</sup> estimated the distance from the suprasternal notch to the mentum and investigated its possible correlation with Mallampati class, jaw protrusion, interincisor gap and thyromental distance. It was measured with the head fully extended on the neck with the mouth closed. A value of less than 12 cm is found to predict a difficult intubation.
- iii. **Mandibulo-hyoid distance (fig. 2)<sup>9</sup> :** Measurement of mandibular length from chin (mental) to hyoid should be at least 4 cm or three finger breadths. It was found that laryngoscopy became more difficult as the vertical distance between the mandible and hyoid bone increased.



- iv. **Inter-incisor distance :** It is the distance between the upper and lower incisors. Normal is 4.6 cm or more; while > 3.8 cm predicts difficult airway.

Wilson and colleagues<sup>10</sup> developed another scoring system in which they took 5 variables – weight, head, neck and jaw movements, mandibular recession, presence or absence of buck teeth. Risk score was developed between 0 to 10. They found that higher the risk score, greater the accuracy of prediction with a lower proportion of false positives.

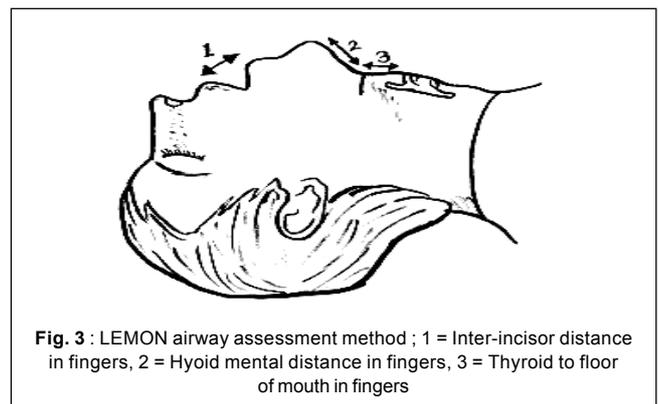
Ame and colleagues<sup>11</sup> produced a new scoring system based on multifactorial analysis. Apart from the above indicators by Wilson et al, it also included presence or absence of overt airway pathology. The sensitivity and specificity levels of this system was above 90%.

**LEMON airway assessment method (fig. 3)**

The score with a maximum of 10 points is calculated by assigning 1 point for each of the following LEMON criteria:

- L =** Look externally (facial trauma, large incisors, beard or moustache, large tongue)
- E =** Evaluate the 3-3-2 rule (incisor distance-3 finger breadths, hyoid-mental distance-3 finger breadths, thyroid-to-mouth distance-2 finger breadths)
- M =** Mallampati (Mallampati score ≥ 3).
- O =** Obstruction (presence of any condition like epiglottitis, peritonsillar abscess, trauma).
- N =** Neck mobility (limited neck mobility)

Patients in the difficult intubation group have higher LEMON scores.<sup>12,13</sup>



**B. Direct laryngoscopy and fibreoptic bronchoscopy**

Difficulty in intubation can be classified according to the view obtained during direct laryngoscopy into 4 grades. These 4 grades of laryngoscopic views were defined by Cormack and Lehane (1984)<sup>14</sup> (fig.4).

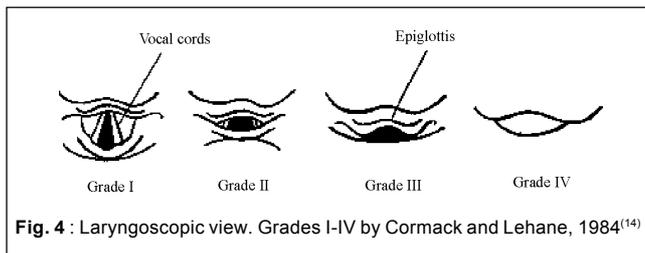


Fig. 4 : Laryngoscopic view. Grades I-IV by Cormack and Lehane, 1984<sup>(14)</sup>

**Grade I** – Visualization of entire laryngeal aperture.

**Grade II** – Visualization of only posterior commissure of laryngeal aperture.

**Grade III** – Visualization of only epiglottis.

**Grade IV** – Visualization of just the soft palate.

Grade III and IV predict difficult intubation.

An optimal position for alignment of axes of mouth, pharynx and larynx achieved by flexion of neck and extension of the head at the atlanto-occipital joint is very important.<sup>5,15</sup>

### C. Radiographic assessment (fig. 5)

1. From skeletal films<sup>16, 17, 18</sup>

Lateral cervical x-ray film of the patients with head in neutral position closed is required for the following measurement:

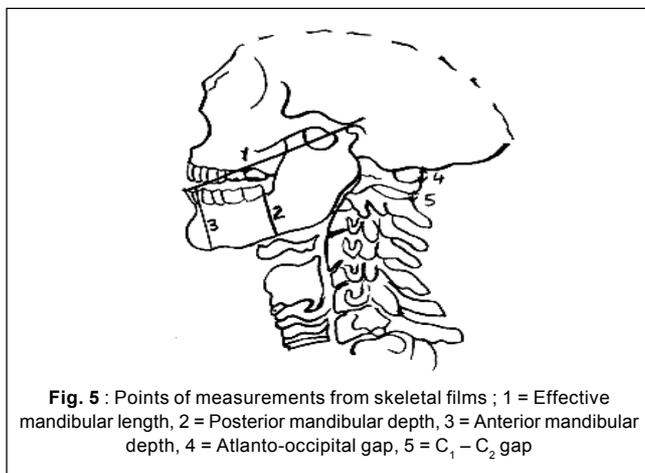


Fig. 5 : Points of measurements from skeletal films ; 1 = Effective mandibular length, 2 = Posterior mandibular depth, 3 = Anterior mandibular depth, 4 = Atlanto-occipital gap, 5 = C<sub>1</sub> – C<sub>2</sub> gap

i. **Mandibulo-hyoid distance** : An increase in the mandibulo-hyoid distance resulted in an increase in difficult laryngoscopy.<sup>9</sup>

ii. **Atlanto-occipital gap** : A-O gap is the major factor which limits the extension of head on neck. Longer the A-O gap, more space is available for mobility of head at that joint with good axis for laryngoscopy and intubation. Radiologically there is reduced space between C<sub>1</sub> and occiput.

iii. **Relation of mandibular angle and hyoid bone with cervical vertebra and laryngoscopy grading** : A definite increase in difficult laryngoscopy was observed when the mandibular angle tended to be more rostral and hyoid bone to be more caudal, position of mandibular angle being more important.

iv. **Anterior/Posterior depth of the mandible** : White and Kander (1975)<sup>18</sup> have shown that the posterior depth of the mandible i.e, the distance between the bony alveolus immediately behind the 3<sup>rd</sup> molar tooth and the lower border of the mandible is an important measure in determining the ease or difficulty of laryngoscopy.

v. **C<sub>1</sub>-C<sub>2</sub> gap**

Calcified stylohyoid ligaments are manifested by crease over hyoid bones on radiological examination. Laryngoscopy is difficult because of inability to lift the epiglottis from posterior pharyngeal wall as it is firmly attached to the hyoid bone by the hyo-epiglottic ligament.

2. Fluoroscopy for dynamic imaging (cord mobility, airway malacia, and emphysema).
3. Oesophagogram (inflammation, foreign body, extensive mass or vascular ring).
4. Ultrasonography (assessment of anterior mediastinal mass, lymphadenopathy, differentiates cyst from mass and cellulitis from abscess).
5. Computed tomography/MRI (congenital anomalies, vascular airway compression).
6. Video-optical intubation stylets (combines viewing capability with the familiar handling of intubation devices).

### D. Predictors of difficult airway in diabetics

Predictors of difficult airway are not the same in diabetics as in non-diabetic groups.

i. **Palm print**<sup>19,20</sup>: The patient is made to sit; palm and fingers of right hand are painted with blue ink, patient then presses the hand firmly against a white paper placed on a hard surface. It is categorized as:

**Grade 0** – All the phalangeal areas are visible.

**Grade 1** – Deficiency in the interphalangeal areas of the 4<sup>th</sup> and 5<sup>th</sup> digits.

**Grade 2** – Deficiency in interphalangeal areas of 2<sup>nd</sup> to 5<sup>th</sup> digits.

**Grade 3** – Only the tips of digits are seen.

ii. **Prayer sign**<sup>19,21</sup>: Patient is asked to bring both the palms together as 'Namaste' and sign is categorized as–

**Positive** – When there is gap between palms.

**Negative** – When there is no gap between palms.

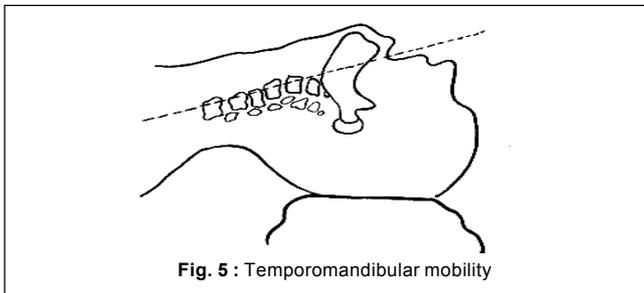
### E. Indicators of difficult intubation

The classic signs altering the operator to difficulty of intubation may be summarised as follows:

- Poor flexion–extension mobility of the head on neck.<sup>22,23</sup>
- A receding mandible and presence of prominent teeth.<sup>24</sup>
- A reduced atlanto-occipital distance, a reduced space between C1 and the occiput.<sup>18</sup>
- Large tongue size – related more to the ratio of the anterior length of the tongue to the length of the chin or mandible.<sup>3,25</sup>

### F. Six standards in the evaluation of airway

- Temporomandibular mobility (fig.6) – One finger
- Inspection of mouth, oropharynx – Mallampati classification (fig.1) – Two fingers
- Measurement of mento-hyoid distance (4 cm) in adult (fig.2) – Three fingers.
- Measurement of distance from chin to thyroid notch – (5 to 6 cm) (fig.3) – Four fingers
- Ability to flex head towards chest, extend head at atlanto-occipital junction and rotate head, turn right and left (five movements).
- Symmetry of nose and patency of nasal passage.



### G. Quick airway assessment

- Can the patient open the mouth widely?
  - Indicative of TM joint movement.
- Can the patient maximally protrude the tongue?
  - Inspects posterior aspect of mouth/pharyngeal structures.
- Patient's ability to move jaw forward?
  - Indicates ease to manoeuvre the laryngoscope.
- Can patient fully bend/extend the head and move it side wards?
  - Indicates neck movements.

For movement at A-O joint ask patient to place the chin on the chest, clasp both hands behind the neck, pull downwards and try to move head upwards.

### H. Assessment of paediatric airway

Assessment of difficult airway in paediatric patients, as in adults begins with a comprehensive history and physical examination.

**History :** Questions regarding complaints of snoring, apnoea, day time somnolence, stridor, hoarse voice and prior surgery or radiation treatment to face or neck should be made. This information may indicate hypoxemia and pulmonary hypertension. History should also consist of a review of previous anaesthetic records with attention being paid to history of oropharyngeal injury, damage to teeth, awake tracheal intubation or postponement of surgery following an anaesthetic.

**Physical examination :** It should focus on the anomalies of face, head, neck and spine.

- Evaluate size and shape of head, gross features of the face; size and symmetry of the mandible, presence of sub-mandibular pathology, size of tongue, shape of palate, prominence of upper incisors, range of motion of jaw, head and neck.
- The presence of retractions (suprasternal/sternal/ infrasternal/ intercostal) should be sought for they usually are signs of airway obstruction.
- Breath sounds – Crowing on inspiration is indicative of extrathoracic airway obstruction whereas, noise on exhalation is usually due to intrathoracic lesions. Noise on inspiration and expiration usually is due to a lesion at thoracic inlet.
- Obtaining blood gas and O<sub>2</sub> saturation is important to determine patient's ability to compensate for airway problems.
- Transcutaneous CO<sub>2</sub> determinations are very helpful in infants and young children.

Many investigators have attempted to develop methods that predict a difficult laryngoscopy in this age group. These methods have been primarily studied in adults and have variable sensitivity in children.

### Mallampati classification and cormack and lehane grading

Size of tongue relative to oral cavity and pharynx which is determined by Mallampati classification as described previously and its relation with the glottic view on laryngoscopy as determined by Cormack and Lehane was assessed by Kopp et al (1995).<sup>26</sup> Mallampati classification does not accurately predict a poor view of glottis during direct laryngoscopy in paediatric patients. Moreover, appropriate classification by Mallampati method is often hampered by a lack of cooperation in infants and young children. The mandibular space assessment is mainly suitable for older children as a predictor of difficult airway. Thus values for thyromental, hyomental and horizontal

mandibular lengths do not exist for the paediatric population. This places the paediatric anaesthesiologist at a disadvantage and increases the likelihood of being confronted with an unexpected DA. It underscores the need for a good history and importance for always being prepared for DA.

Several tests may be done to predict a difficult airway in children.<sup>27</sup>

- a. Plain radiography – For evaluation of nasopharynx, pharynx, subglottic lesion and trachea.
- b. CT scan and MRI can detect choanal atresia, lymphatic malformation of neck, mediastinal masses etc.
- c. Direct or indirect endoscopy of the upper and lower airway for functional assessment and diagnosis of a pathology in nasopharynx, supraglottic, glottic and subglottic areas.
- d. Fluoroscopy – For assessment of dynamic pathology e.g. airway malacia specially when stridor, cough and dysphagia are present.
- e. USG studies – To assist in evaluation of functional and organic airway disorders, assess the dynamic state of certain pathologies.
- f. Pulmonary function studies can provide valuable information about patency of airway passages.

Many medical, surgical conditions and congenital syndromes are associated with a difficult airway in both adults as well as paediatric patients. Techniques to assess the airway have primarily been studied in adults. Fewer predictive tests are available in children. Techniques useful in adults may not be applicable to infants and children and lack of cooperation significantly complicates gathering useful information in children.

### Conclusion

No single airway test can provide a high index of sensitivity and specificity for prediction of difficult airway. Therefore it has to be a combination of multiple tests. It must be recognized, however, that some patients with a difficult airway will remain undetected despite the most careful preoperative airway evaluation. Thus, anaesthesiologists must always be prepared with a variety of preformulated and practiced plans for airway management in the event of an unanticipated difficult airway.

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