



ADDIS ABABA UNIVERSITY
COLLEGE OF HEALTH SCIENCE
DEPARTMENT OF ANESTHESIA

Comparison of the effectiveness of neck circumference to thyromental distance ratio, the ratio of height to thyromental distance, upper lip bite, and modified mallampati tests to predict difficult laryngoscopy among elective adult surgical patients at Addis Ababa Referral Hospitals, Ethiopia Cross-Sectional Study, 2023.

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A research proposal submitted to the Department of anesthesia, College of Medicine and health science; Addis Ababa University in the requirement for the partial fulfilment of a Master of Science in advanced clinical anesthesia.

Addis Ababa, Ethiopia

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Title	Comparison of the effectiveness of neck circumference to thyromental distance ratio, the ratio of height to thyromental distance, upper lip bite, and modified mallampati tests to predict difficult laryngoscopy among elective adult surgical patients at Addis Ababa Referral Hospitals, Ethiopia Cross-Sectional Study, 2023
Study period	From February 1 to April 30, 2023
Study Area	Four Governmental Referral hospitals in Addis Ababa Ethiopia. Including Tikur Anbessa specialized hospital (TASH), St. Petros hospital, St, Paulo's referral hospital and Zewditu memorial hospital
Study Budget	A total of 27000 eth. Birr
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Declaration

I, the undersigned, declare that this thesis is my original work in partial fulfilment of the requirements for the Master of Science degree in Anesthesia. I understand that plagiarism will not be tolerated and all directly quoted material has been appropriately referenced.

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Acknowledgement

First, I would like to thank my advisers Betelihem Girma and Tinbite Daniel and other faculty staff for their relevant support and advice throughout my journey in this study.

I would also like to thank the Department of Anesthesia and Addis Ababa University for providing the opportunity and some support.

Finally, my thanks to the health science Library staff members for Offering useful references for my proposal development, and my thanks go to all individuals for their constructive comments and suggestions while writing the thesis.

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Abbreviations and Acronym

ASA	American Society of Anesthesiologist
AUC	Area Under Curve
BMI	Body Mass Index
CI	Confidence Interval
CLG	Cormack and Lehan's Grading
DA	Difficult Airway
DL	Difficult Laryngoscopy
DTI	Difficult Tracheal Intubation
ETT	Endotracheal Intubation
IID	Inter Incisor Distance
MMT	Modified Mallampati Test
NC	Neck Circumference
NC/TMD	Neck Circumference to Thyromental Distance
NPV	Negative Predictive Value
PLR	positive likelihood ratio
PPV	Positive Predictive Value
RHTMD	Ratio of Height to Thyromental Distance
ROC	Receiver Operating Characteristics
SMD	Sterno Mental Distance
SPSS	Statistical Package for Social Science
TMD	Thyromental Distance
ULBT	Upper Lip Bite Test

Abstract

Introduction: - The preoperative assessment determines anatomical features that contribute to difficult laryngoscopy. The magnitude of difficult laryngoscopy ranged from 6% to 27%. Poor patient evaluation can cause unanticipated difficult intubation and severe adverse effects. A variety of tests were used both separately and together, with varying degrees of success. However, it is unclear which of these bedside tests is best at predicting difficult laryngoscopies.

Objective: - To compare the effectiveness of neck circumference, neck circumference to thyromental distance ratio, the ratio of height to thyromental distance, upper lip bite, and modified mallampati tests to predict difficult laryngoscopy among elective adult surgical patients at Addis Ababa Referral Hospitals, Ethiopia from February 1 to April 30, 2023

Methods: - The multicentered cross-sectional study was carried out on 190 study participants from February 1 to April 30, 2023. Statistical analysis was done using a chi-square test and a student t-test. A P value of < 0.05 was considered statistically significant. The receiver-operating characteristic (ROC) curves were used to diagnose the significance of predictors of difficult laryngoscopy and the cut-off points. The Diagnostic parameters like sensitivity, specificity, Positive predictive value, and negative predictive value were carried out using crosstabs on SPSS, whereas the positive likelihood ratio, negative likelihood ratio, and accuracy were calculated manually from the descriptive statistics.

Result: - The magnitude of difficult laryngoscopy in this study was 13.2%. The cutoff values of Neck circumference, Neck circumference to thyromental distance ratio, and the ratio of height and thyromental distance were >37 cm, >4.66 cm, and >22 cm, respectively. The upper lip bit test and the ratio of height and thyromental distance were the most sensitive, specific, high Positive predictive value, and diagnostic accuracy tests (76%, 98.2%, 86.4%, 96.4%, and 95.2%) and (72%, 95.8%, 72%, and 92.6%), respectively. Neck circumference was the least sensitive single test, with a sensitivity of 60%.

Conclusion: - The upper lip bit test was the most accurate single test, and neck circumference had the least screening ability for predicting difficult laryngoscopy in the study population.

Key words: - Difficult airway, Difficult laryngoscopy, Airway assessment teste, Receiver-Operating Characteristic (ROC) curves

1. INTRODUCTION

1.1 Background

In everyday usage, the word airway implies the upper airway, which is described as the extrapulmonary air channel and includes the oral and nasal cavities, pharynx, larynx, trachea, and major bronchi. A difficult airway is a condition where initiating or sustaining gas exchange using a mask, an artificial airway, or both is difficult. Recognizing the likelihood of a difficult airway (DA) before anesthesia enables optimal planning, using difficult airway care specialists, and choosing appropriate tools and procedures (1)(2).

Pre operative assessment determines anatomical features which are probable to cause difficulty for bag-mask ventilation (BMV), laryngoscopy, intubation, the use of an extra-glottic device (e.g., laryngeal mask airway [LMA]), or surgical airway management compared to patient without those characteristics. The recognition of a problematic airway is an important aspect of every patient's strategy for airway management (3).

The ASA Guidelines developed by 2022, for Difficult Airway Management define Difficult Laryngoscopy as After repeated attempts at laryngoscopy, no part of the vocal cords can be seen (4). Alignment of the oral, pharyngeal, and laryngeal axes is an aid to observing directly from the mouth to the glottic opening, If these structural arrangements fall in reaction to direct laryngoscopy, the laryngoscopy will be challenging (5). All patients having preoperative evaluation are examined for anatomic characteristics that may suggest problems with endotracheal intubation while under general anesthesia (2).

Anesthetists employ several kinds of diagnostic tests to detect potentially challenging airways before general anesthesia. However, the pursuit of an optimal and mostly acceptable categorization system still persists. The following are the most frequently utilized tests: the modified Mallampati test, which was created by Mallampati and revised by Samson (6) ; there are four classes in the modified Mallampati classification. Mallampati Classes III and IV are considered difficult laryngoscopies (2,3).

Khan et al. (7), in 2009, developed the upper lip Bite Test (ULBT), which evaluated a patient's ability to completely cover the top lip with the lower incisors. This test is classified into three classes. the ULBT grade III (the lower incisors fail to bite the upper lip) was reported to be

related to difficult laryngoscopy (7,8) The ratio of height to thyromental distance (RHTMD) test was introduced by Schmitt et al, in 2002 (9), and it was found that the RHTMD > 22.7 cm has higher sensitivity (64%) and specificity (82%) in predicting difficult laryngoscopy (10).

Assessment of neck circumference (NC) was demonstrated by Gonzalez et al.(11), and they showed that it was a predictor of difficult intubation and measured at the level of the cricoid cartilage. Neck circumference to thyromental distance ratio (NC/TMD) was demonstrated by Kim et al. in 2011, and they showed that NC/TMD greater or equal to five was a better difficult laryngoscopy predictor in obese patients than the other recognized approaches (12).

Poor patient evaluation can cause unanticipated difficult intubation and severe adverse effects such as hypoxia, hypercarbia, aspiration of gastric contents, and possible awareness in a relaxed patient (13). Appropriate airway evaluation has a very important role in the prevention of airway-related adverse outcomes and identify possible issues with maintaining oxygenation and ventilation during airway management. To create a suitable airway plan, including a tiered approach to managing an unexpectedly challenging airway or the use of emergency airway management (14). When a difficult airway is identified, a series of communications and preparations are initiated to aid in the establishment and maintenance of the airway (15)..

1.2 Statement of the problem

The practice of establishing and securing a patient's airway is referred to as airway management, and it is one of the cornerstones of anesthetic practice (15). The magnitude of challenging DL in a meta-analysis of elective anesthetic trials ranged from 6% to 27% (3).

Between 30% and 40% of mortality during all anesthesia is attributable to a failure to control a difficult airway (13,16). Respiratory events were one of the most frequent types of injury, accounting for 34% of all claims. 85% of these negative outcomes resulted in brain damage or death (1,17). Failed laryngoscopy and DTI are related to dental damage, ICU admission, oxygen desaturation (< 90%), hypertension (> 200 mm Hg), can't intubate can't ventilate(CICV), awareness, bronchospasm, airway trauma, arrhythmias, hypercarbia, and aspiration of vomitus (18).

There are multiple assessments and markers that can be used for preoperative airway evaluation and predicting challenging airways. The modified Mallampati classification (MMT), TMD, and

SMD are the most widely used tests, and newer airway assessment tests such as the upper lip bite test, the ratio of height to thyromental distance (RHTMD), neck circumference (NC), and neck circumference to thyromental ratio (NC/TMD) were officially investigated (10,15,19). These tests have been used either individually or in various combinations. However, they have variable sensitivity, specificity, and positive predictive value (20). It is unclear which test has the best predictive ability (21).

Efforts have been made to design bedside tests that are simple to carry out, do not take a long time, and do not require particular equipment; however, all of these tests have limitations, and no single one is complete. As a result, comparing these methods to find the best one is unavoidable (10,22).

The following factors were associated with difficult laryngoscopy: Patient characteristics such as race or ethnicity, increasing age and weight, male gender, short neck, and receding mandible (23,24). A history of chronic disorders with reduced joint mobility, such as rheumatoid arthritis, ankylosing spondylitis, diabetic Mellitus, Changes in tissue caused by irradiation, neck infection, or burns, tongue thickness, and fat in the vocal cords (19).

The predictive reliability of the screening parameters differs among researches due, to insufficient statistical validity, variable assessment limits and patient characteristics like ethnicity, gender, and medical condition. For instance, intubating the trachea in Asian patients might be more difficult than in Caucasians (23) and West Africans appear to have a longer neck and sternomental distance (SMD) than Caucasians (20). Appropriate information about normal values in a particular group might help practitioners in identifying individuals who are beyond the usual range and hence possibly challenging (23).

Escalation of the prevalence of overweight from 17.49% to 22.6% and obesity from 3.74% to 6.9% in Ethiopia was found by systemic review and meta-analysis (25), so the explicatory preoperative examination has become mandatory to allows transformation of a potentially dangerous unanticipated airway into an anticipated difficult airway. Moreover, different authors investigated the ability of NC and NC/TMD to recognize difficult laryngoscopy in obesity, whose cut-off values were BMI > 30 kg/m² and had the highest sensitivity, specificity, and predictive values (26). but in Ethiopia, the obesity cut-off value is BMI > 24.5 kg/m² (27), and

the predictive value of these bedside tests for the prediction of difficult laryngoscopy was not investigated.

There is no set guideline for preoperative examination tools, and most anesthetist use MMT, IIG, SMD, and TMD. The anesthesia provider perceives laryngoscopy and intubations as easy when the individual's airway is mallampati class one and two with no obvious difficult airway hazards and no adequate preparation was made for the coming difficult airway. In my clinical practice, I observed difficult laryngoscopy in MMT-1, SMD, and TMD normal-range surgical patients; this might be due to inadequate pre-operative airway assessment tools. Some patients complained of voice changes, throat pain, oral pain, and loose teeth, and some also complained of difficulty breathing after surgery and anesthesia.

Although most preoperative bedside tests to predict difficult laryngoscopy were conducted in Ethiopia, as far as I could find, the predictive value and cutoff value of new techniques like NC, NC/TMD ratio, and RHTMD were not identified and compared with another preoperative test. However, these tests were conducted in other countries, and they are the most valuable predictors that have higher reliability and a good diagnostic value for difficult laryngoscopy and intubation (26).

1.3 Justification of the study

The problematic airways have been linked to patient morbidity and mortality at the time of anesthesia, appropriate preoperative airway assessment and preparedness for challenges are crucial for reducing or avoiding morbidity and mortality in patients.

The founding of various thresholds used for various tests and the lack of cutoff values in this population, particularly quantitative ones for the prediction of difficult laryngoscopy. These five bedside tests were selected because their screening ability to predict difficult laryngoscopy was not investigated and compared with commonly used tests in this populations, while the other bedside tests were investigated frequently.

The variation in the magnitude of difficult laryngoscopy and the diagnostic efficacy of different bedside tests due to differences in patient characteristics like ethnicity, age, gender, and the physical and medical condition of individuals (23,28). As a result, there could be another instance of difficult airway predictive value in the area where We intended to carry out this

research. Even though some of these bedside tests were conducted in Ethiopia, the accurate diagnosis of those different airway parameters might be influenced since they have been studied in a single center of small size. Therefore, it is worth conducting this research by including newer techniques in multicenter areas.

For healthcare providers, updated evidence-based data on the magnitude of the problem and the high predictive value of preoperative tests will improve anesthesia care quality. This study will also be used to alarm professionals to prepare for upcoming difficulties in those with difficulty and those with no obvious difficulty.

The findings of this study will have to contribute information about the best predictive bedside tests for difficult laryngoscopy and set guidelines for preoperative examinations. Furthermore, the results of this research will serve as the basis for future studies.

This research aims to show the magnitude of DL, determine the cutoff value, and describe the sensitivity, specificity, predictive value, and diagnostic accuracy of these bedside tests for predicting difficult laryngoscopy.

2. Literature Review

2.1.1 Overview of literature

Failure to assess and identify potential difficulties, as well as weak management planning judgement may lead to negative consequences (29). Beyond performing a series of tests on the patient at the bedside, airway assessment must make an effort to identify issues with each aspect of managing an airway and incorporate them logically into a plan of action. The use of multiple tests is more accurate than using a single test alone in predicting the difficulty of managing the airway (1,19).

2.1.2 Socio-demographic related variables

A study conducted in Afghanistan on 341 patients shows that difficult intubation in female participants was more likely than in male participants. Patients aged greater than 40 were more likely to require difficult intubation than those aged less than 40 (28).

A study in India conducted on 200 lean and obese $> 25 \text{ kg/m}^2$ patients shows that 14 patients of obese and 13 lean patients were observed difficult laryngoscopy and it was more common in men >40 age and neck circumference greater than 35 cm (30).

2.1.3 Magnitude, predictor and preoperative predictive value of difficult laryngoscopy

The study conducted in Chaiyaphum Hospital, Thailand on 550 consecutive patients, reported that 69 patients (12.5%) had difficult laryngoscopy. RHTMD, TMD, and inter incisor gap were found to be 23.5 cm (sensitivity, 77%; specificity, 66%), 6.5 cm (sensitivity, 52%; specificity, 71%), and 3.5 cm (sensitivity, 39%; specificity, 69%), respectively, for predicting difficult laryngoscopy(31).

A prospective observational study conducted in Iran on 603 study participants planned for elective surgery shows that 41 (6.8%) patients with difficult laryngoscopy occurred. The MMT class 3 and 4 was the most sensitive of the individual tests, having a sensitivity of 87.37%. The ULBT class 3 had the lowest sensitivity of the single tests (66.01%), but the highest specificity and PPV when compared to the other two tests(32).

An observational prospective study conducted in Korea on 125 obese and 125 non-obese patients reported that the prevalence of Cormack grades 3 or 4 was comparable across groups (8.1% in obese vs 7.2% in no obese Group). NC/TMD greater than five resulted with a moderate-to-fair

sensitivity, specificity, and a negative predictive value. A preoperative NC/TM ≥ 5.0 value was shown to be a reliable indicator of difficult intubation in obese patients(12).

Another observational study conducted in Isfahan, Iran on 525 consecutive patients shows that 51 patients (9.7%) of the incidence of DL and ULBT had the highest sensitivity of the single tests, at 90.2%. and the highest, NPV of 98.3%, RHTMD test, with sensitivity and specificity of 70.59%, and 85.41%, respectively, and PPV of 34.3%. The MMT test has a sensitivity of 68.63%, a specificity of 52.85%, and a positive predictive value of 13.6%(33).

A study conducted in Germany on 1425 patients reported that 12% of patients had Cormack and Lehans laryngoscopy grades 3 and 4. The sensitivity and specificity Positive predictive value and accuracy of ULBT and MMT: 28.2%, 92.5%, 33.6%, 84.9%, and 70.2%, 61%, 19.5%, and 62.1%, respectively (8).

A study in Maharashtra, India, on 402 ASA I and II adult patients indicates that 11.4% of patients encountered difficult laryngoscopy and, when used alone, ULBT has a high sensitivity (98.6%) but low specificity (8.7%). Sensitivity and specificity are interdependent; an increase in one usually results in a decrease in the other. MMC or TMD is a more accurate predictive test than ULBT alone (34).

Another study from Iran conducted on 600 participants reported that, the predictive values of five tests in predicting difficult laryngoscopy were (ULBT =RHTMD > NC/ TMD > TMD= NC= MMT), RHTMD (>22.7 cm) has the highest sensitivity (64.77%, 95% CI: 53.9-74.7), and ULBT has the highest specificity (99.41%, 95% CI: 98.3-99.9)..ULBT has the highest PPV and RHTMD has the highest NPV (93.5% and 93.2%, respectively)(10).

Another prospective, observational study conducted in Lourdes Hospital, Kochi, Kerala, India, on 250 patients revealed that RHTMD and TMD had the highest sensitivity (90.0% and 70%, respectively) for difficult laryngoscopy. ULBT and HNM had the highest specificity, with 99.0% and 91.4%, respectively. ULBT and TMD had the highest positive predictive value (90% and 58.3%, respectively), while RHTMD and TMD had the highest negative predictive value (97.8% and 94.1%), respectively (15).

Another study conducted in Seoul, Korea, on 243 patients shows that 14.4% of the incidence of difficult laryngoscopy and the highest specificity (95.2%) and sensitivity (80.0%) were

demonstrated by the HT/TMD ratio and ULBT, respectively. NC/TMD shows a higher positive predictive value than MMT and HT/TMD (35).

Another cross-sectional study conducted in India on 166 obese and 166 non-obese patients indicated that 14.5% of obese patients had difficult intubation and 7.2% of non-obese patients had difficult intubation. In non-obese groups, NC/TM had a very high specificity of 92.9%, a sensitivity of 75%, and a positive likelihood ratio of 10.5%. Thyromental distance had an 88.3% specificity and a 75% sensitivity. The modified Mallampati classification had low sensitivity and a positive likelihood ratio.(24).

According to the study, Cochrane's systematic review of diagnostic accurate in 133 studies (127 cohort types and 6 case-control studies) involved 844,206 participants. The sensitivity and specificity (95% CI) of the ULBT for difficult laryngoscopy were 67% and 92%, respectively; the ULBT sensitivity (95% CI) was significantly higher than that of the mouth opening test (22%).(36).

The study conducted in Pakistan on 383 patients reported that 59 (15.4%) of patients encountered difficult laryngoscopy, and the sensitivity, specificity, PPV, NPV, and accuracy of the height-thyromental distance ratio showed 84.7%, 90.1%, 60.9%, 97%, and 89.3%, respectively, and the ULBT had 83.1%, 89.2%, 58.3%, 96.7%, and 88.3%, respectively. The MMT yielded results of 30.5%, 84.3%, 26.1%, 86.9%, and 79.9%, respectively. The area under the receiver-operating characteristic curve was significantly greater for the first two tests than for the MMT (37).

A prospective study conducted in West Africa on 380 consecutive patients indicated that 13 (3.4%) patients had difficult laryngoscopy, and with a sensitivity of 61.5%, the MMT was the most sensitive and positive predictive value of the single tests. The five airway predictors had the following sensitivity, specificity, and positive predictive values: mallampati teste (61.5%, 98.4%, and 57.1%), thyromental distance (15.4%, 98.1%, and 22.2%), sternomental distance (0%, 100%, and 0%), HLM (30.8%, 76.0%, and 4.3%), and IIG (30.8%, 97.3%, and 28.6%) (20).

A prospective observational study done in Gondar, Ethiopia, on 212 patients shows that 12.3% of difficult laryngoscopy and MMT and IIL were the sensitive, specific, and positive predictive values and negative predictive values (65.4% 92.5% 54.8% 95.0%) and (73.1% 83.3% 58%

95.7%), respectively, in this study. The most sensitive and second-highest specificity tests are mouth opening < 30 mm and Mallampati classes III and IV (38).

Another cross-sectional study conducted in Ethiopia on 148 patients reported that 12.2% of difficult laryngoscopy was encountered, and the upper bite test was more sensitive (90.2%) and NPV (85.3%). The modified Mallampati test predicted difficult laryngoscopy with 45.8% sensitivity and 86% negative predictive value (NPV). Mallampati class and the upper lip bite test (ULBT) predict a higher likelihood of difficult laryngoscopy (39).

From the above literature, we found that the sensitivity, specificity, and predictive value of MMT, ULBT, NC, HTMD ratio, and NC/TMD ratio were different. According to some studies, intubation is more difficult in obese patients with fatty, shorter necks and a small thyromental distance (TMD). Neck circumference (NC), NC/TMD ratio, and height to thyromental distance (RHTMD) ratio have been presented concerning this concept [17]. It is unclear which method is superior to others in predicting difficult laryngoscopy. As a result, I decided to compare the predictive value of NC, NC/TMD, RHTMD, ULBT, and MMT for difficult laryngoscopy.

2.2 Conceptual framework

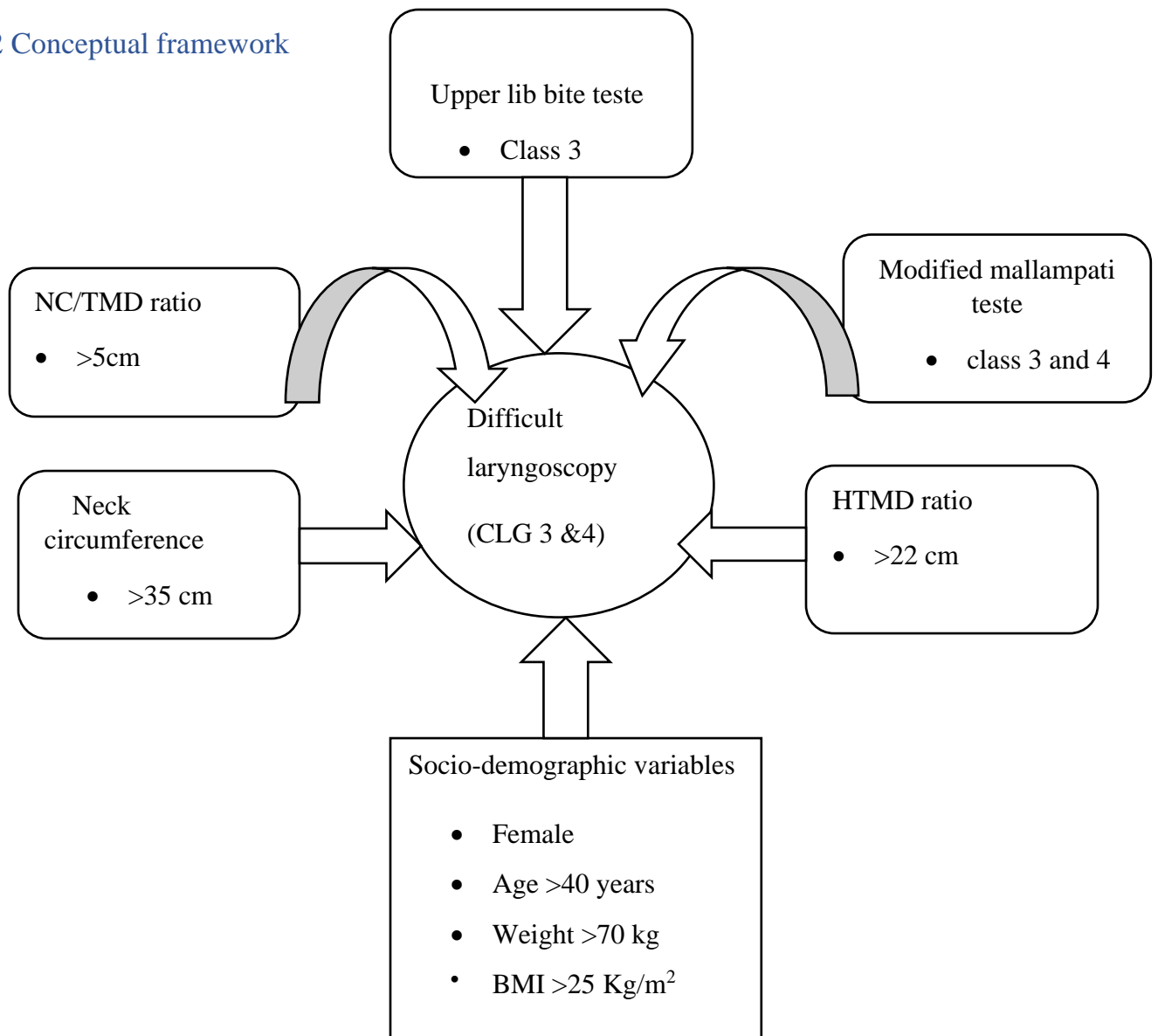


Figure 1:- Conceptual framework showing NC, NC/TMD ratio, RHTMD, ULBT, MMT, and Socio-demographic variables for predicting difficult laryngoscopy; developed by reviewing different works of literature(9)(12)(11) (40).

3. Objective of study

3.1 General objective

To compare the effectiveness of neck circumference, neck circumference to thyromental distance ratio, the ratio of height to thyromental distance, upper lip bite, and modified mallampati tests to predict difficult laryngoscopy among elective adult surgical patients at Addis Ababa Referral Hospitals, Ethiopia, 2023

3.2 Specific objective

1. To determine the magnitude of difficult laryngoscopy among elective adult surgical patients at Addis Ababa Referral Hospitals, Ethiopia, 2023

2 To determine the sensitivity, specificity PPV, and NPV of NC, NC/TMD, RHTMD, ULBT and MMT in predicting difficult laryngoscopy among elective adult surgical patients at Addis Ababa Referral Hospitals, Ethiopia, 2023

3. To compare the sensitivity, specificity, PPV, and NPV of NC, NC/TMD, RHTMD, ULBT and MMT in predicting difficult laryngoscopy among elective adult surgical patients at Addis Ababa Referral Hospitals, Ethiopia, 2023

4. Methods and Materials

4.1 study Area

The study was conducted at government hospitals in Addis Ababa, Ethiopia. Addis Ababa is the capital city of Ethiopia and contains 13 government hospitals and more than 40 private hospitals. The four hospitals were selected based on lottery methods among 13 referral hospitals. This research was conducted at Tikur Anbessa specialized hospital, St. Petros Hospital, St. Paulo's referral hospital, and Zewditu Memorial Hospital.

Tikur Anbessa specialized hospital is an Ethiopian multispecialty tertiary care teaching hospital. Tikur Anbessa specialized hospital is now the primary care teaching hospital for most disciplines in clinical and preclinical training. And it also has more than 700 beds and 12 operating rooms and serves as a teaching and referral hospital. Two additional operating rooms are dedicated to pediatric surgeries, and another table is for ENT cases.

St. Paulo's Millennium Referral Hospital was established in 1968 and since then has grown to include a teaching hospital. It has over 700 beds and 12 operating rooms and serves as a teaching and referral hospital.

St. Petros Hospital was founded in 1953 by Emperor Haile Selassie and was one of the federal hospitals under the Ministry of Health. The hospital is the nation's first tuberculosis referral facility. St. Petros has grown from a single-disease hospital to a multi-service specialized hospital with over 14 specialties and an excellence center. It has 8 operating rooms and serves as a referral hospital.

Zewditu Hospital was founded in the heart of Addis Ababa, Ethiopia. It was established, owned, and administered by the Seventh-day Adventist Church before being nationalized by the Derg administration in 1976. The hospital is named after Empress Zewditu. Zewditu became Ethiopia's largest HIV clinic, caring for over 14,000 patients. It has 8 operating rooms and serves as a referral hospital (41).

4.2 study design and period

A multicentered cross sectional study design was conducted from February 1 to April 30, 2023

4.3 population

4.3.1 source population

All patients who were undergone elective surgical under general anesthesia with ETT at Addis Ababa government referral hospitals.

4.3.2 study population

All randomly selected patients in a daily scheduled lists who fulfilled the inclusion criteria underwent elective surgery under general anesthesia with ETT at Addis Ababa's selected government referral hospitals within the study period.

4.3.3 study unit

The individual patient who was undergone general anesthesia with ETT

4.4 Inclusion and Exclusion criteria

4.4.1 Inclusion criteria

Elective surgical patients, aged 18–65, and ASA states I and II were included.

4.4.2 Exclusion criteria

- Study participants who have known airway difficulties like;
 - Maxillofacial Trauma
 - Congenital facial abnormality
 - DM with positive prayers sign
 - Cervical vertebrate and atlantooccipital joint problem
 - Class III goiter (large goiter mass visible without palpation)
 - Intraoral mass
 - Protrude anterior teeth
 - Severe facial and neck burn contracture
- Patients intubated by less than one-year experience anesthetists include anesthesia students and anesthesiology residents' students
- Obstetrics
- Patients unable to stand erect

4.5 Study Variables

4.5.1 Dependent variable

- Cormack and lehans laryngoscopy grading

4.5.2 Independent variables

- Socio-demographic factors
 - Age
 - sex
 - Height
 - Weight
 - BMI,
- Airway variables (tests):
 - NC
 - TMD
 - NC/TMD ratio
 - HTMD ratio
 - ULBT
 - MMT

4.6 Sample Size determination

The sample size was calculated using a single population proportional formula. Based on a study conducted at Tikur Anbessa specialized hospital in Addis Ababa, Ethiopia, The sample proportion (P) was calculated by assuming a 12.2% magnitude of difficult laryngoscopy (39). With the assumption of a 5% margin of error and a 95% confidence interval, the sample size was determined using the following calculations:

$$n = \frac{(z^{\alpha/2})^2 p(1-p)}{d^2}$$

$$n = 1.96^2 \frac{0.122(1-0.122)}{0.05^2}$$

$$n = 3.841 \times 0.1071 / 0.0025$$

$$n=165$$

where ; n =sample size , $z= 1.96$, $p=0.122$, $d=0.05$, $CI= 95\%$, and $\alpha=5\%$

Add 15% for the nonresponse rate (I, e $165+25=190$); As a result, 190 elective surgical patients were planned for this research.

4.7 Sampling procedure

A situational analysis was performed on the two-month recorded notebook of elective general surgery who are ASA,1&2 and aged between 18-65, they required general anesthesia with ETT. From Tikur Anbessa specialized hospital (206), Zewditu Memorial Hospital (134), St. Petros Hospital (166), and St. Paulo's Millennium Hospital (184) cases were performed in two-month durations. There for these 690 cases were undergo elective surgery with general anesthesia during the study period.

The total sample size of 190 study participants was allocated proportionally to each of the selected hospitals for adult elective surgical patients. The study participant was selected using a systematic random sampling technique from the daily operation schedule lists. The first case was selected by the lottery method from the daily list of operation schedules, and every fourth patient was chosen for each of the hospitals.

Proportional allocation formula

$nh=n*Nh/N$ where: **nh** is the sample size allocated in the hospitals

Nh is the number of elective adult general surgery with ETT in the hospitals.

N is the total number of elective adult general surgery with ETT in selected hospitals

n is the total sample size

the K^{th} value is determined by $N/n=690/190=3.63$

the sample size of each hospital determined by Nh/K^{th} value,

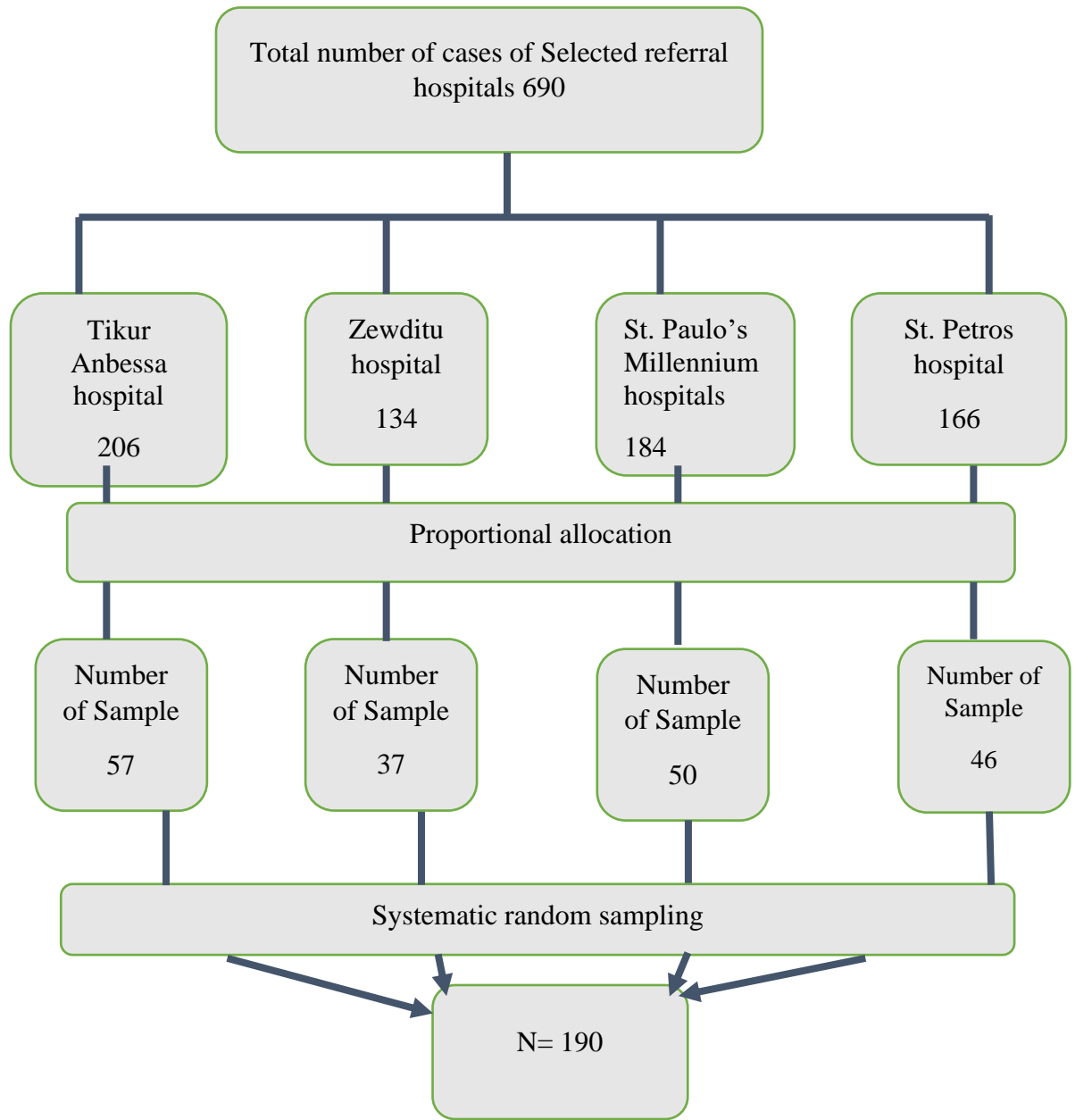


Figure 2: - Schematic presentation of sampling procedure of Comparison of the effectiveness of NC, NC/TMD, RHTMD, ULBT & MMT to predict difficult laryngoscopy among elective adult surgical patients at Addis Ababa Referral Hospitals, 2023.

4.8 Data Collection Methods

The data was collected using an assessment tool adapted from a study conducted by Alemayehu et al. (39). The data was collected by three and above year experienced assigned anesthetists using questionnaires that include pre-anesthetic evaluations such as socio-demographics (age, sex, height, weight, BMI, ASA physical status), elements of airway assessment parameters, intraoperative anesthesia records , and laryngoscope grading.

The questionnaire was pre-tested in 5% of the sample size at Menelik Memorial referral hospital and appropriate modifications were made to the questionnaires according to the pre-test result before the actual data collection. Informed consent was obtained from each patient before data collection

The data collector was assessed the predictors of difficult laryngoscopy before entering the operating room and recorded them on the structured questionnaire. In the operating room, standard monitoring was applied after lying on the bed in the supine position, and the venous line was opened to all patients. All materials were prepared and checked functionally. After preoxygenation of all patients with 100% oxygen, 2mg/kg of fentanyl was administered intravenously, and then anesthesia was induced with 2 mg/kg of propofol IV and 2mg/kg of succinylcholine intravenous for muscle relaxation. Each patient was evaluated for difficult laryngoscopy by an anesthetist with a minimum of two years of work experience. The laryngoscopic grade was assessed and scored with the patient in the sniffing position and no head ring was used . A Macintosh size 3 and 4 laryngoscope blade was used. The patient's Cormack and Lehane's laryngoscopic grade was obtained by the anesthetist who performed the laryngoscopy and documented by the data collector. This study employed the observational data collection method.

4.9 Operational definitions

Difficult laryngoscopy: Define when the Cormack and Lehans grades were three or four.

Cormack and Lehan's grading (3)

Grade I: Complete visualization of the laryngeal aperture

Grade II: if only visualization of the posterior commissure of the laryngeal aperture

Grade III: If only the epiglottis is visible

Grade IV: If only the soft palate is visualized

MMT; it assessed which the seated patient in neutral position will be asked to open the mouth fully with the tongue protruding maximally without phonation and evaluated as (6)

- Class I – pillars, uvula, and soft palate are seen
- Class II – uvula, fauces, and soft palates are seen
- Class III – base of the uvula and soft palate are seen
- Class IV – soft palate not visible

TMD; It measured by setting an upright position from the chin (mentum) to the top of the notch of the thyroid cartilage with the head fully extended and mouth closed, adult TMD <6 cm is a risk of difficulty (2).

NC; it was measured at the level of the cricoid cartilage on subjects in setting upright position , looking forward, with shoulders relaxed (10).

ULBT classification (7)

- Class 1-lower incisors can bite the upper lip above the vermilion line.
- Class 2-lower incisors can bite the upper lip below the vermilion line.
- Class 3-lower incisors cannot bite the upper lip

Height; it measured with the patient in barefoot against the floor.

RHTMD; height /TMD (in cm)

NC/TMD; NC (in cm)/TMD (in cm).

True positive: A DL that will be predicted to be difficult.

False positive: An easy laryngoscopy that will be predicted to be difficult.

True negative: An easy laryngoscopy that will be predicted to be easy.

False negative; A DL that will be predicted to be easy.

Sensitivity is the proportion of accurately predicted DLs that are genuinely difficult.
($TP/TP+FN$).

Specificity is s the proportion of accurately predicted ELs that are genuinely easy. ($TN/TN+FP$).

Positive predictive value (PPV): The proportion of accurately predicted DLs to all anticipated DLs ($TP/TP+FP$).

Negative predictive value (NPV): - The proportion of accurately predicted ELs to all anticipated ELs ($TP/TP+FN$).

Accuracy = the percentage of accurately anticipated easy or DLs as a proportion of all intubations ($TP+FN/TP+TN+FP+FN$)

Receiver Operating Characteristic (ROC) curves can be utilized for comparing the diagnostic performance of a variety of screening tests or investigating the prediction power of two or more variables for the same patient.

4.10 Data quality control

To assure quality, all data collector and supervisor received a half-day of training. The questionnaire was also pre-tested. The supervisor and investigator were closely supervised and checked the data collection process and the collected data every day in data collection time for its completeness, clarity, and consistency. Confidentiality and privacy were assured during the study.

4.11 Data processing and analysis

The collected data were reviewed for completeness, manually cleaned, coded, and put into Epi Data version 4.6 software before being exported to SPSS version 26 for further analysis. Age, weight, height, and BMI were provided quantitatively as mean and standard deviation. For qualitative variables such as sex and for predictors of difficult laryngoscopy after transformation into easy and difficult laryngoscopy, they were provided as frequency and percentage. Shapiro-

Wilk tests were used to determine the normality of age, weight, height, and BMI. To compare the mean difference, a t-test was utilized, and to compare the proportion difference between difficult and easy laryngoscopy, a chi-square test was used.

SPSS 26 software was used to perform descriptive statistics and calculate a p-value. The P value (< 0.05) was deemed as statistically significant. Receiver operating characteristic (ROC) curve analyses were performed on Medcalc statistical software version 20.215 to identify the cutoff values of NC, NC/TMD, and RHTMD and to compare the five airway bedside tests. To determine the most discriminative test, the AUC of the ROC was compared. The diagnostic significance of predictors of difficult laryngoscopy was assessed using receiver-operating characteristic (ROC) curves, and the cut-off point was identified in Youden index. Diagnostic parameters or screening tests like sensitivity, specificity, PPV, and NPV were carried out using crosstabs on SPSS version 26 and 95% confidence intervals on the ROC curve, whereas positive likelihood ratio, negative likelihood ratio, and accuracy were identified manually from the descriptive statistics.

4.12 Ethical Considerations

Ethical approval of the research proposal was obtained from the Institutional Review Board (IRB) of the College of Health Sciences at Addis Ababa University. A formal letter was obtained from the anesthesia department, and an acceptance letter was provided from each hospital to perform the study. Each respondent was informed about the study's goal during the data collection period, and agreement was obtained from each of the study participants. Throughout the study, confidentiality and anonymity were preserved.

4.13 Dissemination of result

A hard and soft copy of the final document of this research was given to the anesthesia department, and a presentation will be made to the Addis Ababa University College of Medicine and Health Sciences community. Finally, the manuscript will be provided to the Addis Ababa University College of Health Science and to each hospital. Additionally, an effort will be made to access the results publicly through publications in reputable journals.

5. Results

A total of 190 ASA I and II and age 18–65 study participants were included in the study. Among study participants, 99 (52.1%) were females and 91 (47.3%) were males. The mean age was 41.46. The mean weight and height of the participant were (63.78) and (168.53), respectively. The mean BMI of the participants was also 22.35.

Table 1: Socio-demographic characteristics of a study participant among elective adult surgical patients at Addis Ababa Referral Hospitals, 2023.

Variables	value	EVL	DVL	P value
Age (mean ±SD)	41.46±13.022	40.43±13.004	48.24±11.163	.005
Sex f (%)				
Male	91(47.9%)	79(86.8%)	12(13.2%)	.991
Female	99(52.1%)	86(86.9%)	13(13.1%)	
Height (mean ± SD)	168.53±6.485	168.71±6.474	167.32±6.556	.320
Weight (mean ± SD)	63.78±9.582	62.45±8.871	72.52±9.683	.000
BMI (mean ± SD)	22.3548±3.2832	21.8116±2.87925	25.9400±3.58050	.000

SD= standard deviation, f= frequency. BMI=body mass index, EVL=Easy visualization of laryngoscopy, DVL=difficult visualization of laryngoscopy

In this study, the Cutoff value of Neck circumference was determined by ROC curve as >37 cm at 60% sensitivity and 84.24% specificity.

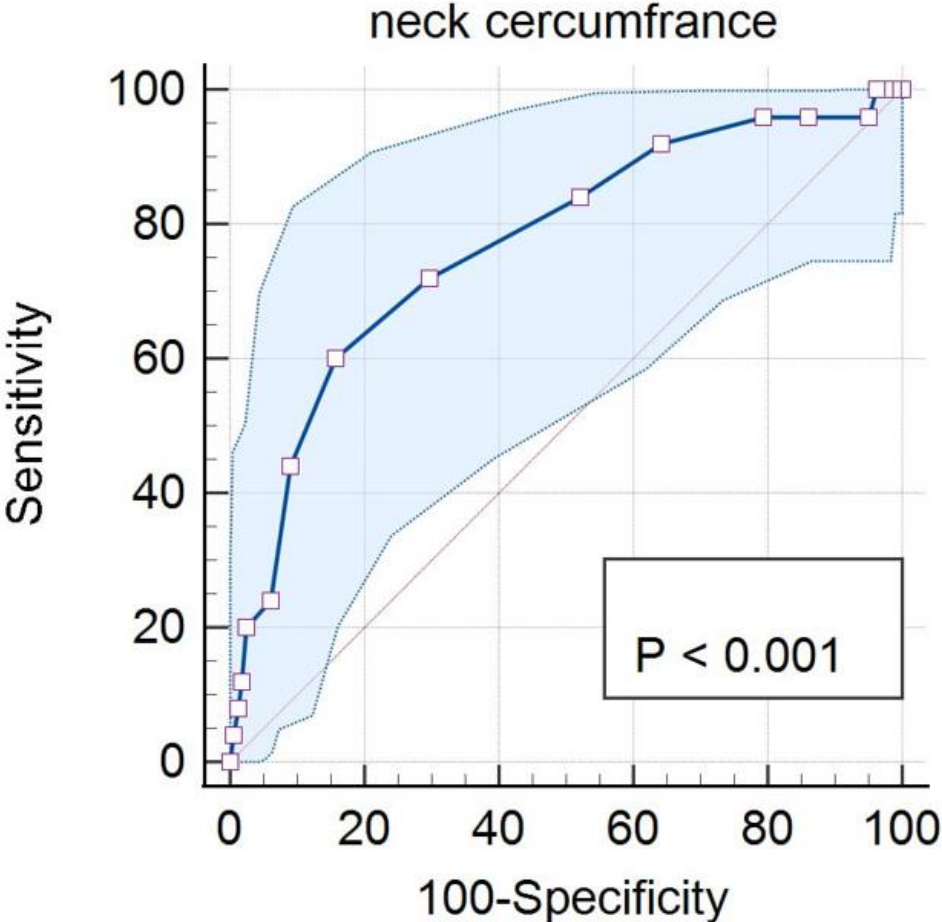


Figure 3: - The Receiver operative characteristics curve for neck circumference

The RHTMD cutoff value (>22cm) was determined by ROC curve analysis at 72% sensitivity and 95.76% specificity

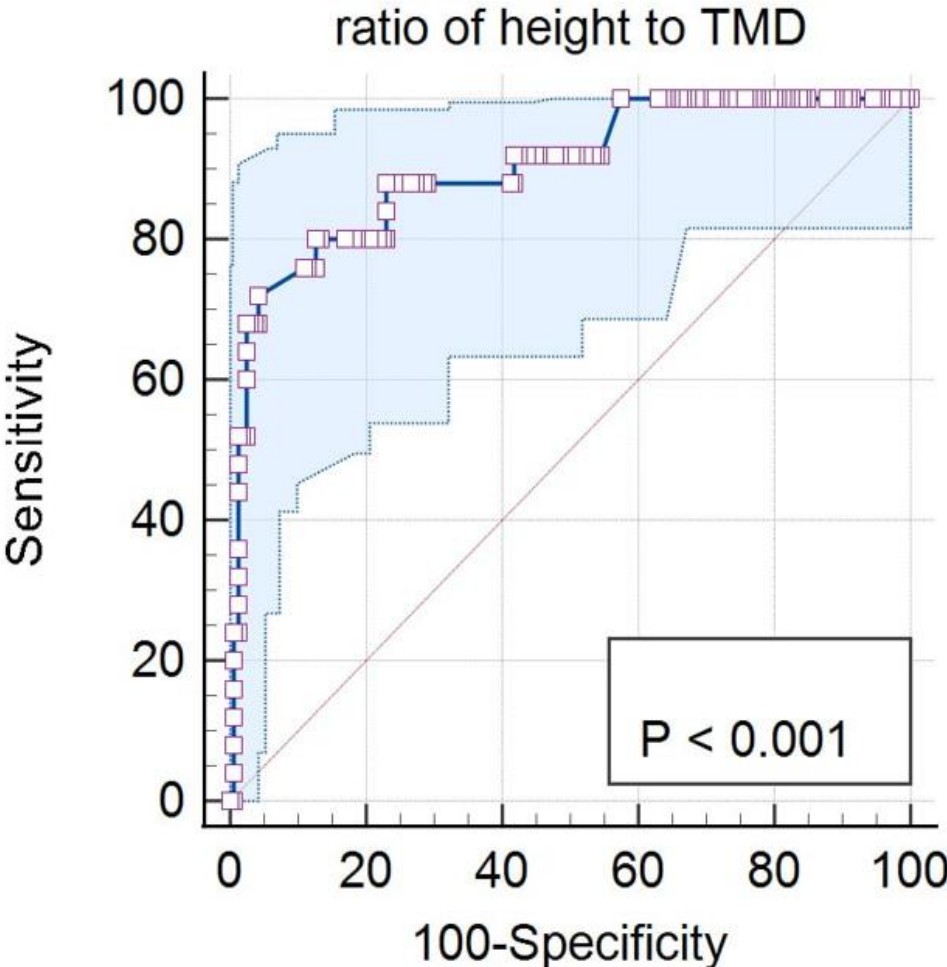


Figure 4: - The Receiver operative characteristics curve for ratio of height to thyromental distance

The NC/TMD cutoff value (>4.66cm) was determined by ROC curve analysis at 68% sensitivity and 86.06% specificity .

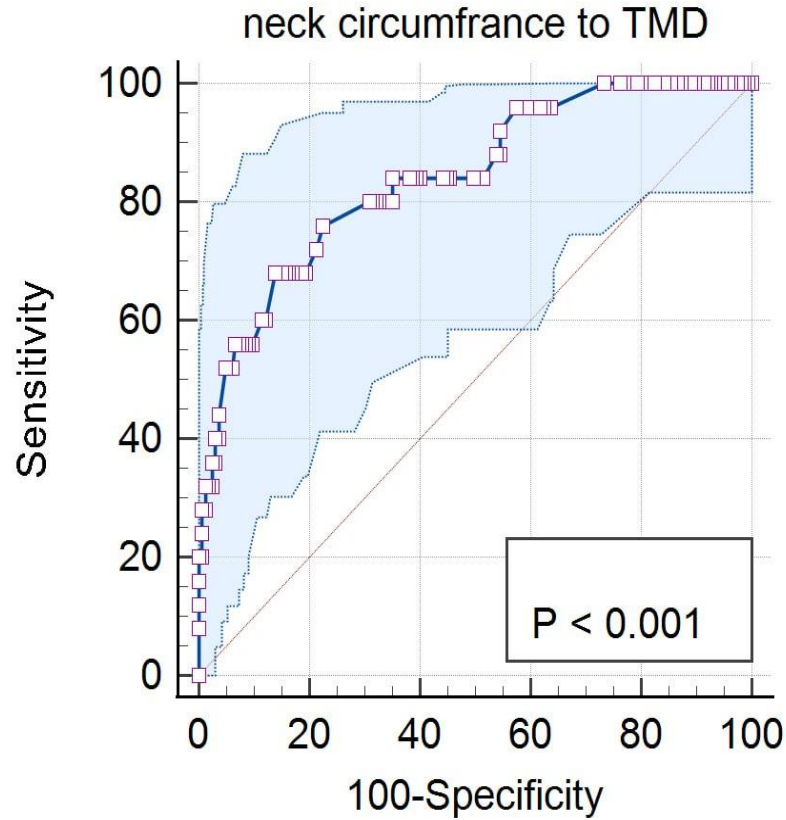
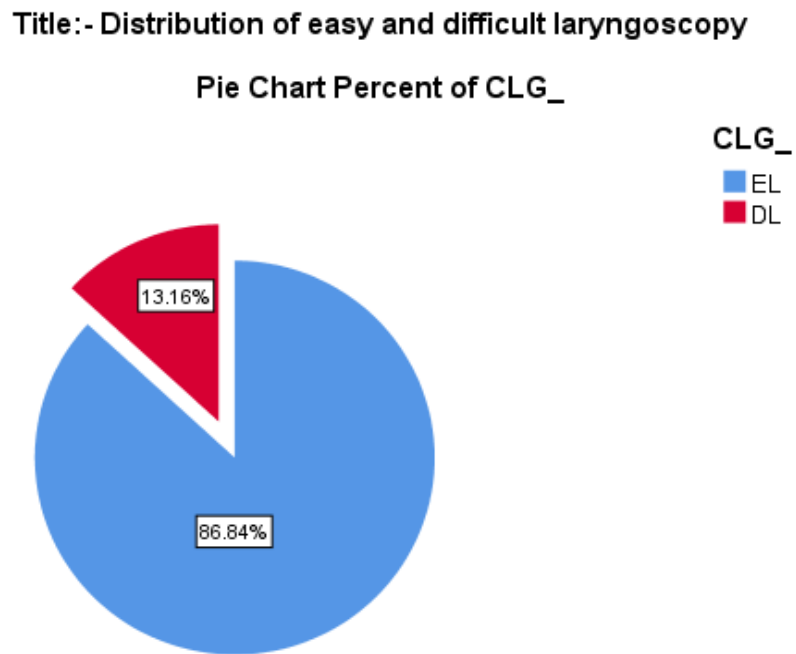


Figure 5: - The Receiver operative characteristics curve for ratio of neck circumference to thyromental distance

Table 2: - Youden index for NC, NC/TMD and RHTMD

category	RHTMD	NC	NC/TMD
Significance level P (Area=0.5)	<0.001	<0.001	<0.001
Youden index J	0.6776	0.4424	0.5406
Associated criterion	>22	>37	>4.66
Sensitivity	72.00%	60%	68%
Specificity	95.76 %	84.24%	86.06%

The magnitude of difficult laryngoscopy in this study was 25 (13.2%). Out of the 25 difficult laryngoscopies, 23 had Cormack and lehans grade III, and 2 study participants had Cormack and lehans grade IV.



EL= easy laryngoscopy, DE=difficult laryngoscopy and CLG= Cormack and lehans grading

Figure 6: - Graphical presentation of the distribution of easy and difficult laryngoscopy among elective adult surgical patients at Addis Ababa selected Referral Hospitals, 2023.

From table 3: - 41 (21.6%) of study participants with NC, 40 (21.1%) of study participants with NC/TMD, and 25 (13.2%) of study participants with RHTMD greater than 22 cm are considered difficult laryngoscopies.

28 (14.7%) of study participants with MMT III and IV and 22 (11.6%) of study participants with ULBT III are considered to have a difficult laryngoscopy.

Table 3: Distribution of NC, NC/TMD, RHTMD, TMD, MMT and ULBT in easy and difficult laryngoscopy among a study participant of elective adult surgical patients at Addis Ababa Referral Hospitals, 2023.

Variable	Category	Frequency	percentage (%)
NC (cm)	<37	149	78.4%
	>37	41	21.6%
NC/TMD	<4.66	150	78.9%
	>4.66	40	21.1%
RHTMD	<22	165	86.8%
	>22	25	13.2%
TMD (cm)	>6	176	92.6%
	<6	14	7.4%
MMT	I&II	162	85.3%
	III &IV	28	14.7%
ULBT	I& II	168	88.4%
	III	22	11.6%
CLG	I	96	50.5%
	II	69	36.3%
	III	23	11.6%
	IV	2	1.6%

NC=neck circumference, NC/TMD= neck circumference to thyromental distance ratio, RHTMD=ratio of height to thyromental distance, TMD=thyromental distance, MMT=modified mallampati test, ULBT=upper lip bite test, Cormack and lehans grading

The predictive values of NC, NC/TMD, RHTMD, MMT, and ULBT in predicting difficult laryngoscopy (sensitivity, specificity, PPV, NPV, PLR, NLR, and accuracy), are presented in Table 4. The area under the curve rates for ULBT (0.871) and RHTMD (0.839) were higher than those obtained from other tests, and this difference was statistically significant ($P < 0.05$). The AUC of MMT (0.784) is slightly higher than NC/TMD (0.770) and NC (0.721).

Upper lip bite test (ULBT) had a sensitivity of 76% (sensitivity = 76%.95% CI), and the RHTMD had a higher sensitivity than MMT at a sensitivity of 72% and a sensitivity of 64%, respectively. ULBT and RHTMD had specificities of (specificity = 98.2%, 95% CI) and (specificity = 95.7%, 95% CI), respectively. ULBT and RHTMD had PPVs of 86.4% and 72%, respectively. Neck circumference was low at 36.6% of PPV and had a high negative likelihood ratio (0.47).

Table 4:- The predictive valve of NC, NC/TMD ratio, RHTMD, MMT and ULBT to predict difficult laryngoscopy based on CLG classification of all included patients among elective adult surgical patients at Addis Ababa Referral Hospitals, 2023.

Tests	SN	SP	PPV	NPV	+LR	_LR	AUC	Accuracy	95% CI	P value
NC	60%	84.24%	36.6%	93.3%	3.8	0.47	0.721	81%	0.652 -0.784	<.001
NC/TMD	68%	86.06%	42.5%	94.7%	4.88	0.37	0.770	83.6%	0.704 -0.828	<.001
RHTMD	72%	95.8%	72%	95.8%	16.9	0.04	0.839	92.6%	0.779 -0.888	<.001
MMT	64%	92.7%	57.1%	94.4%	8.8	0.38	0.784	88.9%	0.718 -0.840	<.001
ULBT	76%	98.2%	86.4%	96.4%	41.8	0.24	0.871	95.2%	0.815-0.915	<.001

Sensitivity=SN, Specificity=SP, PPV=positive predictive value, NPV=negative predictive value, +LR= positive likelihood ratio, _LR= negative likelihood ratio, AUC= area under the curve,95%CL= 95% of confidential interval

The AUC values of NC, NC/TMD, RTMD, MMT, and ULBT were above 0.5, indicating that these variables performed better than chance. A statistical significance ($P < 0.05$) was evident for the diagnostic accuracy. The ROC of the area under the curve of ULBT (AUC = 0.871) and RHTMD (AUC = 0.839) was higher than other airway assessment parameters, and it showed excellent discrimination and the highest screening of true positive rates, followed by MMT (AUC = 0.784), NC/TMD (AUC = 0.770), and NC (AUC = 0.721).

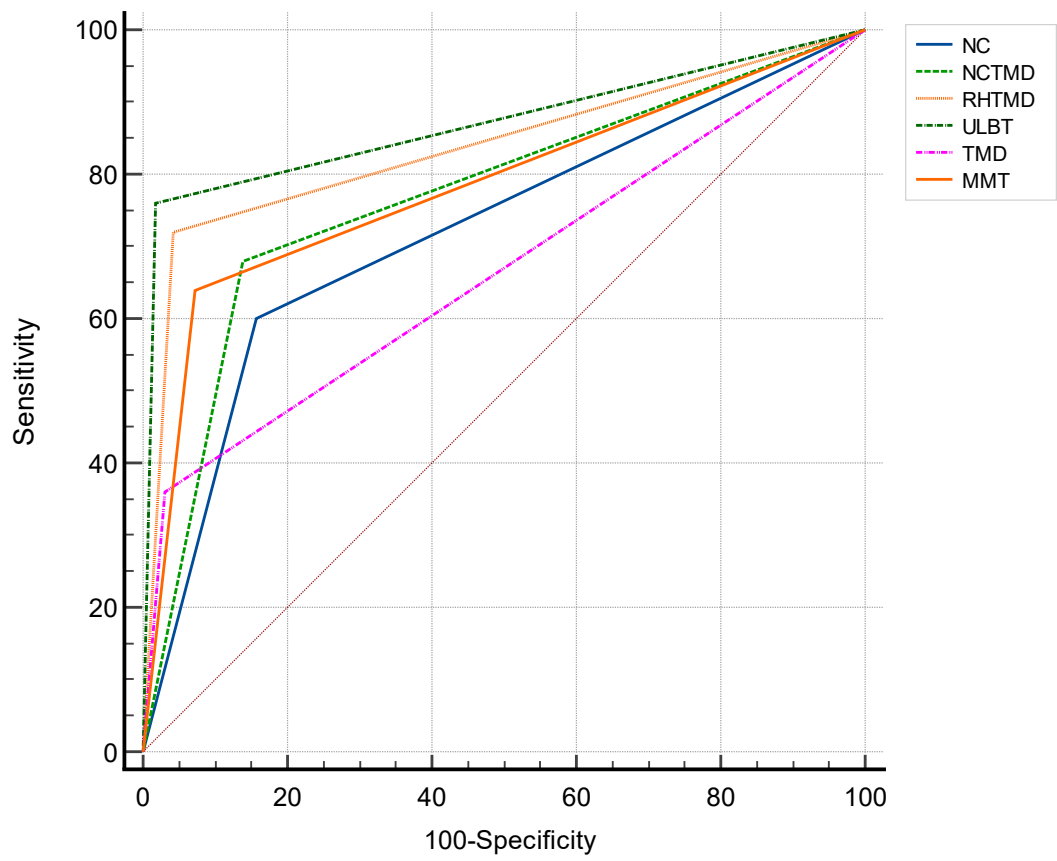


Figure 7:- Comparison of the Receiver operating characteristics curve of NC, NC/TMD ratio RHTMD, TMD, MMT and ULBT for prediction of difficult laryngoscopy according to CLG classification among elective adult surgical patients at Addis Ababa Referral Hospitals, 2023

6. Discussion

A major concern for anesthetist is the prediction of a difficult airway in order to avoid unexpectedly difficult tracheal intubation and the events that follow, as well as to create a plan to turn a difficult intubation into an easy one.

The magnitude of difficult laryngoscopy in this research was 13.2%. The incidence of challenging DL in a meta-analysis of elective anesthetic trials were ranged from 6% to 27% (3). This result's findings were consistent with those of previous research conducted in Ethiopia at different time, which found a 12.2% (39) and 12.3% (38) prevalence of difficult laryngoscopy respectively. Another literatures showed the magnitude of difficult laryngoscopy as 14.7%, 6.8%, 12.5%, 13.95%, and 16% (10,15,31,32,42). Differences in the prevalence of DVL have been linked to a variety of factors, including population differences in anthropomorphic features, a lack of consistency in describing or grading laryngeal views, cricoid pressure application, head position, degree of muscle relaxation, and the type or size of laryngoscope blade (32).

Each method used to predict difficult laryngoscopy and intubation has its own limitations, and no single test has demonstrated 100% sensitivity and specificity (7). Single screening tests have been demonstrated in trials to have low predictive power for difficult airways, and combinations of these single tests or risk variables have been considered to be better diagnostic than each test alone (10).

Preoperative airway assessment tests should be very sensitive to accurately anticipate the highest number of patients requiring difficult laryngoscopy, highly specific to correctly predict easy laryngoscopy, have a high PPV (so that just a few individuals with easy laryngoscopy), have few NPV to minimize adverse and even potentially fatal consequences and have a higher PLR for evaluating the usefulness of a predictive tool in every day practice (42).

In this study, patients with easy and difficult laryngoscopy had comparable demographic factors such as mean height (168.71 cm and 167.32cm, respectively) and sex in frequency: 79 (86.8%) easy and 12 (13.2%) difficulty in men, and 86 (86.9%) easy and 13 (13.1%) difficult laryngoscopy in females. However, the mean age was 40.43 in easy and 48.24 in difficult, the weight was 62.45 in easy and 72.52 in difficult, and the BMI was 21.8 in easy and 25.94 in

difficult. This shows the difficult laryngoscopy group was significantly higher. A Similar study reported by Smita P. (13), showed that the mean age, weight, and BMI were higher in the difficulty group, whereas sex and height were comparable in both groups. Another similar study conducted by Pratibha J. et al. (42), found the mean age of the patient in the easy (41.0) and difficult (46.7) groups and a BMI of 23.7 in the easy laryngoscopy group and 26.6 in the difficult laryngoscopy group, which was statistically high in the difficult laryngoscopy group. The difference in easy and difficult group might be due to pre-tracheal fat at the level of the vocal cords, variable length of the mandible and neck, and also different volumes of soft tissue and tongue according to a proportion of body size (11).

In this study, ULBT showed the best predictor of difficult laryngoscopy with a higher sensitivity (76%), specificity (98.2%), PPV (86.4%), accuracy (95.2%), and AUC of (0.871). This result was comparable with Alemayehu . (39), who showed Upper Lip Bite Test (ULBT) had the highest sensitive of (90.2%), and another study by Azim H. et al. (33) and Jeong. (35), found ULBT was the most sensitive of the single tests, with a sensitivity of 90.2% and the highest specificity of single test (95.2%), respectively. Pratibha J. et al. (42), compared ULBT and RHTMD with other various bedside tests for predicting difficult laryngoscopy and reported that ULBT had the highest sensitivity, specificity, PPV, NPV +LR as 74.63%, 91.53%, 58.82%, 95.7%, and 31.76% respectively. Despite performing well on all another and our statistical tests, another study's showed low sensitivity (45%) by Shoba p, et al. (15) and by Eberhart. (8) sensitivity of 28%. Differences in various research findings might be due to dental (maxillary and mandibular morphology and morphometry) and craniofacial variation among ethnicities(13).

The sensitivity, specificity, PPV, NPV, and accuracy of RHTMD at a threshold value of >22 cm for predicting difficult laryngoscopy were (72%), (95.8%), (72%), (95.8%), and (92.6%), respectively, in this study. This was in line with Pratibha J et al. (42), who reported the sensitivity, specificity, PPV, and NPV of RHTMD at different cut-off values > 23.5 as 71.64%, 92.01%, 59.26%, and 95.24%, respectively. Another comparable result was found by Krobbuaban et al.(31), who reported 77% sensitivity of RHTMD at the cutoff value of >23.5 and by Azim H et al. (10), who found a sensitivity of (64.77%) RHTMD at the cut of value of >22.7 at 0.764 of AUC for predicting difficult laryngoscopy. A study done by Liaskou C et al. (43), found the predictive value of RHTMD at a cutoff value of >18.4cm with a higher

sensitivity of 88.4% but poor specificity (33.2% and PPV (16%) and another study by Mohammadreza S et al. (32), reported 75.62% of sensitivity and 96.2% of PPV. Azim H. et al. (33), reported that the cutoff point for RHTMD for the prediction of direct laryngoscopy was race-dependent, and it is recommended that the cutoff point be calculated separately for each population.. According to various studies, the RHTMD cutoff values for predicting difficult laryngoscopy range from 18.4 cm to 25 cm. Variations with the results of this study might be due to the cut value difference, ethnicity and physical characteristics of the study population.

In this study Modified mallampati test was found to have 64% sensitivity ,92.7% of specificity, 57.1% of PPV and 88.9% of accuracy. This result was comparable with the following study: Barsha S. et al.(44), found Modified Mallampati Score of 89.1% specificity, 57% PPV and 87.3 % of diagnostic accuracy ; Shoba et al.(15), found a sensitivity of 65%; Sileshi A. et al. (39), research done in Gondar, Ethiopia; and a study by Nkihu A. et al. (22), in East Africa, found mallampati teste to have sensitivity, specificity, and PPV of (75%), (91.7%) & (48.4%) and (61.5 %), (98.4%) & (57.1%) respectively. However, this result was in contrast to studies conducted by Ashem J. et al. (45) and Pratibha J. et al. (42), who reported that modified mallampati test had low sensitivity, specificity and PPV. This difference might be due to inadequate mobility of the head and neck; the influence of phonation and the patient's cooperation result in high inter-observer variability and decreased reliability.

This study revealed NC/TMD greater than 4.66 cm was a predictor of difficult laryngoscopy at a sensitivity, specificity, PPV, and accuracy of 68%, 86.1%, 42.5%, and 83.6% respectively. This result was relatively in line with Azim H. et al. (10), who found NC/TMD at > 5.13 cm with 57.95 % of sensitivity & 72 % of specificity. Kim et al. found the predictive value of difficult intubation of NC/TMD at a cutoff value of >5 in obese and non-obese study participants whose BMI>27.5kg/m² as sensitivity (88.2%), specificity (83.0%), and PPV (45.5%)(12). Variations in the results of this study might be due to differences in BMI and cutoff point.

In this study NC greater than 37 cm was a predictor of difficult laryngoscopy at a sensitivity, specificity, PPV, and accuracy of 60%, 84.2 %, 36.6%,and 81% respectively. A study conducted by Liaskou C. et al. (43), found NC at the cutoff value of 37.5 cm was comparable to our result in sensitivity (69.8%) and NPV (91.1%) but different specificity (44.6%) and PPV (15.4%). Azim H. et al. (10), found NC greater than 41cm had 26.14% of sensitivity, 98.24% of

specificity, and 71.9% of PPV. Another study by Venkata et al. (44), showed that neck circumference at a cutoff value of >37.5cm had lowest specificity (32.41%), PPV (7.98%), and accuracy (35.1) among a test, the use of NC in predicting difficult laryngoscopy/intubation is influenced on the BMI of those being studied, with most research focusing on patients with BMIs more than 35 kg/m². for an NC of 40 cm, there is a 5% chance of difficult intubation in patients with a BMI more than 40 kg/m², increasing to 35% for an NC of 60 cm. The result showed that NC had a lower ability to identify a true positive rate and a true negative rate for screening of difficult laryngoscopy compared to other bedside testes.

This study showed the positive predictive values of ULBT, RHTMD, and MMT as 85.7%, 72%, and 57.1%, respectively. In contrast to the above finding, Azim H et al.(33), showed low PPV for MMT (13.6%), ULBT (16.3%), and RHTMD (34.3%), with moderate to high sensitivity and specificity. The variations in the results of this study might be due to differences in ethnicity, physical characteristics, cutoff values, subjective measurement and grading classifications and sample size.

Strength

This study was performed in a multi-center area, and we identified the cutoff values of RHTMD, NC/TMD, and NC and determined their predictive value. All the study participants' laryngoscopic grades were identified by a minimum of two-year anesthesia providers.

limitation of the study

Our study only included elective surgical patients; emergency patients, extremes of age, and pregnant women were excluded, this affects the generalizability of the study to all groups. There is a possibility of observer bias in subjective measurements and interobserver variability in laryngoscopic grading.

7. Conclusion and recommendation

7.1 Conclusion

The magnitude of difficult laryngoscopy was 13.2% among elective adult surgical patients at Addis Ababa Referral Hospitals, Ethiopia.

The cutoff value of NC, NC/TMD ratio, and RHTMD for prediction of difficult laryngoscopy in our population were $>37\text{cm}$, $>4.66\text{ cm}$, and $>22\text{cm}$ respectively.

The ROC curve showed ULBT and RHTMD had the larger AUCs of 0.871 and 0.839, respectively, which have excellent predictions of difficult laryngoscopy compared to other airway assessment tests. ULBT showed the most accurate diagnostic test, and RHTMD and MMT had comparable diagnostic accuracy. ULBT and RHTMD showed the highest sensitivity, specificity, and positive predictive value, and NC/TMD and NC had comparable screening abilities to the true negative rate. ULBT showed a higher positive likelihood ratio. NC had a lower sensitivity, a higher positive predictive value, and a higher negative likelihood ratio. In general, all these tests had a higher diagnostic accuracy value, so they can be used effectively as bedside screening tests to predict difficult laryngoscopy before surgery in the general population.

As we conclude, out of the five predictive tests, the upper lip bit test (ULBT) is the best predictor of difficult laryngoscopy. The height-to-thyromental-distance ratio (RHTMD) and MMT are appropriate options with good predictability. Because the etiology of difficult airways is multifaceted, combining ULBT and RHTMD with other regularly used predictive tests might be beneficial in improving difficult airway prediction. In general, anesthetist should anticipate challenging laryngoscopy in an apparently normal airway since the magnitude of difficult laryngoscopy is not minor.

7.2 Recommendation

We recommend using ULBT and RHTMD to accurately diagnose difficult airways. We recommend using the cutoff value for only our population; since there is a difference in race, it may not be appropriate for other populations. We recommend preparing airway assessment guidelines to anticipate difficult airways. We recommend studying different airway assessment tools with a larger sample size and including high risk populations.

REFERENCES

1. Gupta S, Sharma R, Jain D. Airway assessment: predictors of difficult airway. *Indian J Anaesth.* 2005;49(4):257–62.
2. Orebaugh SL, Bigeleisen PE. *Atlas of airway management: techniques and tools.* Lippincott Williams & Wilkins; 2012.
3. Brown CA, Sakles JC, Mick NW. *The Walls manual of emergency airway management.* Lippincott Williams & Wilkins; 2017.
4. Apfelbaum JL, Hagberg CA, Connis RT, Abdelmalak BB, Agarkar M, Dutton RP, et al. 2022 American Society of Anesthesiologists practice guidelines for management of the difficult airway. *Anesthesiology.* 2022;136(1):31–81.
5. Gupta K, Gupta PK. Assessment of difficult laryngoscopy by electronically measured maxillo-pharyngeal angle on lateral cervical radiograph: A prospective study. *Saudi J Anaesth.* 2010 Sep;4(3):158–62.
6. Sanyal R, Ray S, Chakraverty P, Bhattacharya MK. Comparison of airway assessment by Mallampati classification and cormack and lehane grading in Indian population. *Indian J Clin Anaesth.* 2019;6(1):140–2.
7. Khan ZH, Mofrad MK, Arbabi S, Javid MJ, Makarem J. Upper lip bite test as a predictor of difficult mask ventilation: a prospective study. *Middle East J Anaesthesiol.* 2009 Oct;20(3):377–82.
8. Eberhart LHJ, Arndt C, Cierpka T, Schwanekamp J, Wulf H, Putzke C. The reliability and validity of the upper lip bite test compared with the Mallampati classification to predict difficult laryngoscopy: an external prospective evaluation. *Anesth Analg.* 2005;101(1):284–9.
9. Schmitt HJ, Kirmse M, Radespiel-Troger M. Ratio of Patient's Height to Thyromental Distance Improves Prediction of Difficult Laryngoscopy. *Anaesth Intensive Care.* 2002;30:763–5.
10. Honarmand A, Safavi M, Yaraghi A, Attari M, Khazaei M, Zamani M. Comparison of

five methods in predicting difficult laryngoscopy: Neck circumference, neck circumference to thyromental distance ratio, the ratio of height to thyromental distance, upper lip bite test and Mallampati test. *Adv Biomed Res.* 2015;4.

11. Gonzalez H, Minville V, Delanoue K, Mazerolles M, Concina D, Fourcade O. The importance of increased neck circumference to intubation difficulties in obese patients. *Anesth Analg.* 2008 Apr;106(4):1132–6, table of contents.
12. Kim WH, Ahn HJ, Lee CJ, Shin BS, Ko JS, Choi SJ, et al. Neck circumference to thyromental distance ratio: a new predictor of difficult intubation in obese patients. *Br J Anaesth.* 2011;106(5):743–8.
13. Hester CE, Dietrich SA, White SW, Secrest JA, Lindgren KR, Smith T. A comparison of preoperative airway assessment techniques: the modified Mallampati and the upper lip bite test. *AANA J.* 2007;75(3).
14. Bradley P, Chapman G, Crooke B, Greenland K. Airway assessment. *Aust New Zeal Coll Anaesth.* 2016;
15. Philip S, Nizar FF. Prediction of difficult laryngoscopy in patients undergoing endotracheal intubation: A comparative study of various airway assessment tests. *Astrocyte.* 2016;3(2):90.
16. Salimi A, Farzanegan B, Rastegarpour A, Kolahi A-A. Comparison of the upper lip bite test with measurement of thyromental distance for prediction of difficult intubations. *Acta Anaesthesiol Taiwanica.* 2008;46(2):61–5.
17. Metzner J, Posner KL, Lam MS, Domino KB. Closed claims’ analysis. *Best Pract Res Clin Anaesthesiol.* 2011;25(2):263–76.
18. Cook TM, MacDougall-Davis SR. Complications and failure of airway management. *BJA Br J Anaesth [Internet].* 2012 Dec 1;109(suppl_1):i68–85. Available from: <https://doi.org/10.1093/bja/aes393>
19. Crawley SM, Dalton AJ. Predicting the difficult airway. *BJA Educ.* 2015;15(5):253–8.
20. Merah NA, Wong DT, Ffoulkes-Crabbe DJ, Kushimo OT, Bode CO. Modified

- Mallampati test, thyromental distance and inter-incisor gap are the best predictors of difficult laryngoscopy in West Africans. *Can J anaesthesia= J Can d'anesthesie*. 2005;52(3):291–6.
21. El-Radaideh K, Dheeb E, Shbool H, Garaibeh S, Bataineh A, Khraise W, et al. Evaluation of different airway tests to determine difficult intubation in apparently normal adult patients undergoing surgical procedures. *Patient Saf Surg*. 2020;14(1):1–8.
 22. Srinivasan C, Kuppuswamy B. Comparison of validity of airway assessment tests for predicting difficult intubation. In: *The Indian Anaesthetists Forum*. Medknow Publications; 2017. p. 63.
 23. Prakash S, Kumar A, Bhandari S, Mullick P, Singh R, Gogia AR. Difficult laryngoscopy and intubation in the Indian population: An assessment of anatomical and clinical risk factors. *Indian J Anaesth*. 2013;57(6):569.
 24. Nadia R. Comparison of Difficult Intubation and Neck Circumference to Thyromental Distance Ratio. *Obese Non-Obese A Clin Study J Med Sci Clin Res*. 2017;5(3):19670–9.
 25. Kassie AM, Abate BB, Kassaw MW. Prevalence of overweight/obesity among the adult population in Ethiopia: a systematic review and meta-analysis. *BMJ Open*. 2020 Aug;10(8):e039200.
 26. Yadav BB, Mishra V, Bogra J, Agarwal A, Rai S, Prakash A. Evaluation of modified Mallampati score with neck circumference and thyromental distance to predict difficult intubation in non-obese patients. 2019;
 27. Sinaga M, Worku M, Yemane T, Tegene E, Wakayo T, Girma T, et al. Optimal cut-off for obesity and markers of metabolic syndrome for Ethiopian adults. *Nutr J [Internet]*. 2018;17(1):109. Available from: <https://doi.org/10.1186/s12937-018-0416-0>
 28. Oria MS, Halimi SA, Negin F, Asady A. Predisposing Factors of Difficult Tracheal Intubation Among Adult Patients in Aliabad Teaching Hospital in Kabul, Afghanistan - A Prospective Observational Study. *Int J Gen Med*. 2022;15:1161–9.
 29. Cook TM, Woodall N, Frerk C, Project FNA. Major complications of airway management in the UK: results of the Fourth National Audit Project of the Royal College of

- Anaesthetists and the Difficult Airway Society. Part 1: anaesthesia. *Br J Anaesth*. 2011;106(5):617–31.
30. Shailaja S, Nichelle SM, Shetty AK, Hegde BR. Comparing ease of intubation in obese and lean patients using intubation difficulty scale. *Anesth essays Res*. 2014;8(2):168–74.
 31. Krobbuaban B, Diregpoke S, Kumkeaw S, Tanomsat M. The predictive value of the height ratio and thyromental distance: four predictive tests for difficult laryngoscopy. *Anesth Analg*. 2005;101(5):1542–5.
 32. Safavi M, Honarmand A, Zare N. A comparison of the ratio of patient's height to thyromental distance with the modified Mallampati and the upper lip bite test in predicting difficult laryngoscopy. *Saudi J Anaesth*. 2011;5(3):258.
 33. Honarmand A, Safavi M, Ansari N. A comparison of between hyomental distance ratios, ratio of height to thyromental, modified Mallampati classification test and upper lip bite test in predicting difficult laryngoscopy of patients undergoing general anesthesia. *Adv Biomed Res*. 2014;3.
 34. Wajekar AS, Chellam S, Toal P V. Prediction of ease of laryngoscopy and intubation-role of upper lip bite test, modified mallampati classification, and thyromental distance in various combination. *J Fam Med Prim care*. 2015;4(1):101.
 35. Min JJ, Kim G, Kim E, Lee J-H. The diagnostic validity of clinical airway assessments for predicting difficult laryngoscopy using a grey zone approach. *J Int Med Res*. 2016;44(4):893–904.
 36. Roth D, Pace NL, Lee A, Hovhannisyan K, Warenits AM, Arrich J, et al. Bedside tests for predicting difficult airways: an abridged Cochrane diagnostic test accuracy systematic review. *Anaesthesia*. 2019;74(7):915–28.
 37. Ali ST, Samad K, Raza SA, Hoda MQ. Ratio of height to thyromental distance: a comparison with mallampati and upper lip bite test for predicting difficult intubation in Pakistani population. *J Pak Med Assoc*. 2021;71(6):1570.
 38. Workeneh SA, Gebregzi AH, Denu ZA. Magnitude and predisposing factors of difficult airway during induction of general anaesthesia. *Anesthesiol Res Pract*. 2017;2017.

39. Alemayehu T, Sitot M, Zemedkun A, Tesfaye S, Angasa D, Abebe F. Assessment of predictors for difficult intubation and laryngoscopy in adult elective surgical patients at Tikur Anbessa Specialized Hospital, Ethiopia: A cross-sectional study. *Ann Med Surg.* 2022;77:103682.
40. Khan ZH, Kashfi A, Ebrahimkhani E. A Comparison of the Upper Lip Bite Test (a Simple New Technique) with Modified Mallampati Classification in Predicting Difficulty in Endotracheal Intubation: A Prospective Blinded Study. 2003;595–9.
41. Selvi O, Kahraman T, Senturk O, Tulgar S, Serifsoy E, Ozer Z. Evaluation of the reliability of preoperative descriptive airway assessment tests in prediction of the Cormack-Lehane score: A prospective randomized clinical study. *J Clin Anesth.* 2017;36:21–6.
42. Shah PJ, Dubey KP, Yadav JP. Predictive value of upper lip bite test and ratio of height to thyromental distance compared to other multivariate airway assessment tests for difficult laryngoscopy in apparently normal patients. 2013;29(2):191–5.
43. Chara L, Eleftherios V, Maria M, Anastasia T, Chryssoula S. Anatomic features of the neck as predictive markers of difficult direct laryngoscopy in men and women: A prospective study. *Indian J Anaesth.* 2014;58(2):176–82.
44. Sen B, Mitra M, Kundu K, Basu M. Diagnostic Accuracy of Modified Mallampati Test (MMP) and Thyromental Distance Test (TMD) in Predicting Difficult Laryngoscopy- A Comparative Study in a Tertiary Care Teaching Hospital in India. 2020;7(28).
45. Jack Meitei A, Kumar Behera K, Anita Devi N, Sarat Singh S, Eshori Devi L, Ratan Singh N, et al. A Comparative Study Of The Modified Mallampati Classification With The Ratio Of Patient’s Height To Thyromental Distance And Upper Lip Bite Test In Predicting Difficult Laryngoscopy. *IOSR J Dent Med Sci e-ISSN [Internet].* 2018;17(4):66–71. Available from: www.iosrjournals.org

ANNEXES

Annex 1: - participants' Information sheet and consent form

Hello, my name is _____ and I'm a data collector for the study entitled Comparison of the effectiveness of neck circumference to thyromental distance ratio, the ratio of height to thyromental distance, upper lip bite, and modified mallampati tests to predict difficult laryngoscopy among elective adult surgical patients at Addis Ababa Referral Hospitals. It is a study aimed to compare the predictive value of airway assessments. I will ask you a few questions and do some physical examinations that will only take 10-15 minutes of your time regarding this matter.

Being a part of this study will not affect the care you receive at this hospital. You are chosen at random to participate in the study solely because you are undergoing surgery at this hospital; no other special criteria apply. Only the principal investigator and data collectors will access your information. Your name won't be mentioned anywhere.

Rights: - You have full right to refuse from participating in this research. You can choose not to respond to some or all questions if you do not want to give your response. You have also the full right to withdraw from this study at any time you wish

Contact address: If there is any questions or unclear idea at any time about the study or the procedures, do not hesitate to contact and speak to the principal investigator at the following address.

Cell phone: 0921266631 or e-mail address – asmroalebachew8@gmail.com

Consent Form

I have read the information sheet concerning this study. I understand that participation in this study is completely voluntary and that I may withdraw at any time without reason. I agree to participate in this study to be interviewed

Participants' signature _____ Date _____

Data collector name _____ Date _____

የአማርኛጥያቄቅፅ

ሰላም፣እኔ _____ እባላለሁ።የምሰራው ነው።

በቀዶ ጥገና ጊዜ የሰመመን ህክምና ሲጀመር የአየርቧንቧ ቱቦ ከማስገባት ጋር ተያይዞ የሚፈጠር የአየርቧንቧ ችግር ላይ ጥናት በማድረግ ላይ እንገኛለን።

እኔም የቡድኑ አንድአካል ነኝ።የተመደበው ሀኪም የአየርቧንቧ ቱቦውን በተገቢው የአካል ክፍል ሲያስገባና የዚህ ጥናት አላማ የችግሩን ስፋትና አጋላጭ ነገሮችን ለማወቅ ነው።

ይህ ጥናት የበሽተኛውን ደህንነትና የችግሮቹን አስከፊነት ለመቀነስና አጋላጭ ምክንያቶቹን እንዲሁም የችግሩን ጥ ልቀትና አሳሳቢነት በሆስፒታሉ ለማሳወቅ ነው። በዚህ ጥናት ሂደት ውስጥ የሚሰበሰበው ማንኛውም አይነት መረጃ ሙሉ በሙሉ በምስጢር የሚጠበቅ መሆኑን ል ናረጋግጥልዎ እንወዳለን።

የማንኛውም ተሳታፊ ስም ከግምት ውስጥ የማይገባና የሚሰጡትም ማንኛውንም መ ረጃ ለማንም ተላልፎ እንደማይሰጥ ብሎም የዚህ ጥናት ውጤት እርሶን በስም እንደማይለይዎት እናረጋግጣለን።

መጠይቁ በፈቃደኝነት ላይ የተመሰረተ ሲሆን እርሶ በዚህ ጥናት ላይ የመሳተፍ ሙሉ መብት አለዎት።ይህም ብቻ ሳይሆን ከ ጀመሩ በኋላም በማንኛውም ጊዜ ማቋረጥ እንዲሁም ሙሉ በሙሉ ያለመሳተፍ መብት አለዎት።

መቀጠል እችላለሁ; 1. አዎይቻላል

2. አይቻልም

Annexe 2:- Questionnaire

Participant Code: _____

Code of the hospital: _____

Section1. Socio-demographic characteristics

Instruction: - For each question, please circle the number of alternative (s) that fit the response, and fill the black space provided or choice from the given alternatives

S.no	Questions	Response	Remark
101	Sex	1. male 2. female	
102	Age	..... Years	
103	Weight	..... kg	
104	Height	..... Cm	
105	BMI	..... kg/m ²	
106	ASA classification	A) ASA (I) B) ASA (II)	

Section 2. Airway assessment characteristics and clinical preoperative patient data

S.no	Questions	Response	Remark
201	MMT	A. I B.II C.III D. IV	
202	TMD	.....cm	
203	NC	.....cm	
204	ULBT	A class a B, class b C, class c	
205	RHTMD	.....cm	
206	NC/TMD	.....cm	
207	Type of surgery		
208	Is there any comorbidity other than surgical diagnosis	A, yes B, no	If no jump to question 211
209	If yes, what is it?		
210	Does it contribute to difficult airways?	A, yes B, no	
211	Laryngoscopy type	A, Macintosh B, miller C, other...	

212	Laryngoscopy size	A, 3 B, 4	
213	Qualification of anesthetist	A Diploma B.BSC C MSC D, anesthesiologist	
214	Work experience	.....year	
215	Is the patient premedicated?	A, yes b, no	If no jump to question 218
216	Drug name	A, fentanyl B, morphine c, dexa D, lidocaine E, other	
217	If yes what is the dose?	.....mg	
218	The type of induction agent	a, propofol b, ketamine c, thiopental d, ketophol e other	
219	The dose of the induction agent	.....mg	
220	The type of Relaxant used during induction time	A, suxamitonium b, vecronium c, other...	
221	The Dose of muscle relaxant?	.....mg	

Section 3: post induction patient information

S. no	Questions	Response	Remark
301	Do you apply external laryngeal pressure during laryngoscopy	A, yes B, NO	
302	CLG	A, I B, II C, III D, IV	
303	No. of attempt	.....

Annex 3 : - Cormac and lehans laryngoscopic classification

