

Original Article

A prospective study assessing the anatomical parameters of neck for predicting the difficult direct laryngoscopy in adult Indian population

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ABSTRACT

Introduction: Difficult airway is a calamitous incident as it can lead to airway or oesophageal mucosal tear, leading to aspiration, severe hypoxaemia and finally death. The aim of the study is to measure thyromental distance, sternomental distance, ratio of height to thyromental distance and neck circumference to anticipate difficult intubation as defined by Cormack-Lehane grading and to evaluate anatomical predictors of neck for difficult direct laryngoscopy in adult Indian population.

Methods: The study is conducted in Teerthankar Mahaveer Medical College & Research Centre, Moradabad for the period of one year on 200 patients undergoing general anaesthesia. Following parameters like Thyromental distance, Sternomental distance, Neck circumference and Ratio of height to thyromental distance were measured and prediction of difficult laryngoscopy was done by Cormack-Lehane grade.

Results: The cut-off points of neck parameters in both the genders in Indian population were TMD ≤ 9.7 / ≤ 7.6 cm, STMD ≤ 18.6 / ≤ 15.8 cm, NC ≥ 40.3 / ≥ 38.2 cm and RHTMD ≥ 18.2 cm / ≥ 21.5 cm. There was significant difference (p value <0.001) in all the parameters between the two genders. The Kappa values for TMD, STMD, NC and RHTMD are 0.7, 0.5, 0.72 and 0.45 respectively.

Discussion: TMD and NC has good agreement with kappa value of 0.7 and 0.72 respectively. STMD and RHTMD with kappa values of 0.57 and 0.45 (Moderate agreement) shows that they are not good predictors of difficult intubation.

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1. Introduction

Endotracheal intubation is an important technique to shelter the airway while sustaining ventilation and oxygenation of the patient. Difficult intubation is a foremost apprehension for the anesthetist. Unsuccessful endotracheal intubation is not an unusual occurrence. The unexpected hitches in the intubation can be a substantial etiological factor in morbidity and mortality in clinical practice.^{1,2} The frequency of difficult intubation is about 1.5–13% in patients undergoing surgical procedures.³ The problem of difficult intubation becomes more serious when it is unexpected. In Indian patients with apparently normal airways, incidence for difficult laryngoscopy and difficult intubation is about 9.7% and 4.5% respectively.⁴

Numerous bedside screening tests like Mallampati classification, mouth opening and upper lip bite test are being used to predict difficult laryngoscopy.^{5,6} But, all these methods need

assistance of the patient and thus cannot be done in unconscious patients.

Similar to Mallampati, Cormack and Lehane in 1983 proposed a different method of classifying difficult intubation, on the basis of view obtained in direct laryngoscopy into 4 grades.⁷ Intubation is considered as difficult in patients with a laryngoscopy view of Cormack-Lehane grade 3 or 4.⁸

Difficult airway is a calamitous incident as it can lead to airway or oesophageal mucosal tear, leading to aspiration, severe hypoxaemia and finally death.⁹ Oxygenation/ventilation - via various devices - is the primary goal in the management of emergency conditions. Tracheal intubation is the gold standard in securing the airway and ensuring optimal ventilation and oxygenation.¹⁰

But in developing country like India, various equipment are not available and the technical staff is not trained. So, various simple anthropometric parameters should be used to assess the airway of the patient.⁸

In the neck, skeletal element (Hyoid and thyroid cartilages) make essential landmarks which are used for measuring various parameters. In the receding angle below the chin, the hyoid bone,

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situated opposite the fourth cervical vertebra, can easily be made out. A finger's breadth below it is the laryngeal prominence of the thyroid cartilage; the space intervening between the hyoid bone and the thyroid cartilage is occupied by thyrohyoid membrane. The outlines of the thyroid cartilage are readily palpated; below its lower border is a depression corresponding to the middle cricothyroid ligament. The level of the vocal folds corresponds to the middle of the anterior margin of the thyroid cartilage.¹¹ The anterior part of the cricoid cartilage forms an important landmark on the front of the neck; it lies opposite the sixth cervical vertebra, and indicates the junctions of pharynx with esophagus, and larynx with trachea. Below the cricoid cartilage the trachea can be felt, though it is only in thin subjects that the separate rings can be distinguished; as a rule there are seven or eight rings above the jugular notch of the sternum, and of these the second, third, and fourth are covered by the isthmus of the thyroid gland.¹²

In this study we evaluated certain anatomic features of neck that can be measured preoperatively with minimal patient cooperation and can be used to assess difficult intubation. Thyromental distance (TMD) indicates the mandibular space and ease of the alignment of laryngeal axis with the pharyngeal axis when the neck is extended for laryngoscopy.¹¹ Sternomental distance (SMD) indicates the head and neck mobility¹² which is required for better visualization during direct laryngoscopy. Ratio of height to thyromental distance has a good predictive value and is a comparable test, as an alternative to upper lip bite test for predicting difficult intubation.^{13,14} Neck circumference gives the idea of the amount of soft tissue and fat present. Increase amount of soft tissue/fat in obese patients raises the pressure on the pharynx since it is a collapsible structure, thus leading to difficult intubation.^{15,16}

The aim of the study is to measure thyromental distance, sternomental distance, ratio of height to thyromental distance and neck circumference to anticipate difficult intubation as defined by Cormack-Lehane grading and to evaluate anatomical predictors of neck for difficult direct laryngoscopy in adult Indian population.

2. Materials and methods

The study is conducted in Teerthanker Mahaveer Medical College & Research Centre, Moradabad for the period of one year on 200 patients undergoing general anaesthesia with tracheal intubation in routine planned surgery.

2.1. Pre-operative assessment

In order to avoid inter-observer variability, all the preoperative airway assessments is performed by the same person.

Pre-operative evaluation of all patients is done on a day before surgery on routine pre-anaesthetic visit in the hospital for routine non-emergency surgical procedures. Detailed history is taken particularly regarding airway difficulty with previous anaesthetic exposure, any disease either congenital, neoplastic or trauma that exists in the vicinity of the path to be followed by endotracheal tube.

History of disease and syndromes affecting other parts of body which have a component which may make intubation difficult like rheumatoid arthritis and acromegaly is also enquired. Thorough general physical examination in all patients is done which include patient's weight, height, pulse rate and blood pressure. Patients will be specifically examined for patency of nostrils, shortness of neck, maxillary overgrowth, micrognathia, macroglossia, swelling or growth, condition of the teeth and cervical spine mobility by flexion-extension and side to side movement.

Systemic examination particularly of cardiovascular and respiratory system is done. After evaluating Anaesthesia risk according to classification of American society of anaesthesiologists patients will be graded accordingly 1–4 grades.

2.2. Inclusion criteria

- Patients above the age of 18 years
- ASA physical status 1 and 2
- Patients requiring general anaesthesia with tracheal intubation in routine planned surgery

2.3. Exclusion criteria

- Patients with ASA grade III and IV
- Severe obesity (body mass index [BMI] more than 35 kg/m²)
- Patients with obvious adverse anatomical features like
 - Short neck
 - Large high arched palate
 - Receding mandible
 - Patients with pathological conditions in form of
 - TM joint ankylosis
 - Macroglossia
 - Micrognathia
 - Fracture of mandible, maxilla or cervical spine
 - Neoplasm of oropharynx
 - Restricted mouth opening

2.4. Pre-operative measurements of anatomical parameters

- 1 Thyromental distance(TMD) – It is measured as described by Patil et al.,¹⁷ measuring a straight line distance between thyroid notch to the bony point of the mentum, with the head fully extended and mouth closed.
- 2 Sternomental distance (STMD)¹⁸ - It is measured as a straight line from bony point of the mentum to the upper border of the manubrium sterni, with the head fully extended and mouth closed.
- 3 Neck circumference(NC)^{17,18} – It is measured at the level of thyroid cartilage with the head in neutral position
- 4 Height of patients is recorded to calculate ratio of height to thyromental distance (RHTMD).

In the operating room, the concerned anaesthesiologist is kept unaware about the pre-op airway assessment of the patient.

The laryngoscopic view is classified according to the Cormack-Lehane grading.²

- Grade 1- Full view of glottis visible
- Grade 2- Only posterior commissures of arytenoids visible
- Grade 3- Only epiglottis visible
- Grade 4- Not even epiglottis visible

Difficult laryngoscopy is defined as Cormack-Lehane grade view 3 or 4 under direct laryngoscopy without any external pressure or other manoeuvre applied.²

2.5. Data analysis

Different parameters were studied by analysing the readings by using Student's 't' test and the p value <0.001 was considered as significant. The Cohen's Kappa (κ) coefficient was calculated to measure the level of agreement and thus identify which is the better parameter (transverse diameter / height) for sexual dimorphism.

$$K = \frac{\text{Pr}(a) - \text{Pr}(e)}{1 - \text{Pr}(e)}$$

Where,

K= Kappa coefficient

Pr (a) = Relative observed agreement among raters

Pr (e) = Hypothetical probability of chance agreement

Pr (e) = $1 / N^2 \sum nk_1 nk_2$ where N=Number of items, Cohen's kappa measures the agreement between two raters nk_1 and nk_2 .

Interpretation of value of κ ,

<0.2 = Poor agreement

0.2 – 0.5 = Moderate agreement

0.6–1 = Good agreement

In addition comparisons between men and women will be made regarding the incidence of difficult intubation and also the values and optimal cut-off points of the variables.

3. Results

Data from 200 patients were studied. Demographic features of the patients are presented in Table 1. Laryngoscopic blade size was kept constant in all the cases. The laryngoscopy was considered as difficult i.e. Cormack–Lehane grades 3+4 in 14.5% of the patients [Fig. 1]. There were no failed tracheal intubations but the number of attempts varied. In 164 patients (82%), intubation was done in the first attempt. In only 8 patients (4%), process of intubation was completed by use of a gum elastic bougie.

Laryngoscopy was difficult in 14.5% of the patients. Comparisons between two genders showed no significant difference regarding the incidence of difficult intubation ($P > 0.05$). The median values in men/women were, for TMD: 9.7/7.6 cm (t value 8.94, $p < 0.001$), for STMD: 18.6/15.8 cm (t value 13.41, $p < 0.001$), for RHTMD: 18.2/21.5 (t value 13.41, $p < 0.001$) and for NC: 40.3/38.2 cm (t value 8.94, $p < 0.001$). The optimal cut-off points also fluctuated between the genders, as shown in Table 2.

Calculation of Kappa coefficient of Thyromental distance (cm).

Out of 100 male and 100 female patients, according to TMD cut off value difficult intubation is suggested in 15 and 10 patients respectively. In both the groups 2 patients underwent difficult intubation even after having TMD more than the cut off value.

$$\kappa = \frac{\text{Pr}(a) - \text{Pr}(e)}{1 - \text{Pr}(e)}$$

$$\text{Pr}(a) = \frac{15 + 10}{29} = 0.86$$

$$\text{Pr}(e) = (0.58 * 0.58) + (0.41 * 0.41) = 0.51$$

$$\kappa = \frac{0.86 - 0.51}{1 - 0.51} = 0.7$$

Calculation of Kappa coefficient of Sternomental distance (cm).

Out of 100 male and 100 female patients, according to TMD cut off value difficult intubation is suggested in 14 and 9 patients respectively. In both the groups 3 patients underwent difficult intubation even after having STMD more than the cut off value.

$$\kappa = \frac{\text{Pr}(a) - \text{Pr}(e)}{1 - \text{Pr}(e)}$$

Table 1

Demographic profile of patients.

Characteristics	Mean \pm S.D.
Male : Female	1 : 1
Age (yrs)	54 \pm 16
Weight (kg)	71 \pm 11
Height (cm)	164 \pm 8
BMI (Kg/m ²)	25 \pm 5

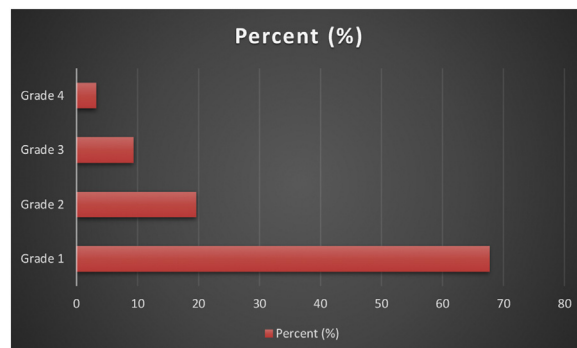


Fig. 1. Distribution of patients on basis of laryngoscopic view according to the Cormack and Lehane grade.

Table 2

The cut-off points of neck parameters in both the genders.

Parameter (Cut off values) (cm)	Males	Females
TMD	≤ 9.7	≤ 7.6
STMD	≤ 18.6	≤ 15.8
NC	≥ 40.3	≥ 38.2
RHTMD	≥ 18.2	≥ 21.5

$$\text{Pr}(a) = \frac{14 + 9}{29} = 0.79$$

$$\text{Pr}(e) = (0.58 * 0.58) + (0.41 * 0.41) = 0.51$$

$$\kappa = \frac{0.79 - 0.51}{1 - 0.51} = 0.5$$

Calculation of Kappa coefficient of Neck circumference (cm).

Out of 100 male and 100 female patients, according to NC cut off value difficult intubation is suggested in 15 and 10 patients respectively. In males 3 patients and in females 1 patient underwent difficult intubation even after having NC more than the cut off value.

$$\kappa = \frac{\text{Pr}(a) - \text{Pr}(e)}{1 - \text{Pr}(e)}$$

$$\text{Pr}(a) = \frac{15 + 10}{29} = 0.86$$

$$\text{Pr}(e) = (0.62 * 0.55) + (0.37 * 0.45) = 0.5$$

$$\kappa = \frac{0.86 - 0.5}{1 - 0.5} = 0.72$$

Calculation of Kappa coefficient of RHTMD (cm).

Out of 100 male and 100 female patients, according to RHTMD cut off value difficult intubation is suggested in 10 and 11 patients respectively. In both the groups, patient underwent difficult intubation even after having RHTMD more than the cut off value.

$$\kappa = \frac{\text{Pr}(a) - \text{Pr}(e)}{1 - \text{Pr}(e)}$$

$$\text{Pr}(a) = \frac{10 + 11}{29} = 0.72$$

$$\text{Pr}(e) = (0.48 * 0.48) + (0.51 * 0.51) = 0.49$$

$$\kappa = \frac{0.72 - 0.49}{1 - 0.49} = 0.45$$

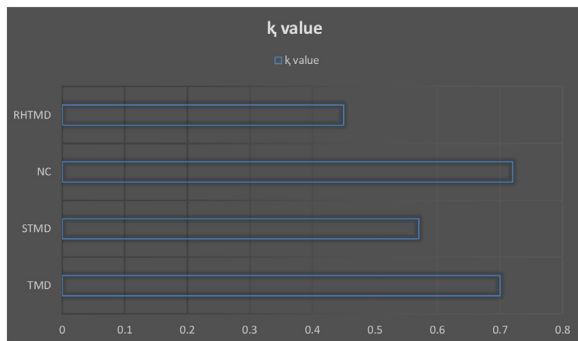


Fig. 2. Comparison of κ (Kappa) value of different parameters of neck.

Fig. 2 shows that TMD and NC has good agreement with kappa value of 0.7 and 0.72 respectively. On other side both STMD and RHTMD with kappa values of 0.57 and 0.45 (Moderate agreement) shows that they are not good predictors of difficult intubation.

4. Discussion

Foreseeing difficult intubation is one of the biggest defies for anesthesiologists so that timely precaution can be taken to prevent its related impediments. Various different new methods are used for predicting difficult intubation but the literature regarding limitations of these techniques is lacking.⁹

The existing knowledge displays that, all the bedside methods of assessments for difficult intubation are poor interpreters. But they play important role in the patients, who are mentally or physically incapable. In such patients, the accurate tests like Mallampati and upper lip bite tests cannot be performed because they require patient's co-operation. It is also eminent that the parameters we considered exhibit better inter-observer reproducibility than other tests, and thus are characterized by high inter-rater variability mainly in poorly collaborating patients.²

In this study, cut-off points of neck parameters in both the genders in Indian population was studied. The measurements of TMD, STMD, NC and RHTMD in male population was ≤ 9.7 cm, ≤ 18.6 cm, ≥ 40.3 cm and ≥ 18.2 cm in males respectively. Similarly in females it was found to be ≤ 7.6 cm, ≤ 15.8 cm, ≥ 38.2 cm and ≥ 21.5 cm respectively. There was significant difference (p value <0.001) in all the parameters between the two genders. Similar study was done by Chou et al¹⁹ on patients and the median values in men/women which were found were, TMD: 9/8 cm (P <0.001), for STMD: 18/17 cm (P = 0.003), for RHTMD: 19.2/20.4 (P = 0.009) and for NC: 41/36 cm (P <0.001). In this study only TMD and NC showed sexual dimorphism significantly whereas in our study, done on Indian people revealed sexual dimorphism in all the parameters. These morphometric dimensions are affected by racial characteristics and thus in this study mean of different parameters in Indian population in both the genders was studied which will have both clinical and forensic significance.

Different studies display sensitivity and specificity of different parameters in deciding the difficult intubation. Many studies^[10,14,18] proved that neck circumference has low sensitivity in foreseeing difficult laryngoscopy in different populations. Gonzalez et al.,²⁰ studied patients with a BMI below and above 30 kg/m², and found mean NC values of 39 and 42 cm, respectively in females and males. Interestingly, these investigators also found that a circumference over 43 cm was independently correlated with difficult intubation in both populations, with a sensitivity of 92%. Similarly, Brodsky et al.²¹ revealed that in patients with a BMI >40 kg/m², NC was a significant predictor of difficult

intubation. The probability of difficult intubation with neck circumference of 40 cm was approximately 5%, while the percentage raised up to 35% at a NC of 60 cm. According to the literature, the use of ultrasound proved that not only the circumference but also the amount of pre-tracheal soft tissue decides the difficult intubation. In contrast to other studies, we calculated the agreement between different parameters and difficult intubation. Similar to other studies neck circumference showed the good agreement with the difficult intubation as compared to other parameters.

A study done in India by Jain et al²² revealed that TMD has sensitivity of 22%, specificity of 98%, positive predictive value of 58%, and negative predictive value of 92.5% in deciding the difficult intubation. Etezadi et al²³ found its specificity as 80% and sensitivity as 26% which is comparatively same as seen in other studies. In the present study TMD is considered as the second most common parameter which should be used as the predictor of difficult intubation with the kappa value of 0.7 (Good agreement).

The limitation of present study is that different anesthesiologists did the laryngoscopy. Only precaution which was taken that experienced anesthetists were involved to limit the likelihood of systematic error in the outcome.

5. Conclusion

- The cut-off points of neck parameters in both the genders in Indian population were TMD ≤ 9.7 / ≤ 7.6 cm, STMD ≤ 18.6 / ≤ 15.8 cm, NC ≥ 40.3 / ≥ 38.2 cm and RHTMD ≥ 18.2 cm / ≥ 21.5 cm. There was significant difference (p value <0.001) in all the parameters between the two genders.
- The Kappa values for TMD, STMD, NC and RHTMD are 0.7, 0.5, 0.72 and 0.45 respectively.
- TMD and NC has good agreement with kappa value of 0.7 and 0.72 respectively.
- STMD and RHTMD with kappa values of 0.57 and 0.45 (Moderate agreement) shows that they are not good predictors of difficult intubation.

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