Original Research Article

# Diagnostic value of different screening tests for predicting difficult intubation

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## Abstract

**Aims:** The aim of current study was to compare the diagnostic value of different screening test in predicting difficult intubation. **Settings and Design:** Hospital based observational cross sectional study **Methods and Material:** It was a study of 84 patients with the American society of anaesthesiologists' physical status 1, 2 going through elective surgical procedures in general anaesthesia by tracheal intubation. Preoperative parameters such as Neck Circumference (NC) (cm), Sternomental Distance(SMD)(cm),Thyromental Distance(TMD)(cm),NC/TMD,NC/SMD, Modified Mallampati Test (MMT) and Wilson Score were measured in all the patients by the similar investigator. The primary outcome includes the prediction of difficult intubation as described by Intubation difficulty scale, patients were classified in to two groups with IDS score of ≥5 and <5 as the difficult and easy groups, respectively. **Statistical analysis used:** chi-square test, unpaired t-test. **Results:** Laryngoscopy was difficult in 10.7% patients. The highest sensitivity and negative predictive value was observed in the NC/TMD while the highest specificity and positive predictive value was observed in the MMT. **Conclusions:** The combination of individual tests or risk factors adds some incremental diagnostic value as compared to the value of each test alone. However, the application of NC/TMD may be superior to NC/SMD, MMT and Wilson score in predicting difficult airway.
**Key Word:** Difficult Intubation, NC/TMD, NC/SMD, MMT, Wilson Score, IDS.

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## INTRODUCTION

Difficult tracheal intubation is a most important apprehension for anaesthetists and contributes to perioperative morbidity and mortality[1]. Numerous of efforts have been done to develop trustworthy predictors for difficult intubation or difficult laryngoscopy. Recommended predictors for difficult intubation have a history of obstructive sleep apnoea syndrome (OSAS), high Mallampati score[2], increased age, male, short neck and the Wilson score[3]. Most airway difficulties arise while they are not identified before induction of anaesthesia. There are multiple screening tests available to assess the difficult intubation. However, they have poor discriminative power when used alone as compared to a combination of tests. Mallampati score[2], Thyromental distance (TMD), Sternomental distance (SMD), and Wilson's risk sum score[3] were commonly used as tools for predicting difficult intubation. These screening tests showed the variation in the diagnostic accuracy from trial to trial. It may be due to differences in the incidence of difficult intubation, inadequate statistical power, different test thresholds, or differences in patient characteristics.[4] The aim of current study was to determine the incidence of difficult intubation and also to evaluate the diagnostic accuracy of the following bedside tests in predicting difficult intubation; The ratio of neck circumference (NC) to Thyromental distance (TMD) (NC/TMD), The ratio of neck circumference (NC) to Sternomental distance (SMD) (NC/SMD), Modified Mallampati Test and Wilson score.

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## SUBJECTS AND METHODS

All the eligible patients admitted in our hospital undergoing elective surgical procedures in general anaesthesia with endo-tracheal intubation during the study period (6 months) in the department of surgery, gynaecology, ENT and orthopaedic will be recruited for the study with written informed consent.

**Inclusion criteria**

- Patients going through elective surgical procedures in general anaesthesia with tracheal intubation
- Patient age between 18 to 60 years.
- ASA physical status grade One, Two.
- Both male and female patients.

**Exclusion criteria:**

- Patients going through elective surgical procedures in general anaesthesia without tracheal intubation
- Age of patient less than 18 years or more than 60 years
- ASA grade Three, Four.
- Patients with upper airway pathology i.e. maxillofacial fractures, tumours etc.
- Patients with restricted mobility of the neck and the mandible i.e. cervical disc disorders or rheumatoid arthriti
- Patients requiring awake intubation.

**Pre-operative Assessment:** A day before surgery, a detailed pre-anaesthetic check-up was carried out. Patients were asked to restrict fluid and solids by mouth at least eight hours before the operation. Preoperative parameters such as Neck Circumference (NC) (cm),Thyromental Distance (TMD) (cm), Sternomental Distance (SMD) (cm), NC/TMD, NC/SMD, Modified Mallampati Test (MMT) and Wilson Score were measured in all patients by the same investigator using a measuring tape. The information related to snoring and difficult intubation in the previous surgery was collected. Each patient was kept in the supine position, with the head on a fixed table. They were informed to look straight ahead, maintenance the head in the neutral position, closing the mouth and not permitting swallowing. The neck circumference (NC) was determined at the level of cricoid cartilage i.e. at C5–C6 level. It was determined in the neutral position of patient. The Thyromental distance (TMD) was described as the straight line distance (cm) between the lower border of the thyroid notch and the bony point of the mentum in mouth closed and the head extended condition.[5, 6] The Sternomental distance (SMD) was termed as the straight line distance (cm) from the bony point of the mentum to the upper border of the manubrium sterni, in the head extended and the mouth closed condition.[7] The ratio of the NC to TM (NC/TMD) and NC to SMD (NC/SMD) were estimated from measured parameters. Modified Mallampati score was recorded with the patient sitting with his mouth at the level of examiner's eye with tongue being protruded and allowing no phonation.

**Modified Mallampatti classification without phonation:**

- Class1: soft palate, fauces uvula and pillars visible
- Class 2: soft palate, fauces and uvula visible
- Class 3: soft palate and the base of uvula visible
- Class 4: soft palate not visible

**Other parameters evaluated:**

- The occurrence of the impaired temporomandibular joint mobility (the lower teeth unable to move in front of the upper teeth or retrognathia)
- Mouth opening (cm) was determined as the inter incisor gap in the mouth fully opened condition.
- Limited neck movement (unable to extend and flex the neck to a range around 90 degree)
- The abnormally protruding upper teeth

Then, the Wilson's risk sum score was calculated.

| Risk factors | | Risk score |
|---|---|---|
| Weight | 0 | less than 90kg |
| | 1 | 90- 110kg |
| | 2 | more than 110kg |
| Head and neck movement | 0 | Above 90 degrees |
| | 1 | About 90 degrees |
| | 2 | below 90 degrees |
| Jaw movement | 0 | IG>5 |
| | 1 | IG=5 |
| | 2 | IG<5 |
| Receding mandible | 0 | Normal |
| | 1 | Moderate |
| | 2 | Severe |
| Buck teeth | 0 | Normal |
| | 1 | Moderate |
| | 2 | Severe |

***(IG = Inter-incisor gap)***

The primary outcome measured in this study include the prediction of difficult intubation by as defined by Intubation difficulty score using the following indices, NC/TMD, NC/SMD, modified Mallampatti test and Wilson score. In the operating theatre, the patients were positioned with 10 cm pack under the head with neck extended. An electrocardiogram, pulse oximetry and non-invasive arterial pressure were routinely monitored in all the patients was monitored. The difficult airway cart was kept ready. Patients were administered 100% oxygen through a face mask for 3 min. Patients were premedicated with midazolam 1 mg and fentanyl (2mg/kg) as per weight. Anaesthesia was induced by

propofol (2mg/kg) and suxamethonium (2mg/kg). In each case, laryngoscope blade a size 3 Macintosh was used for the first laryngosopy. An anaesthesiologist with more than 2 years of experience performed all the tracheal intubations and they were blined to the assignment of the patient. Spo 2 decreased to <90 during the intubation period, it was considered d as a hypoxic episode. As per Cormack and Lehane's scale, the laryngoscopic view was graded [8] such as Grade 1: the vocal cords were completely visible, Grade 2: only the arytenoids were visible, Grade 3: only the epiglottis was visible, Grade 4: epiglottis was not visible.

**Difficulty of intubation was measured according to the Intubation difficulty scale (IDS) [9]. The IDS is graded as follows:**

- N1, number of additional intubation attempt
- N2, number of additional operators;
- N3, number of alternative intubation techniques used;
- N4, laryngoscopic view as defined by Cormack and Lehane (grade 1, N4=0; grade 2, N4=1; grade 3, N4=2; grade 4, N4=3);
- N5, lifting force applied during laryngoscopy (N5=0 if inconsiderable and N5=1 if considerable);
- N6, needed to apply external laryngeal pressure for optimized glottic exposure (N6=0 if no external pressure or only the Sellicks manoeuvre was applied and N6=1 if external laryngeal pressure was used);
- N7, position of the vocal cords at intubation (N7=0 if abducted or not visible and N7=1 if adducted)

The two groups of patients were further divided as per the IDS score. Those have an IDS score of ≥5 and <5 were mentioned as difficult and easy groups, respectively.

## RESULT

In the current study, a total 84 adult patients (20 males and 64 females) were evaluatedas scheduled for elective surgery by tracheal intubation. As per IDS scale, nine patients had difficult intubation with an overall incidence of 10.71% from 84 patients.

**Table 1:** Demographic Data

| | IDS < 5 | IDS ≥ 5 | |
|---|---|---|---|
| **N** | **75** | **9** | **P value** |
| **Parameters** | **Mean (± SD)** | **Mean (± SD)** | |
| Age (Years) | 40.34 (±13.43) | 41.11(±12.94) | 0.8708 |
| Sex | 17-M/58-F | 3-M/6-F | 0.478 |
| Height(cm) | 1.56 (±0.08) | 1.57(±0.01) | 0.7104 |
| Weight(Kg) | 56.56(±13.59) | 59.66(±14.07) | 0.5212 |
| BMI(Kg/m²) | 23.11 (±5.02) | 23.99(±5.51) | 0.624 |

The various airway and demographic parameters were compared between the two groups using binary univariate logistic regression analysis as shown in table 1.

**Table 2:** TESTS FOR DIFFICULT INTUBATION. NC, Neck Circumference; TMD, Thyromental Distance; SMD, Sternomental Distance; NC/TMD, The ratio of neck circumference to Thyromental distance; NC/SMD, The ratio of neck circumference to Sternomental distance; PPV-positive predictive value; NPV, Negative predictive value

| TEST | Sensitivity | Specificity | PPV | NPV |
|---|---|---|---|---|
| **NC≥40** | 44.44% | 94.66% | 50% | 91.02% |
| **TMD<5** | 66.66% | 80% | 28.57% | 95.23% |
| **SMD<12.5** | 66.66% | 94.66% | 60% | 89.87% |
| **NC/TMD≥5** | 88.88% | 81.33% | 38.09% | 96.82% |
| **NC/SMD≥2.4** | 77.77% | 72% | 25% | 96.42% |
| **Mallampati 3-4** | 44.44% | 97.33% | 66.66% | 93.58% |
| **Wilson ≥2** | 66.66% | 54.66% | 15% | 93.18% |

**NC/TMD vs IDS:** The prediction of the difficult intubation by NC /TMD and actual IDS (Intubation Difficulty Scale) were compared. 8 out of 9 patients with IDS more or equal to 5 had NC/TMD more or equal to 5 while 1 out of 9 patients with IDS more or equal to 5 had NC/TMD less than 5. 14 out of 75 patients with IDS less than 5 had NC/TMD more or equal to 5. While 61 patients out of 75 with IDS less than 5 had NC/TMD less than 5. The sensitivity of NC/TMD for difficult intubation (by using IDS) was 88.88% and specificity was 81.33%. The test had positive predictive value of 38.09% and negative predictive value of 96.82% (Table 2)

**NC/SMD vs IDS:** The prediction of the difficult intubation by NC /SMD and actual IDS (Intubation Difficulty Scale) were compared. 7 out of 9 patients with IDS more or equal to 5 had NC/SMD more or equal to 2.5 while 2 out of 9 patients with IDS more or equal to 5 had NC/SMD less than 2.4. 21 out of 75 patients with IDS less than 5 had NC/SMD more or equal to 2.4. While 54 patients out of 75 with IDS less than 5 had NC/SMD less than 2.4. The sensitivity of NC/SMD for difficult intubation (by using IDS) was 77.77% and specificity was 72%. The test had positive predictive value of 25% and negative predictive value of 96.42% (Table 2)

**Modified Mallampati Test vs IDS:** The prediction of the difficult intubation by Modified Mallampati Test and actual IDS (Intubation Difficulty Scale) was also compared. 4 out of 9 patients with IDS more or equal to 5 had Modified Mallampati Test more or equal to 3 while 5 out of 9 patients with IDS more or equal to 5 had Modified Mallampati Test class 1 and 2. 2 out of 75 patients with IDS less than 5 had Modified Mallampati Test more or equal to 3. While 73 patients out of 75 with IDS less than 5 had Modified Mallampati Test class 1 and 2. The sensitivity of Modified Mallampati Test for difficult intubation (by using IDS) was 44.44% and specificity was 97.33% the test had positive predictive value of 66.66% and negative predictive value of 93.58% (Table 2)

**Wilson Score vs IDS:** The prediction of the difficult intubation by Wilson Score and actual IDS (Intubation Difficulty Scale) was also compared. 6 out of 9 patients with IDS more or equal to 5 had Wilson Score more or equal to 2 while 3 out of 9 patients with IDS more or equal to 5 had Wilson Score less than 2. 34 out of 75 patients with IDS less than 5 had Wilson Score more or equal to 2. While 41 patients out of 75 with IDS less than 5 had Wilson Score less than 2. The sensitivity of Wilson Score for difficult intubation (by using IDS) was 66.66% and specificity was 54.66% the test had positive predictive value of 15% and negative predictive value of 93.18% (Table 2)

**Statistical Terms:**

- True positive = a difficult intubation that had been forecasted to be difficult.
- False positive = an easy intubation that had been forecasted to be difficult.
- True negative = an easy intubation that had been forecasted to be easy.
- False negative = a difficult intubation that had been forecasted to be easy.
- Sensitivity = the percentage of correctly predicted difficult intubations as a proportion of all intubations that were truly difficult.

## DISCUSSION

In anaesthetic practice, difficult tracheal intubation remains a relatively constant and significant reason of morbidity and mortality. Preoperative detection of patients at risk for difficult intubation is the primary step in airway management. There are multiple screening tests to predict difficult intubation. However, numerous of studies demonstrated their poor diagnostic accuracy when they were used alone.[5] Therefore, combinations of individual tests or risk factors may add diagnostic value as compared to the value of each test alone. Thus, combining two of the most valuable risk factors may increase the diagnostic value, at the same time it does not significantly increase the burden of the test. There are numerous of studies to predict the diagnostic accuracy of screening tests for predicting difficult intubation. However, they showed a significant difference between the trials. This variation could be due to variation in the patient characteristics as most of these studies were performed in the Western population. There is a significant difference in the anthropometry of Indian and the Western population that is also translated into the anatomical indices used to predict difficult laryngoscopy[10]. Thus, it is essential to analyse that similar parameters and cut-off values can be applied in the Indian population to predict difficult airway. The incidence of a difficult laryngoscopy or intubation varies from 1.5 to 13% and failed intubation has been identified as one of the causes of death or permanent brain damage related to anaesthesia.[11] Problems in airway management can be predicted based on previous anaesthesia records, the medical history of the patients and a physical examination. Several radiologic measurements were reported to be associated with a difficult intubation. However, simple clinical examination is a widely used method to predict difficult intubation. Difficulty in intubation is usually described using IDS(intubation difficulty scale). IDS≥5 describing difficult intubation. Theoretically, anideal predictor is distinguished by high sensitivity and high specificity; thus, a high diagnostic accuracy, in order to recognize almost each patient at risk with minimal false positive predictions. In clinical practice, anaesthesiologists are mostly worried for the unanticipated difficult airway (false negative predictions), which may find them unprepared. The incidence of difficult intubation was 10.71% (9 out of patients)in our study as assessed according to IDS(intubation difficulty scale).The incidence 10.71% is consistent with the incidence demonstrated in the previous literature. No failed tracheal intubation observed. The recent study by SangeetaDhanger *et al* [12]showed 13% incidence of

difficult intubation. In the previous study by SamikshaKhanooja *et al* incidence of difficult intubation was found to be 6.25% [13].W.H.Kim *et al* [7] reported the incidence of difficult intubation 13.8% in obese patients. Merah *et al* [9] found an incidence of difficult laryngoscopy to be 10%in Nigerian parturient. This variation in incidence of difficult laryngoscopy might be due to factors such as different anthropometric features among the population, cricoid pressure application, head position or degree of muscle relaxation. The ideal test for IDS prediction should have 100% sensitivity and specificity.However, sensitivity and specificity are inversely proportional to each other. Optimal cut offs used in our study to calculate the sensitivity and specificity were NC/TMD≥5, NC/SMD≥2.4, modified Mallampati ≥3(difficult intubation), Wilson ≥2(difficult intubation) and IDS ≥5(difficult intubation). Previous evidences suggested that NC at the thyroid cartilage is animportant predictor of difficult laryngoscopy in both obese as well as nonobese patients. However, NC does not show the quantity of soft tissue at various topographic regions within the neck. Distribution of fat in particular neck areas, especially the anterior neck, may provide a better indication of difficult intubation than NC.TMD is considered to be an indicator of mandibular space.This test indicates that the displacement of the tongue with the laryngoscope blade will be easy or difficult. A meta-analysis performed by Shiga *et al*showed the diagnostic value of TMD as an unsatisfactory individual predictor. [4] NC/TMD might indicate the distribution of fat in the neck better than either NC or TMD alone. In the current study, overall specificity and sensitivity of diagnostic predictors was relatively comparable. Statistical analysis of present data indicated that the specificity, sensitivity, positive predictive value and negative predictive value of NC/TMD for predicting IDS was 88.88%, 81.33%,38.09% and 96.82% respectively which is statistically highly significant (p value < 0.001). These findings are consistent with the study of W.H. Kim *et al*[7] which demonstrated the sensitivity and specificity of NC/TMD to predict IDS was 88.2% and 83.0% respectively. Samiksha Khanooja *et al*[13] showed that sensitivity of and specificity of NC/TMD to predict IDS was 94.44% and 50.37% respectively. Anahita Hirmanpour *et al*[14] indicated that NC/TMD >5.6 (sensitivity =71.7%, specificity = 70.2%) have a moderate to fair sensitivity, specificity and a relatively large AUC on the ROC curve, which disclosed that NC/TMD is highly predictive. The Sternomental distance may be a good indicator of maximum neck extension therefore enabling a more accurate assessment of head extension than any other subjective assessment and avoiding the need for radiological examination which in fact is an infringement on patient's safety. In current study the sensitivity, specificity, positive predictive value and negative predictive value of NC/SMD were 77.77%, 72.0%, 25% and 96.42% respectively which was statistically significant (p value <0.05). The Mallampati score may assessthe tongue size relative to the oral cavity and may possibly demonstrate whether the displacement of the tongue through the laryngoscope blade is likely to be easy or difficult.It also show whether the mouth can be opened adequately to allow the intubation. The Mallampati test assesses the pharyngeal structure as well as head and neck mobility. In present study, Mallampati score was found 3 or 4to be a good predictor of difficult intubation. In the current study, the analysis of the data was found 44.44%, 97.37%, 66.66% and 93.58% of the sensitivity, specificity, positive predictive value and negative predictive value, respectively in modified Mallampati test for predicting IDS. In the current study, the Modified Mallampti score was found to be statistically significant (p value <0.001). In another study conducted by W.H. Kim *et al* [7]was found 58.8% and of 89.60%the sensitivity and specificity respectively in using Mallampati grade 3 and 4 to predict IDS. SamikshaKhanooja *et al* [13] in their study found the sensitivity and specificity to be 55% and 81.34%respectively for modified mallampati score of 3 and 4. Bhavdeep *et al* [15] was found the sensitivity and specificity to be 28.6% and 93% respectivelyusing the modified mallampati test. They also found that by combing MMT and (TMD+SMD) parameters the sensitivity and specificity of predicting difficult intubation increased to 100% and 93% respectively. In a Frerk study MMT had sensitivity (81%) and specificity (81.5%) whereas In a study by Kuriakose *et al*, MMT had sensitivity (81.8%), PPV (61.76%), specificity (75.15%). Kuriakose *et al* [16] concluded that modified Mallampatti Test predicts difficult intubation more accurately than others among independent predictors. The previously reported studies suggested that the NC is an independent risk factor for difficult intubation in obese patients. Wilson *et al* [3] used weight, head and neck movement jaw movement, receding mandible and buck teeth and suggested a risk-sum in their prospective study to assess the prediction of difficult laryngoscopy. In the current study, the sensitivity, specificity, positive predictive value and negative predictive value of Wilson score were 66.66% , 54.66%, 15% and 93.18% respectively which was less significant statically (p=0.226). Multivariate analysis identified the Mallampati score, Wilson score, and NC/TM to be independently associated with difficult intubation in obese patients. In our study, all the preoperative parameters measured by a single investigator performed, in order to eliminate every bias from inter

observer variability, The limitation of current study is that the different anaesthesiologist were measured the laryngoscopy. In our results, only experienced anaesthetists were involved in order to limit the possibility of systemic error. An additional limitation of the study includes it was not complete blind study. The IDS score could have been increased intentionally if anaesthesiologist knew the purpose of this study. Furthermore, a Macintosh No. 3 the first laryngoscopy was performed by laryngoscopic blade in each case; it may be unsuitable for some patients as a first choice. The operator has chosen the size of the blade as case by case. Further studies with larger samples should be conducted to determine the clinical predictors that can assist in diagnosis of difficult laryngoscopy, as a way to decrease the incidence of complications related to inadequate airway management.

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