PREDICTABILITY OF DIFFICULT LARYNGOSCOPY AND INTUBATION USING THE CLINICAL AND RADIOLOGICAL IMAGING STUDY

Dissertation submitted in partial fulfillment of

M.D. DEGREE EXAMINATION

M.D. ANAESTHESIOLOGY- BRANCH X

CHENGALPATTU MEDICAL COLLEGE AND HOSPITAL

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CHENNAI, TAMILNADU.

APRIL 2015

CERTIFICATE

This is to certify that the dissertation entitled, “Predictability of Difficult Laryngoscopy and Intubation using the Clinical and Radiological Imaging Study” submitted by Dr. SIVARAJ P in partial fulfillment for the award of the degree Doctor of Medicine in Anaesthesiology by the Tamilnadu Dr. MGR Medical University, Chennai is a bonafide record of the work done by him in the Chengalpattu Medical College and Hospital, Chengalpattu, during the academic year 2013-2015.

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DECLARATION

I, Dr.SIVARAJ P, solemnly declare that the dissertation "Predictability of Difficult Laryngoscopy and Intubation using the Clinical and Radiological Imaging Study" is a bonafide work done by me in the Department of Anaesthesiology, Chengalpattu Medical College & Hospital, Chengalpattu, after getting approval from the Ethical committee under the guidance of Prof. Dr. SUGANTHARAJ ANURADHA MD DA, Head Of the Department, Department of Anesthesiology, Chengalpattu Medical College and Hospital, Chengalpattu.

Place : Chengalpattu

Date : 29-09-2014

(Dr. SIVARAJ P)

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INSTITUTIONAL ETHICS COMMITTEE

CHENGALPATTU MEDICAL COLLEGE , CHENGALPATTU

APPROVAL OF ETHICAL COMMITTEE

To

Dr.P.Sivaraj
Post Graduate
Dept of Anaesthesia

Dear Dr.

The Institutional Ethical Committee of Chengalpattu Medical College reviewed and discussed your application to conduct the clinical / dissertation work entitled

PREDICTABILITY OF DIFFICULT LARYNGOSCOPY AND INTUBATION USING THE CLINICAL AND RADIOLOGICAL IMAGING STUDY

On 13.11.2013

The following documents reviewed

a. Trial protocol, dated ______version no
b. Patient information sheet and informed consent form in English and / or vernacular language.
c. Investigators Brochure, dated ___________version
d. Principal Investigators current CV
e. Investigators undertaking

The following members of the Ethics committee were present at the meeting held on
Date 13.11.2013 Time 12.00 Noon Place Chengalpattu Medical College

Approved__________________ Chairman Ethics Committee

__________________13/11/13 Member secretary of Ethics Committee.

Name of each member with designation

Clinical Members

1. Dr.G.Raja Billy Graham MS.,
   Prof & HOD of Surgery, CHMC

2. Dr.K.Srinivasagalu MD.,
   Prof & HOD of Medicine, CHMC

Biological Scientist

3. Dr.K.Baskaran MD.,
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Non Clinical Members

4. Dr.P.Parasakthi MD
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5. Member from Nongovernmental
   Voluntary Organisation : Mr.P.Durairaj

6. Philosopher : Mr.K.S.Ramprasad

7. Lawyer : Lr. I. M. Karimala Basha

8. Layperson : Mr.Dilli

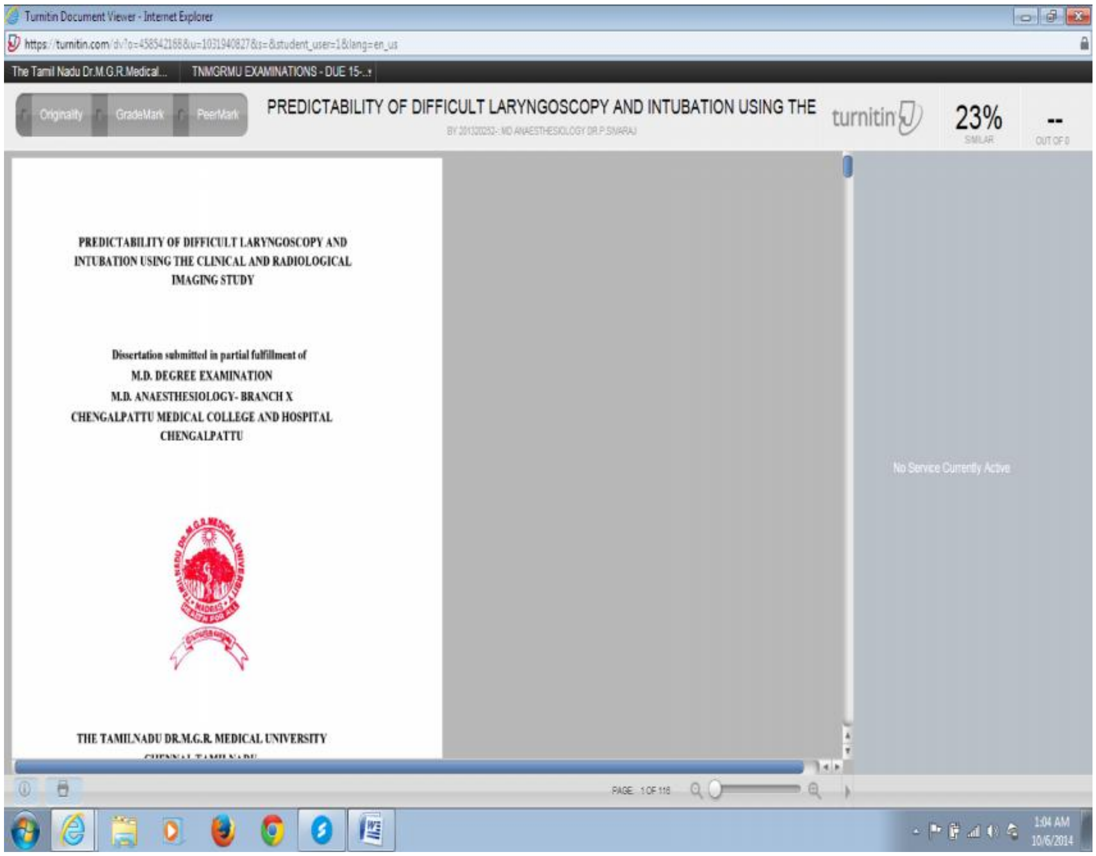
We approve the clinical trial to be conducted in its presented form

The Institutional Ethics Committee expects to be informed about the progress of the study and any SAE occurring in the course of the study, any changes in protocol and patient information / informed consent and asks to provide copy of final report.

Yours sincerely

13/11/13

Member secretary, Ethics Committee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ABSTRACT

Background: Airway management is of prime importance to an anaesthesiologist. Unanticipated difficult laryngoscopy and endotracheal intubation remains a primary concern of anaesthesiologists. The reported incidence of a difficult laryngoscopy or endotracheal intubation varies from 1.5% to 13% in patients undergoing surgery. Failure to intubate is detected in 0.05 - 0.35% of the patients. Thus preoperative airway assessment is of pivotal importance for the anaesthesiologist to predict difficult intubation. Thus we aimed to study the usefulness of ten different airway assessment predictors as a clinical and radiological tool to predict difficult intubation.

Methods: Two hundred and eight patients between 15-75 years of age and either sex were included in our study. We assessed the clinical risk factors: modified Mallampati classification, mouth opening, thyromental distance, sternomental distance and Wilson's risk score and radiologiocal risk factors : the atlanto-occipital distance,cervical vertebra C-2 spine depth, effective mandibular length, anterior mandibular depth, posterior mandibular depth in all the patients. Patients with tumours or malformations of head and neck and oral cavity, edentulous patients, pregnancy and those requiring emergency surgeries were excluded. A Cormack Lehane grade of I & II were considered easy intubation and III & IV were considered to be difficult.

Results: Thirty eight patients had difficulty during intubation. The sensitivity and specificity of the clinical model were found to be, respectively, 97.2% and 95.3%. The sensitivity and specificity of the combined clinical and radiological model were found to be 100% and 95.3%, respectively. The area below the ROC curves, measures the probability of the correct prediction of the clinical and the combined models. It was found to be 0.992 and 0.993, respectively. This means that the clinical and combined models correctly predicted the outcome with a probability of 99.2% and 99.3%, respectively.

Conclusion: From our study we found that 1. Clinical models: modified Mallampati classification, sternomental distance, thyromental distance, inter-incissor gap and Wilson sum risk score, are important predictor of difficult intubation. 2. Radiological imaging- atlanto-occipital distance is also an important predictor of difficult laryngoscopy and intubation. 3. The other radiological predictors are of value when they are combined with clinical variables, but not as single predictor.

INTRODUCTION

Indirect visualisation of the larynx had started in the year 1854, when Manuel Garcia[1], a Spanish vocal pedagogist, was the first man to view the movement of the glottis in a living person. After that many persons developed various techniques for indirect visualization of glottis.

In the year 1878, Sir William McEwan[1] was able to intubate the trachea from the mouth with a tube, in a conscious patient with his fingers carcinoma from base of the tongue. His technique was an attempt to describe endotracheal intubation for providing anaesthesia.

In the year 1913, Chevalier Jackson[2] was the first person to publish a report of tracheal intubation using direct laryngoscopy at a high rate of success.

Further advances were made by Sir Ivan Whiteside Magill[3] by introducing the awake blind nasal technique as a method of tracheal intubation. He also devised the Magill forceps and the Magill laryngoscope blade.

In 1943, Sir Robert Reynolds Macintosh[4] introduced a curved laryngoscope blade for tracheal intubation and it became the most common and widely used laryngoscope blade for oral intubation.

Airway management is of prime importance to an anaesthesiologist. For securing the airway, the gold standard is tracheal intubation through direct laryngoscopy. No anaesthetic technique is safe unless diligent efforts are made to secure and maintain a patent airway.

Unanticipated difficult laryngoscopy and endotracheal intubation is the foremost task and concern for the anaesthesiologists. In patients undergoing general anaesthesia, an incidence of difficult intubation of 1.5 % - 13% has been reported[5]. The incidence of failure to intubate is reported as 0.05% to 0.35%[6].

Difficult laryngoscopy and intubation causes high risk of complications (ranging from sore throat to airway trauma) in the patients. In few cases, if anaesthesiologist is unable to maintain the airway patency, the dreaded nightmare for any anaesthesiologist so called ‘Cannot intubate-Cannot Ventilate’ situation, may lead to serious complications like hypoxic brain damage or death.

Of all the anaesthesia related deaths 30% to 40% are attributed to the inability to manage a difficult airway[7]. Of the overall claims against anaesthetist in a closed claims study, 17% involved difficult or impossible intubation [8]. Most of the dire consequences of unanticipated and failed tracheal intubations can be prevented and hence comes under preventable factors in anaesthetic mishaps.

Although prediction and forecasting is a tough task, prediction of difficult laryngoscopy and intubation has gained importance because of the serious consequences of failed tracheal intubation[9].

The difficulty in achieving airway patency varies with anatomic and acquired individual patient factors. Thus performing an airway assessment preoperatively in identifying a patient for a potentially difficult intubation is of pivotal importance for the anaesthesiologist.

Difficulty in intubation is usually associated with difficulty in exposing the glottis by direct laryngoscopy. This involves a series of manoeuvres like extending the head, flexion at lower cervical spine, adequate opening of mouth, left side displacement and lodgement of the tongue on the floor of the mouth and lifting the mandible forward. The ease of difficulty in performing each of these manoeuvres can be assessed by one or more parameters.

Initially the airway assessment was carried out by single factors like head extension and neck flexion, Mallampati's oropharyngeal classification[10,11], thyromental distance[12], inter incisor gap, protrusion of the mandible etc.

But when it was realized that the visualization of larynx during intubation is affected by many factors, the concept of multivariate factors came into existence [14-18]. These include Mallampati test, thyromental distance, inter - incisor gap, sternomental distance etc. to create a scoring system. By adapting these multivariate factors one can overcome the deficiency occurring with individual factors and anticipate difficult intubation with much better accuracy.

Even with the use of multivariate factors there have been instances when a patient predicted to have difficult intubation had an easy intubation and vice versa.

So predicting a difficult intubation employing a myriad of measurements and observations has not demonstrated itself to be practicable or even reliable. Thus, the search for a predictive test that has ease of applicability, reliability and accuracy of prediction (discriminating power) continues.

With the application of these airway predictive factors one can identify, true positives, (those who are predicted and had difficult intubation), false positives (those who are predicted intubation but had easy intubation), true negatives (those who were predicted to have easy intubation and had easy intubation) and false negatives (those who were predicted to have easy intubation but had difficult intubation).

Using this concept one can determine how sensitive and specific these tests are and also obtain the positive and negative predictive values of these tests.

Thus we proposed a prospective model to study the usefulness of ten different airway assessment predictors using clinical and radiological variables before surgery to the Cormack Lehane’s grading of difficulty in intubation during anaesthesia. The clinical variables are the modified Mallampati, inter incisor gap, thyromental distance, sternomental distance and Wilsons risk score and radiological variables are the atlanto-occipital distance,cervical vertebra C-2 spine depth, effective mandibular length, anterior mandibular depth, posterior mandibular depth. We also evaluated the role of combining the clinical and radiological measurements in enhancing the validity in predicting difficult intubation based on Cormack and Lehanne in patients aged 15 years and older.

AIM OF THE STUDY

To identify and compare the most reliable variables, in prediction of difficulty in laryngoscopy and intubation through the clinical and radiological [x-ray lateral view] measurements. This test was conducted using sensitivity, specificity, positive predictive value, negative predictive value as indicators.

1. Clinical
    a. Samsoon and Young modification of Mallampati
    b. Interincissor gap
    c. Thyromental distance
    d. Sternomental distance
    e. Wilson risk score
2. Radiological [lateral x-ray] measurements.
    a. Atlanto-occiptital distance
    b. Anterior mandibular length
    c. Posterior mandibular length
    d. Effective mandibular length
    e. C-2 spine depth

REVIEW OF LITERATURE

Bannister et al. 1944[18] described the importance of position of the head and neck in direct laryngoscopy in order to achieve proper axis alignment of the mouth, pharynx and larynx.

Savva et al (1948)[33] estimated the distance from suprasternal notch to the mentum and reported its possible correlation with modified Mallampati, jaw protrusion, inter incisor and thyromental distance. It was measured with the head fully extended on the neck with the mouth closed. A value of less than 12 cm is found to predict a difficult intubation.

Ramadhani et al 1996[9], conducted another study on sternomental distance and the relation to its view at laryngoscopy. A Sternomental distance of thirteen and half cm or less with the head fully extended on the neck and the mouth closed provided the best cut -off point for predicting difficult laryngoscopy. Thus they concluded that sternomental distance on its own may not be an adequate sole predictor of subsequent difficult laryngoscopy.

Gillespie 1950[19], has highlighted the importance of positioning of the patient by elevating the head, flexing the neck at lower cervical joints and extending the neck at atlanto-occipital joint during intubation to get the three axes, the oral, pharyngeal and laryngeal axes in a straight line as possible, is needed for a successful intubation.

White & Kander et al (1975)[53] reported an important measurement, the depth of the posterior mandible. It is measured between the bony alveolus behind the third lower molar tooth and the lower border of the mandible.

Jones and Pelton 1976[20] identified diseases and syndromes primarily affecting other parts of the body, but having a component that makes intubation difficult like acromegaly, rheumatoid arthritis, temporomandibular joint impairment and Treacher collins syndrome.

Tunstall et al. 1976[54] pointed out that proper airway management consists of more than a collection of techniques for achieving intubat ion. He emphasized the importance of having at one's fingertips, a logical and organized sequence of responses when confronted with an unexpectedly difficult intubation. His concept of "Failed Intubation Drill" in the obstetric setting is also applicable to failed intubations in other contexts.

Nichole and Zuck 1983[21] suggested that the Atlanto-occipital distance is a major anatomical factor that determines the ability to extend the head on the neck and exposure of larynx.

Patil et al. 1983[12] suggested that if during the initial clinical examination existing signs of a potentially difficult intubation supplement a distance less than 6.0 cms between the lower border of chin and the thyroid notch, then intubation is going to be difficult and Fibreoptic laryngoscopy is indicated.

Cormack RS, Lehane J et al[22]. 1984, described a classification of the laryngeal view to denote the degree of difficulty with intubation. They graded laryngeal view into 4 grades depending on the exposure of larynx at laryngoscopy.

Grade I: both the vocal cords visible.

Grade II: Only the posterior commissure is visible.

Grade III: Only the epiglottis is visible.

Grade IV: None of the above structures are visible.

They felt that grade III and IV cases are often not recognized preoperatively. So most anaesthesiologists will not meet this problem and also will not have sufficient experience of handling such difficult situations. Hence they advocated the conversion of grade I or II view into grade III or IV during routine laryngoscopy, so that intubation has to be per formed with difficulty which will help at the time of real difficulty – the concept of simulated difficult intubation.

Mallampati et al. 1985[10] proposed a clinical sign to predict difficult tracheal intubation. It was described as the concealment of faucial pillars and uvula by the base (posterior part) of the tongue, when the tongue is maximally protruded in a seated patient. Adult patients with an ASA physical status 1 or 2, who required general endotracheal anaesthesia, were included in the study. Patients were divided into three classes:

Class 1 - Faucial pillars, soft palate and the uvula could be visualised.

Class 2 - Faucial pillars and the soft palate could be visualised, but uvula was masked by the base of the tongue.

Class 3 – Only the soft palate could be visualised.

Their results were highly significant ($p < 0.001$) and supported their earlier hypothesis that difficult laryngeal visualization can be predicted in most cases by this test.

John McIntyre 1987[23] has elaborated the need for anticipation of difficulties in intubation, attempts to overcome them and the various possible outcomes of attempts at intubation.

He also suggested the important factors to be taken into consideration during laryngoscopy include

(1) The distance to the vocal cords.

(2) The compressibility of tongue and softt issues into the mandibular space.

(3) Prominent upper incisor teeth.

(4) Blade manoeuvrability in small mouth.

To improve the visualization at laryngoscopy, he has suggested a change in laryngoscope blade may help in improving the visualization which is selected on the basis of its length, degree and character of curvature, depth of step and width. Selection of the blade is based on the preference of the anaesthetist. Sequential attempts to intubate a patient are made in a rational fashion and in as atraumatic a manner as possible.

G.L.T Samsoon and J. R. B Young 1987[11], in their study they classified the visibility of oropharyngeal structures into four classes and correlated them with laryngeal view based on Cormack and Lehane's classification. This test is performed in a seated patient who opens his mouth as wide as he can and protrudes the tongue as far as possible, while the observes looks from the patient eye level and inspects the pharyngeal structures with a pen torch. It is important when performing this test that the patient does not phonate since this can alter what is seen. The view is then graded as:

Class I: Soft palate, fauces, uvula and pillars seen.

Class II: Soft palate, fauces and uvula seen.

Class III: Soft palate and base of uvula seen.

Class IV: Soft palate not visible.

They found significant association of class I and II with Cormack and Lehane's grade I / II and class III and IV with Cormack and Lehane's grade III / IV.

Lloyd F. Redick 1987[24] stressed the importance of the integrity of the temporomandibular joint for tracheal intubation. He stated that forward sliding motion of the joint is very important to obtain an opening of the mandible wide enough to permit laryngoscopy and tracheal intubation. This criterion is one of the essential components of temporomandibular joint integrity and of course of adequate Mouth Opening.

Wilson M E et al. 1988[13] studied parameters to predict difficult intubation. A scoring system was developed by integrating all the parameters as the adverse influence of one factor could offset by the other favourable features which was called as Wilson risk sum scoring.

Oates et al. 1990[25, 26] compared two tests modified Mallampati and Wilson scoring for prediction of difficult laryngoscopy and to assess the inter-observer variations. They found out that both the tests have poor predictive powers; however they preferred Wilson risk scoring for airway assessment because it was associated with less inter-observer variations. Many patients involuntarily phonate during the performance of MMC and that there was considerable inter –observer variations.

Frerk et al. 1991[14] compared Modified Mallampati test and the Thyromental Distance which was initially described by Patil and his colleagues to predict difficult intubation. He found that, when both the tests were combined they have greater sensitivity and specificity but when used alone they were poor predictors. Also showed Modified Mallampati test has got greater inter – observer variability and high false positive results.

Benumof JL 1991[6] has classified difficulty in intubation from zero to infinite. Zero degree of difficulty in intubation is when an endotracheal tube can be inserted into a fully visualized laryngeal aperture with little effort – Grade I laryngoscopic view. As the view worsens, it requires increasing anterior lifting force with the laryngoscope blade, optimal sniffing position, multiple attempts and external laryngeal pressure to push the larynx more posteriorly and cephalad for better view. He has highlighted the importance of three extremely easy to perform, preoperative examinations to predict difficulty in intubation which include

a. Relative tongue or pharyngeal size based on modified Mallampati test

b. Atlanto-occipital joint extension

c. Mandibular space expressed as thyromental or Hyomental distances.

Tham et al. 1992[28] conducted another study to observe the effects of phonation and posture on the modified Mallampati test. It was observed that phonation (the patient saying "Ah") produced a marked, systematic improvement of view and moving to the supine posture produced a small, systematic, non-significant worsening of the view. Thus they concluded that this test was useful in an emergency when the anaesthesiologist is presented with the patient supine or with pat ient who is unable to situp.Thus it was recommended that anaesthetists make their own assessments of modified Mallampati classification, with the patient in either of the postures but always either with or with out phonation, and there by gradually "calibrate" their assessments against the degree of difficulty encountered in intubation.

American Society of Anaesthesiologists Task Force 1993[31] developed the practice guide lines for management of the difficult airway to reduce the likely hood of adverse outcomes. They have recommended a detailed airway history and physical examination to be taken prior to initiation of anaesthetic care in all patients to detect medical, surgical and anaesthetic factors that may indicate the presence of a difficult airway. In case of anticipated difficult airway, a portable storage unit that contains specialized equipment for difficult airway management should be readily available. The patient or his attenders should be informed of the special risks and procedures pertaining to the management of the difficult airway. They have also stressed the importance of the presence of an expert assistant in difficult airway management. They have evaluated a strategy for intubation as well as extubation of the difficult airway which depends on the surgery, the condition of the patient and the preferences and skills of the anaesthesiologists. They have stressed the importance of documenting the presence and nature of the airway difficulty in the medical record to guide and facilitate future care.

Keith Rose et al. 1994[32] in their study described methods, risk factors, and outcomes of airway management in all patients (obstetrics excluded). Preoperatively, anaesthetists recorded patient factors and assessed four airway characteristics. Airway characteristics predictive of difficult tracheal intubation were decreased mouth opening, shortened thyromental distance, poor visualization of the hypopharynx, and limited neck extension. They concluded that difficult tracheal intubations occurred infrequently but were associated with increased morbidity. Patient factors and four physical airway characteristics were useful predictors but limited in identifying all problems.

Tse et al. 1995[15] conducted a prospective, blind study to determine whether a difficult endotracheal intubation could be predicted preoperatively by evaluation of one or more anatomic features of the head. They determined that Modified Mallampati Classification of class 3, a thyromental distance less than or equal to seven centimeters, and a head extension less than or equal to eighty degrees, considered either alone or in various combinations. They concluded that these three tests were of little value in predicting difficult intubation in adults, although the likely hood of an easy endotracheal intubation was high when they yield negative results.

El - Ganzouri et al[16]. 1996 proposed to study a multivariate model for stratifying risk of difficult endotracheal intubation and its accuracy compared to currently apply clinical methods. They concluded that improved risk stratification for difficulty with visualization during rigid laryngoscopy (Grade IV) can be obtained by use of a simplified preoperative multivariate airway risk index, with better accuracy compared to oropharyngeal (Mallampati) classification at both low and high risk levels.

Arné et al. 1998[17] proposed a study to develop and validate a single clinical index for prediction of difficulty in tracheal intubation in both ENT and general surgeryThey concluded that difficult intubation can be predicted if the score exceeds 11. When a score less than 11 are found, a difficult intubation can be excluded, with a risk of false prediction of 1–2%.

Ezri et al. 2001[35] introduced class Zero to Modified Mallampati Classification. Class Zero is defined as the ability to see any part of the epiglottis on mouth opening and tongue protrusion. They found all the patients with class Zero had a grade I Cormack and Lehane view on laryngoscopy and an airway class >2 (grade III and above) was a good predictor of difficult laryngoscopy. They suggested that for a better prediction of difficult intubation, the Mallampati scoring should be combined with other predictors.

Turkan et al. 2002[36] designed a prospective study to investigate the age and sex- related changes in the morphometric measurements of the airway. Hyomental, Thyromental Distance, Sterno mental distance and

Modified Mallampati test were evaluated. They concluded that hyomental distance was not affected by age and all the other criteria was affected by age.

Shiga et al. 2005[37] conducted a meta analytic study to systematically determine the diagnostic accuracy of bedside tests for predicting difficult intubation in patients with no airway pathology. Screening tests included the Mallampati oropharyngeal classification, thyromental distance, sternomental distance, mouth opening, and Wilson risk score. They concluded that currently available screening test for difficult intubation has only poor to moderate discriminative power when used alone. Combinations of tests add some incremental diagnostic value in comparison to the value of each test alone and that the clinical value of bedside screening tests for predicting difficult intubation remains limited.

Lee et al. 2006[38], conducted a study to determine the accuracy of the original and modified Mallampati tests, as they are used commonly to predict the difficult airway. Thus they concluded that, used alone, the modified Mallampati tests have limited accuracy for predicting the difficult airway and thus were not useful screening tests.

Vasudevan A et al. 2008[39], proposed a study with simple approach by ranking the difficult intubation predictors. The glottis was graded based on Cormack-Lehane classification. The low head extension degree, Mentohyoid distance of less than four cm and modified Mallampati class III & IV had a good clinical and statistical significance.

Gupta A K et al. 2009[40] conducted a prospective study to compare the efficacy of airway parameters to predict difficult intubation viz; degree of head extension, thyromental distance, inter incisor gap, and modified Mallampati test. They concluded that head & neck movements, high arched palate, thyromental distance & Modified Mallampati test are the best predictors of difficult intubation and head & neck movements strongly correlated for patients with difficult intubation.

Rudin Domi 2009[41] conducted a study to find the best predicting test for difficult intubation. All of the following parameters, i.e., Mallampati score, Thyromental, Sternomental and interincisive distances, and Wilson score, were recorded for every patient. For each parameter, the sensitivity, specificity, predictive positive value, and predictive negative value were calculated, with a significant P value < 0.05. The specificity of all parameters was low; nevertheless the sensitivity was high. The combination of the parameters improved the predictive model, thus increasing the specificity. He concluded that the Wilson score was the best predictive test than the combination of Mallampati -sternomental - thyromental distances.

Smita Prakash et al. 2011[42], conducted a prospective, randomized study to evaluate the effect of patient position on mask ventilation, laryngoscopic view, intubation difficulty, and the stance adopted by the anaesthesiologist during laryngoscopy and tracheal intubation was investigated anesthetized adults. They concluded that the sniffing position is superior to simple head extension with regard to the ease of intubation. An upright stance is adopted by more anaesthesiologists performing intubation with patients in the sniffing position.

Hyoung-Yong Moon et al. 2013[43], reported that there exist a difference among the airway assessment tests. They conducted the study in the young, middle and old age groups. They concluded that in comparison to young individuals, the middle aged or elderly adults have high incidence of difficulty in endotracheal intubation.

Basunia S R et al. 2013[44] conducted an analytical study comparing different tests and their combinations to predict difficult intubation. Five predictors were evaluated including Modified Mallampati Class, Sternomental Distance, Thyromental Distance, Delilkan's test and Calder test. Thyromental Distance and Calder tests showed highest sensitivity. They concluded that Thyromental distance and Calder test are better predictors and the combination of the clinical variables, increased the chances of prediction of difficult intubation.

McIntyre & Randall[23] reported that radiological measurements were unable to provide a good sensitivity for difficult airway predictability. They also demonstrated that these radiological studies may be of value in studying problems arising during difficult laryngoscopy or intubation.

Karkouti & colleagues[50] found that inter incisor gap and chin protrusion had excellent interobserver reliability. Whereas the other tests (thyromental distance, mandible subluxation, atlanto occipital extension, Mallampati classification, ramus of the mandible length, oropharyngeal view) were only moderately reliable between observers. The Mallampati technique had poor interobserver reliability.

Yildiz and colleagues[55], in a study, demonstrated that the interincisor gap has high sensitivity when used alone. The incidence of difficult intubation in their study was significantly higher in patients with Mallampati class III and IV, less thyromental distance, less sternomental distance and low interincisor gap value, or decreased protrusion of mandible. The study also proved that the combination of the above variables did not improve their results.

Matthew and colleagues[56], reported that all konwn difficult intubation patients have a thyromental Distance < 6 cm and Mallampati classifications of III or IV. In contrast all easy intubation patients have thyromental distance > 6.5 cm and Mallampati classification of I or II.

Recently, Iohom and colleagues[57] suggested that the Mallampati classification, in conjunction with measurement of the Thyromental Distance and Sternomental Distance, may be a useful routine screening test for prediction of difficult intubation preoperatively.

Wong and Hung[58], concluded in their studies that the laryngoscopic grade will be high (i.e., difficult intubation) if the model of study involves a combination of atlanto –occipital distance and Mallampati yielding a more negative value, derived from regression equation.

Bellhouse & Dore[59] identified radiological predictors that closely relates to clinical measurements, in a group of patients with known airway difficulty.

Naguib and colleagues[52] used clinical and radiologic data and identified risk factors for difficult airway prediction. Their study demonstrated that the clinical model has more sensitivity, specificity and positive predictive value than the radiological factors. They also reported that combining clinical and radiological variables has predicted difficult intubation at a higher sensitivity, specificityand positive predictive value than clinical and radiological variables alone. In their study, the incidence of difficult intubation is > 40% but the role of advanced radiological techniques in the predictability of difficult intubation has to be recognised.

Cattano & colleagues[60] demonstrated that modified Mallampati has a linear correlation index with Cormack-Lehane. The index was 0.904 and they have correlated Mallampati class III with a Cormack- Lehane grade 2. Modified Mallampati class IV correlates to Cormack-Lehane grade 3 and 4.

ANATOMY OF THE AIRWAY

The airway extends from mouth or nose to terminal bronchioles. Anatomical structures relevant to endotracheal intubation include mouth, oral cavity, pharynx, larynx and trachea.

MOUTH AND ORAL CAVITY: (Figure 1)

The mouth extends from the lips to the oropharyngeal isthmus, at the level of the palatoglossal folds it is divided by the teeth into an outer vestibule and oral cavity proper.

Boundaries: It is bounded anterolateral by the teeth and gums, superiorly by the hard and soft palates. Floor is occupied by tongue, posteriorly cavity communicates with pharynx through oropharyngeal isthmus.

The Tongue: The tongue is a muscular organ situated in the floor of the mouth, which can be moved in any direction. Its bulk prevents direct vision of the larynx. Each half contains four intrinsic and four extrinsic muscles.

- Intrinsic muscles: occupy the upper part of the tongue. They alter shape of the tongue (superior, inferior, transverse and vertical muscles)

- Extrinsic muscles: connect tongue to the fixed bony points. (Genioglossus, hyoglossus, styloglossus, palatoglossus). The under surface of the tongue is attached to the floor of the mouth by a fold of mucous membrane called frenulum.

ANATOMY OF ORAL CAVITY

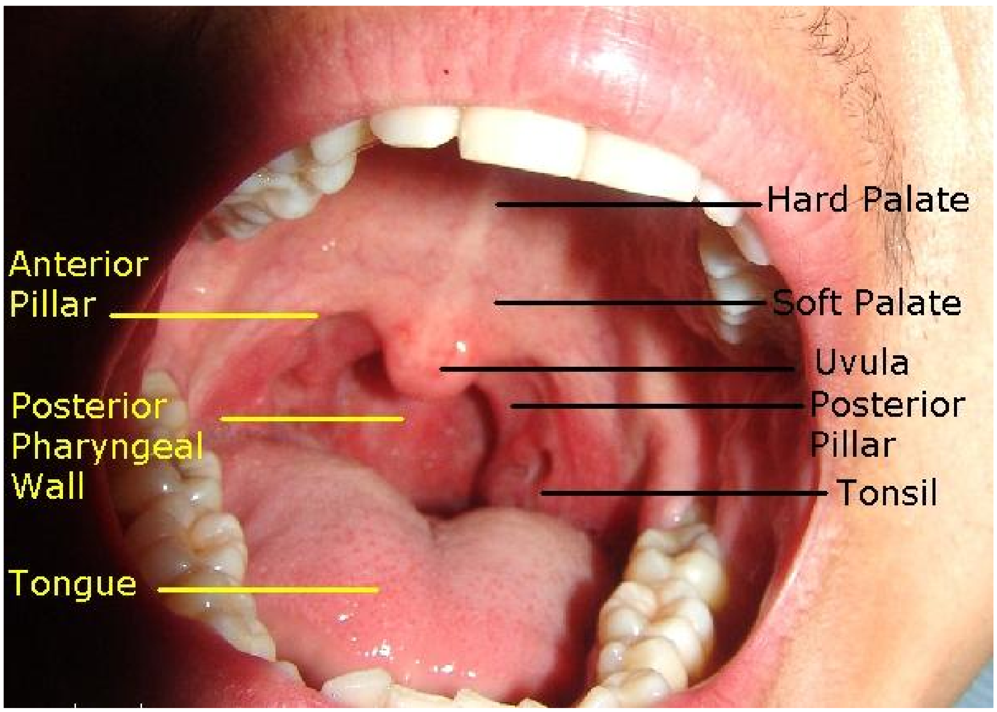


Figure 1

The motor supply to the tongue is from hypoglossal nerve, sensory innervation to the anterior two thirds is by facial nerve, and to posterior one third by glossopharyngeal nerve.

SOFT PALATE

Soft palate consists of an aponeurotic sheath into which several muscles are inserted laterally. It is attached anteriorly to the back of the hard palate and its free posterior edge bears the midline uvula which separates nasopharynx from the oropharynx. While the inferior aspect of the soft palate is lined with the squamous epithelium, its superior surface bears a ciliated columnar epithelium.

Muscles acting on the soft palate

Tensor palati and levator palati attach laterally and they tense and elevate the palate respectively.

Palatoglossus passes in palatopharyngeal fold to the tongue and narrows the oropharyngeal opening.

Palatopharyngeus lies in palatopharyngeal fold (posterior pillar) and joins with pharyngeal constrictor muscle. It narrows the oropharyngeal opening.

Musculus uvulae are an intrinsic muscle which draws up the uvula.

Somatic innervations of oral cavity

The vestibule

- Sensory: Trigeminal (V2 & V3) via alveolar and labial branches.
- Motor: Facial (VII)

Hard palate

- Sensory: Trigeminal via palatine and nasopalatine branches
- Taste: Facial (VII) .

Soft palate

- Sensory: Trigeminal via palatine branches to anterior region and Glossopharyngeal to the posterior region.
- Motor: Trigeminal to tensor levi palatini and via pharyngeal plexus (IX, X, XI) to all other muscles
- Taste: Facial (VII) via greater petrosal nerve.

Blood Supply and Lymphatic Drainage

Arterial supply: Lingual, facial & maxillary branches of external carotid artery. Drainage of blood is to the corresponding veins. Soft palate drains into the pharyngeal venous plexus.

Lymphatic drainage: Deep cervical lymph chain drains the anterior tongue and floor of the mouth drain initially into submental and subsequently to submandibular nodes.

THE PHARYNX (Figure 2, 3 and 4)

The pharynx is located between the nose and oral cavitiy. It is a fibromuscular hollow struture. It is composed of a thin fascial layer that forms thick buccopharyngeal fascia posteriorly, continues as adventitia of the oesophagus inferiorly and gets attached to the skull base superiorly. There are three constrictor muscles within the pharynx.

1. The superior constrictor which inserts into the base of the skull.
2. The middle constrictor which inserts into the mandible and hyoid bone.
3. The inferior constrictor which inserts into the cricoids cartilage.

The inferior constrictor contributes to a muscular band and the cricopharyngeus forms the upper oesophageal sphincter. All the muscle segments are inserted posteriorly into a tendinous median raphe.

Divisions of the pharynx (Figure 4)

The pharynx is divided into the nasopharynx, the oropharynx and the hypopharynx.

1. Nasopharynx: It is situated directly behind the nasal cavity. Its inferior boundary lies at the level of the soft palate. The roof is formed by the sphenoid and occipital bones of the skull base. The posterior nasopharyngeal wall is separated from the spinal column

by a tough prevertebral fascia which covers the longus capitis muscle, the deep prevertebral musculature and the arch of the first cervical vertebra. Five passages communicate with nasopharynx, the two nasal choanae, the orifices of the two Eustachian tubes, and the oropharynx. Mucous membranes of the roof and posterior walls contain lymphoid tissue termed as the adenoid tonsil.

2. Oropharynx: It lies directly posterior to the oral cavity and extends from the soft palate superiorly to the tip of the epiglottis inferiorly. The posterior wall consists of the prevertebral fascia and the bodies of second and third cervical vertebrae. The lateral walls contain the paired tonsillar fossae which are formed by the palatoglossal and palatopharyngeal folds and contain the palatine tonsils. Medial to the tonsillar fauces lays the base of the tongue. The tongue base is anterior to the laryngeal inlet and attaches to the epiglottis by the paired lateral glossoepiglottic folds and by the single median glossoepiglottic fold. Glossoepiglottic folds bind two spaces, the epiglottic and the valleculae. The posterior dorsal tongue surface is irregularly contoured because of the lingual tonsils.

3. Hypopharynx: It extends inferiorly from the upper edge of the epiglottis to the inferior edge of the cricoid cartilage and communicates with the oropharynx, the laryngeal inlet and the

oesophagus. On the side of the larynx are the funnel shaped pyriform recesses. These recesses are bound superiorly by the lateral glossoepiglottic folds and lie between the aryepiglottic folds and the internal lining of the thyroid cartilage. The posterior border of the hypopharynx comprises the buccopharyngeal, prevertebral fascia and deep prevertebral musculature. The hypopharynx is located at the level of the 4th to 6th cervical vertebrae.

THE MUSCLES OF PHARYNX

LATERAL VIEW

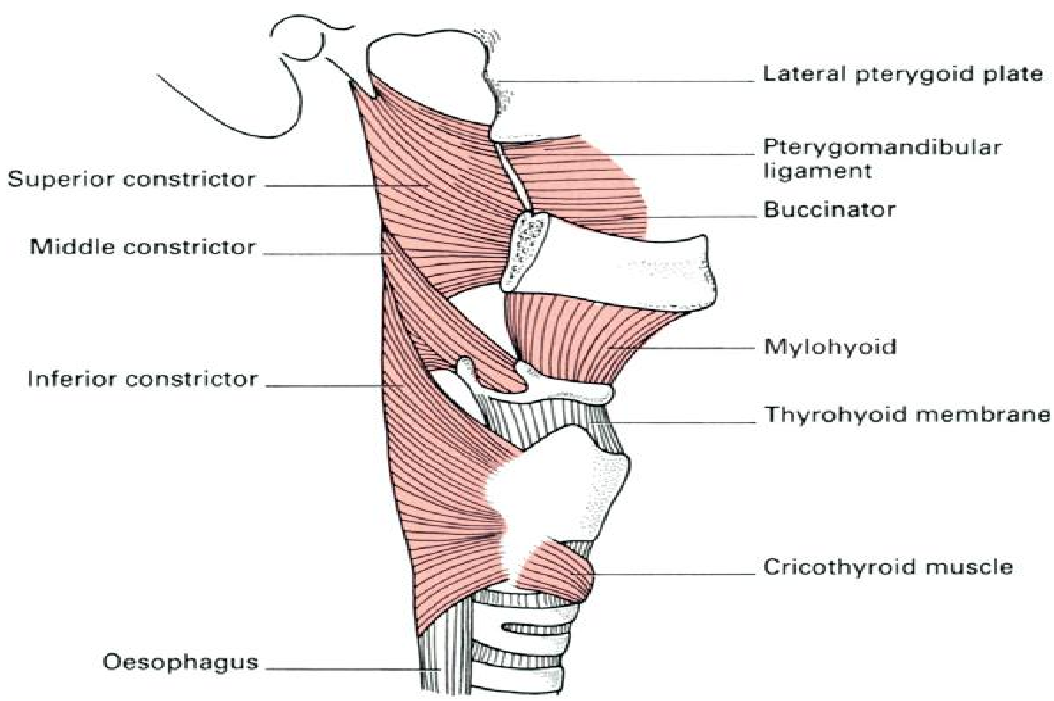


Figure 2

THE MUSCLES OF PHARYNX

POSTERIOR VIEW

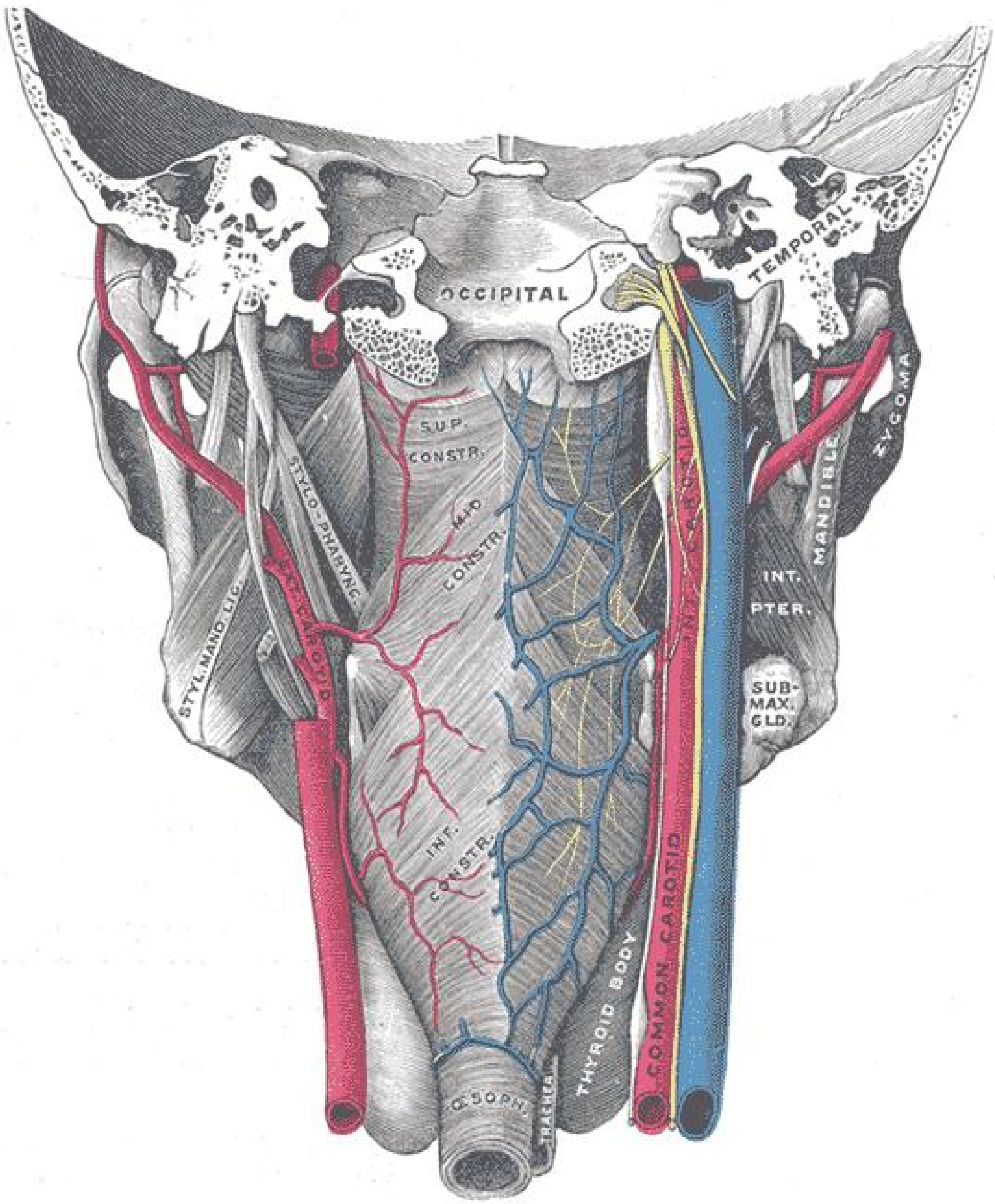


Figure 3

DIVISIONS OF THE PHARYNX

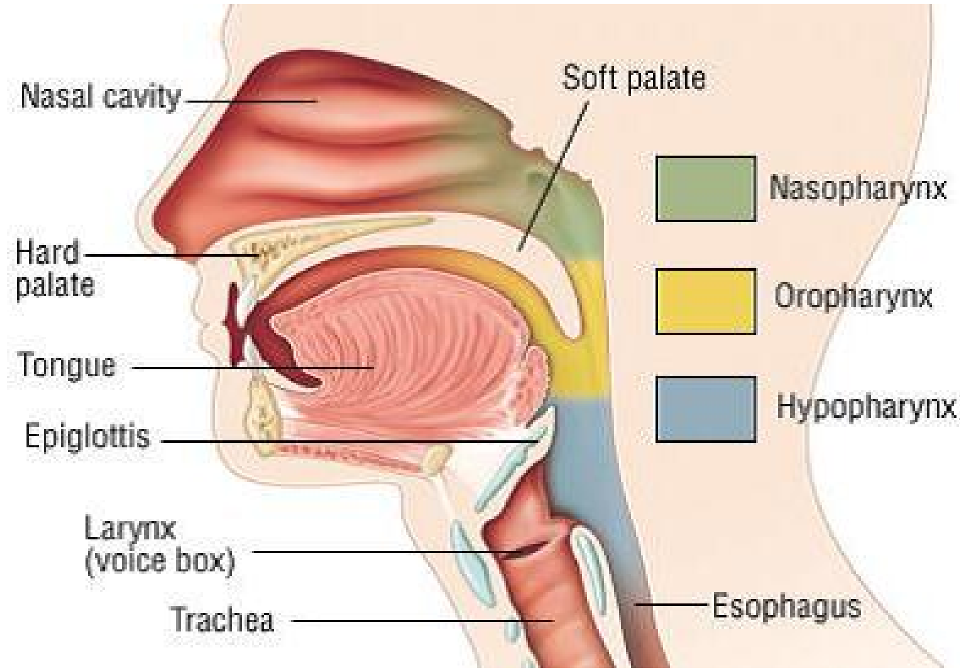


Figure 4

THE LARYNX (Figure 5 and 6)

It lies at the level of the 4th to 6th cervical vertebrae. It is "slung" from the underside of the hyoid bone and can be easily palpated through the skin of the anterior neck. The larynx is covered by the skin, deep fascia and thin strap muscles of the neck superficially.

Functions of the larynx

The larynx is continuous with the trachea and has specialized constrictor -dilator mechanism in the airway. The constrictor mechanism results in an effective and rapid closure that prevents aspiration into the lower airway. The vocal cords help in the act of phonation.

THE CARTILAGES OF LARYNX

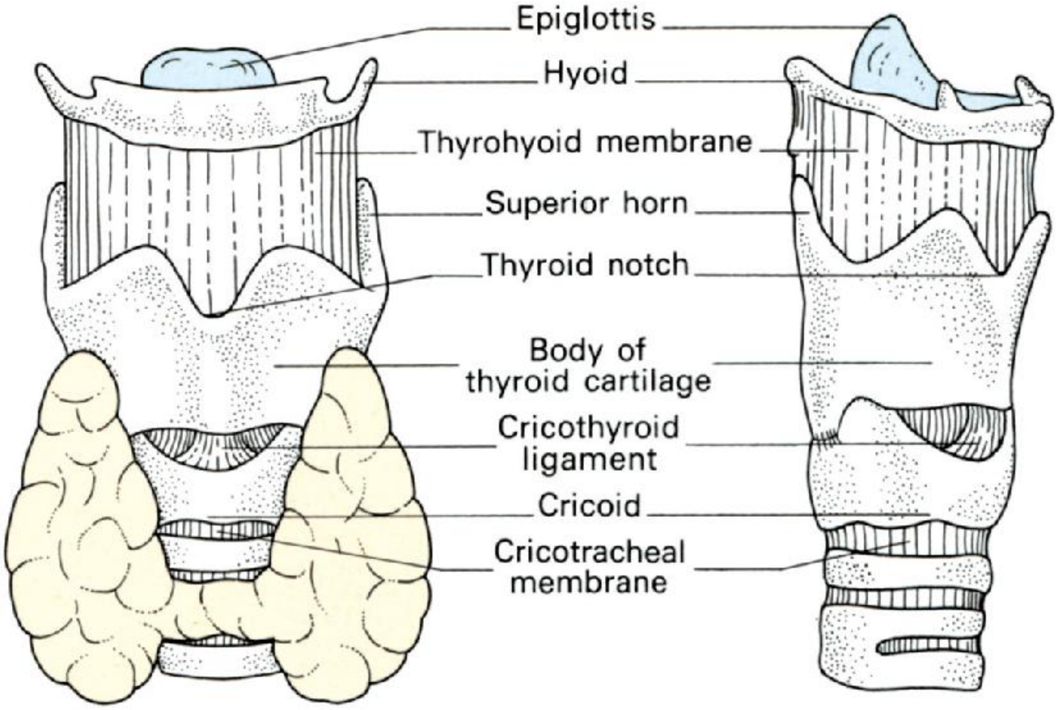


Figure 5

Laryngeal skeleton: (Figure 5)

There are three unpaired (thyroid, cricoid and epiglottis) and three paired (arytenoids, corniculate and cunei form) cartilages which form the skeleton of the larynx.

1. Thyroid cartilage: It is the largest cartilage of the larynx. It is composed of two superior horns that aid in its suspension from the

hyoid bone. The inferior horns articulate with the cricoids cartilage below to form cricothyroid joint. It is often described as 'shield shaped' and consists of two laminae that are joined in the midline anteriorly but posterior borders are far apart. The cartilaginous protrusion in front of the neck is known as the Adam's apple.

2. Cricoid cartilage: It is shaped like a signet ring. It lies immediately below the thyroid cartilage and is the only complete cartilaginous ring in the larynx. The anterior portion is short, 5 -7 mm in height and is called the arch, and the posterior portion is taller, 2-3 cm in height and is called the lamina. The lamina project upwards behind the thyroid cartilage and articulates superiorly with the arytenoid cartilages. The inferior cornu of the thyroid cartilage articulates with the side of cricoid cartilage at the junction of the arch and lamina.

3. Epiglottis cartilage: It is a leaf shaped cartilage placed in the anterior wall of the upper part of the larynx. The upper end is broad and free. It projects upwards behind the hyoid bone and the tongue and overhangs the laryngeal inlet. The lower end is attached to the laryngeal inlet. The lower end is attached to the upper part of the angle between the two laminae of the thyroid cartilage and to the back of the hyoid bone on its upper end.

4. Arytenoid cartilages: The two arytenoids are pyramidal in shape and articulate into the upper lateral border of the cricoid. The vocal folds are attached to the anterior surface of the arytenoids. The posterior and lateral cricoarytenoid muscles are inserted onto the lateral sides of the arytenoid.

5. Corniculate cartilages: These are the two small cartilages which articulate with apex of the arytenoid cartilages and lie in the posterior part of the aryepiglottic folds.

6. Cuneiform cartilages: These are two small cartilages placed in the aryepiglottic folds just vertical to the corniculate cartilages.

LIGAMENTS OF LARYNX

Ligaments of larynx are divided into Extrinsic & Intrinsic ligaments.

Extrinsic - Medial Thyroid Ligament, Lateral Thyroid Ligament, Cricotracheal Ligament & Hyoepiglottic Ligament.

Intrinsic - Cricovocal Ligament, Vestibular Ligament & Aryepiglottic fold.

Cavity of larynx is made up of two folds, the upper vestibular and the lower vocal fold (or the false and true vocal cords) between which, there is slit like recess termed the sinus of the larynx. From the anterior part of the sinus, the saccule of the larynx ascends as a pouch between the vestibular fold and the inner surface of the Thyroid cartilage.

MUSCLES OF THE LARYNX

Muscles of the larynx are divided into Extrinsic and Intrinsic. Extrinsic muscles attach the larynx to the neighbouring structures and maintain the position of larynx in the neck.

Extrinsic muscles are divided into Suprahyoid and Infrahyoid.

Suprahyoid muscles are Mylohyoid, Geniohyoid, Stylohyoid, Stylopharyngeus, Palatopharyngeus and Salpingopharyngeus.

Infrahyoid muscle

Those that alter the shape of include the Thyrohyoid, Sternohyoid, Sternothyroid and Omohyoid.

Intrinsic muscles (Figure 6) are of great importance in regulating the mechanical properties of the vocal folds. They may be divided into:

- Those that open and close the glottis, namely the posterior cricoarytenoids, lateral cricoarytenoid and transverse and oblique arytenoids.
- Those that control the tension of the vocal folds, namely the thyroarytenoids (Vocalis) and cricothyroid.
- The inlet of the larynx namely the aryepiglottis and thyroepiglottis.

THE INTRINSIC MUSCLES OF LARYNX

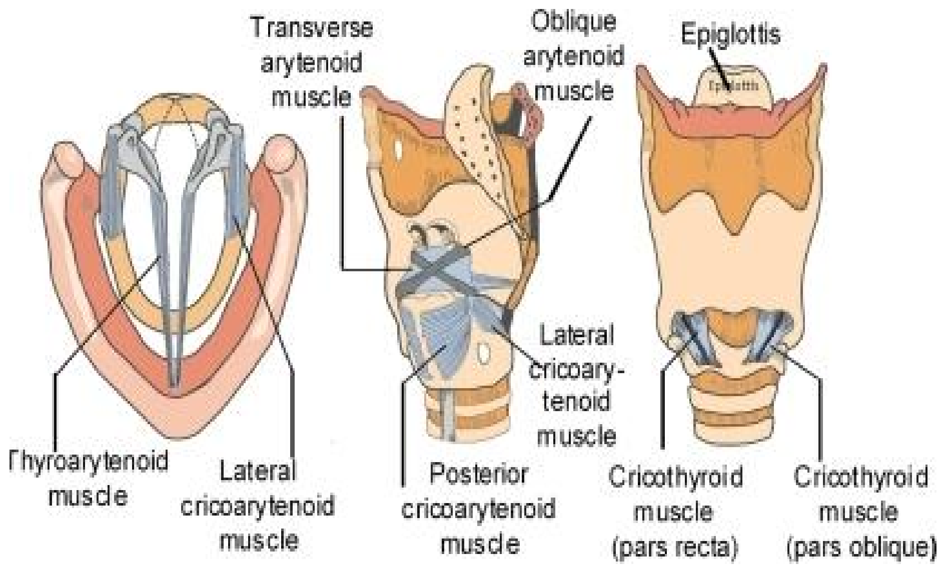


Figure 6

VOCAL CORDS: (Figure 8)

These are composed of muscles, ligaments, submucosal soft tissue and the covering mucous membrane. They extend from the arytenoids posteriorly to the thyroid cartilage anteriorly. The laryngeal cavity begins at its entrance. The vestibule of the larynx lies below the vocal cords, which in turn leads to the rima vestibuli. Two mucosal folds that bind the Rima vestibuli are called the ventricular folds. The lateral spaces between the ventricular and vocal folds are called the ventricles. The narrow space between the vocal folds is called the rima glottides (Glottis). The space that leads from the rima glottides to the trachea is the infraglottic cavity or the subglottis.

Nerve Supply of the Larynx: (Figure 7)

The nerve supply of the larynx is from the vagus through the superior and recurrent laryngeal branches. The superior laryngeal nerve divides into a small external branch and a large internal branch. The external branch provides motor supply to the cricothyroid muscles while the internal branch supplies to laryngeal mucous membranes above the vocal folds.

The recurrent laryngeal nerve divides into motor and sensory branches. The motor branch supplies all the intrinsic muscles of the larynx with the exception of the cricothyroid. The sensory branch supplies the laryngeal mucous membrane below the level of the vocal folds.

NERVE SUPPLY OF LARYNX

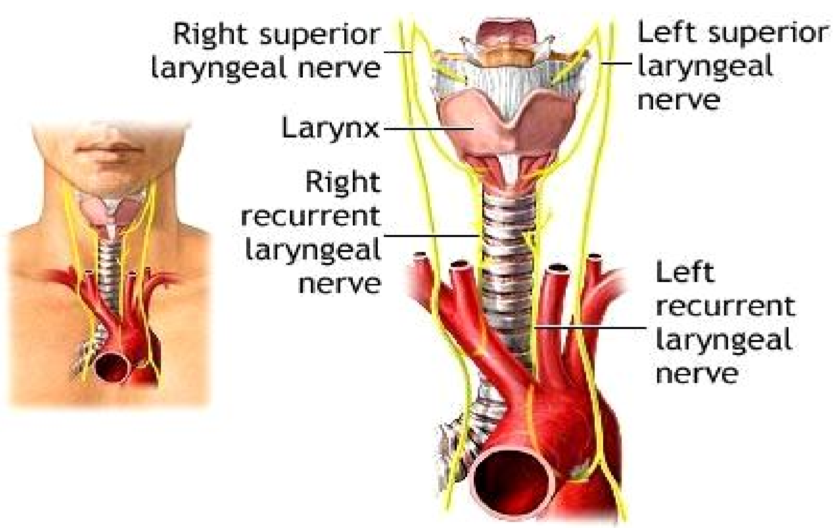


Figure 7

VOCAL CORDS AT LARYNGOSCOPY

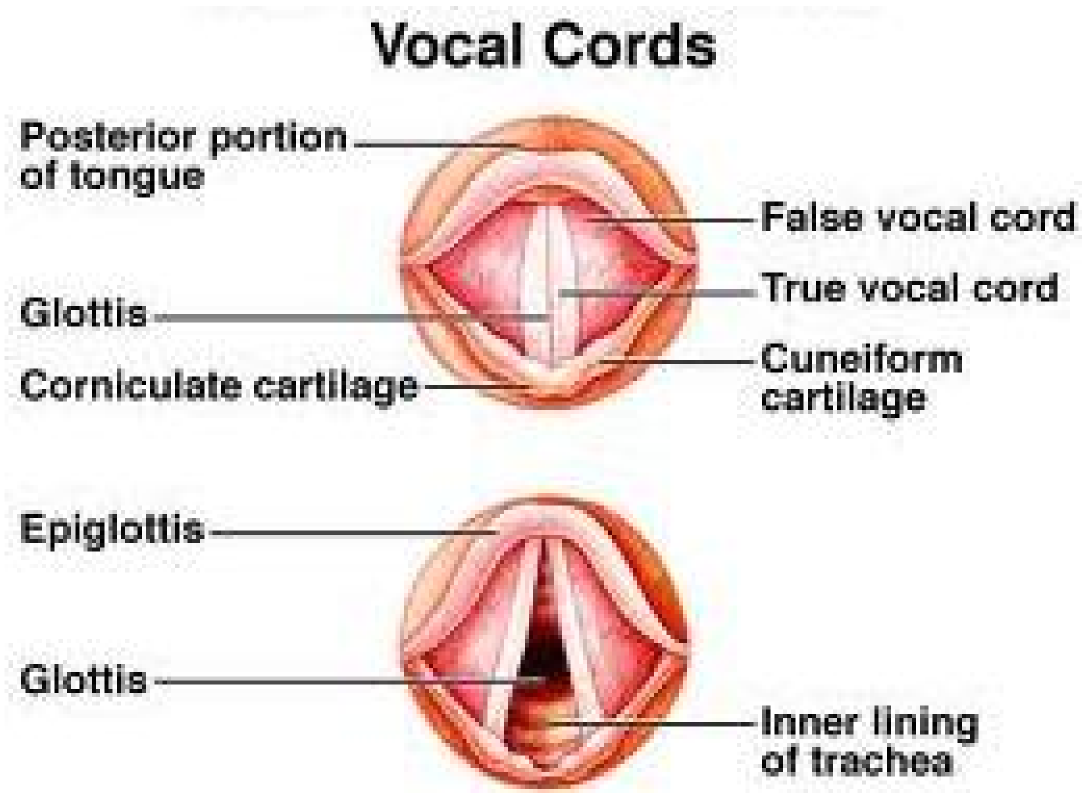


Figure 8

TRACHEA

The trachea begins at the level of C5 vertebrae. It is about 11 -14 cm long in adults and ends at the carina. The position of the carina alters with posture and respiration but is usually regarded as being at about T4-5 level. At carina, it divides into right and left main bronchi. Tracheal wall is supported by many ‘C’ shaped cartilages which are deficient posteriorly. This part of the tracheal wall is lined by tracheal is muscle. The anterior aspect of the trachea is covered with the skin, pretracheal fascia, the thyroid isthmus, and the thin strap muscles of the neck until it passes behind the sternum. Posteriorly it is related to the oesophagus. The pseudo stratified ciliated columnar epithelium lines the tracheal mucosa. The sensory supply is from the vagus.

DIRECT LARYNGOSCOPY & ENDOTRACHEAL INTUBATION

History[48]

Andreas Vesalius in 1543 described the technique of tracheal insufflation in animals.

Charles Kite in 1788 described about the oral and nasal intubation for resuscitation in apparently drowned patient.

Curry in 1792 described several metal endotracheal tubes.

M. Garcia 1854, a singing teacher in London, described indirect laryngoscopy with a mirror.

In 1858, John Snow intubated through a tracheostomy wound to anaesthetize the animals.

In 1878, William Macewan intubated the trachea orally using a tube. His finger was used as a guide in conscious patient for removal of carcinoma of mouth. He gave chloroform through the tube in the trachea. The idea came from the fact that he was using the tube for relief of obstruction in laryngeal diphtheria.

In 1895, Alfred Kirstein and in 1912 Gustav Killian demonstrated the direct laryngoscopy.

In 1899: Chevalier Jackson demonstrated his first bronchoscopy and popularised direct laryngoscopy.

Edgar Stanley Rowbotham (1890-1979) and Ivan Whiteside Magill (1888-1986) passed tracheal tube via laryngoscope. The laryngoscope was designed by Magill (1926) adopting and modifying that of Alfred.

Edgar Stanley Rowbotham performed the first blind naso oral intubation.

In 1928, Ralph Milton Waters and Arthur E. Guedel reintroduced cuffs that are inflatable.

Miller and Macintosh designed a laryngoscope in 1932.

Muscle relaxant to facilitate intubation was pioneered by Bourne.

INDICATIONS OF ENDOTRACHEAL INTUBATION

Surgery on the head and neck

During anaesthesia using IPPV and muscle relaxat ion

Protection of the respiratory tract

To facilitate suction of the respiratory tract (Pulmonary toilet)

Thoracic surgery

Cardiopulmonary arrest

Mechanical Ventilation

TECHNIQUE OF ORAL INTUBATION

Head Positioning

The correct position for the head is the"sniffing position", with the neck (lower cervical joints) slightly flexed and the head (At lanto-occipital joint) extended. One places a pillow or folded sheets (5 cms in height) below the occiput to maintain the position (Figure 9). All these aforesaid manoeuvres help to put the oral, pharyngeal and laryngeal axes in a straight line as mentioned in the Figure 9.

Direct Laryngoscopy

The Macintosh laryngoscope is held in the left hand and introduced into the right hand side of the mouth. The tongue is swept to the left and the tip of the blade is advanced until a fold of cartilage is visualized at 12 'O' Clock position. This is the Direct Laryngoscopy and Endotracheal Intubation.

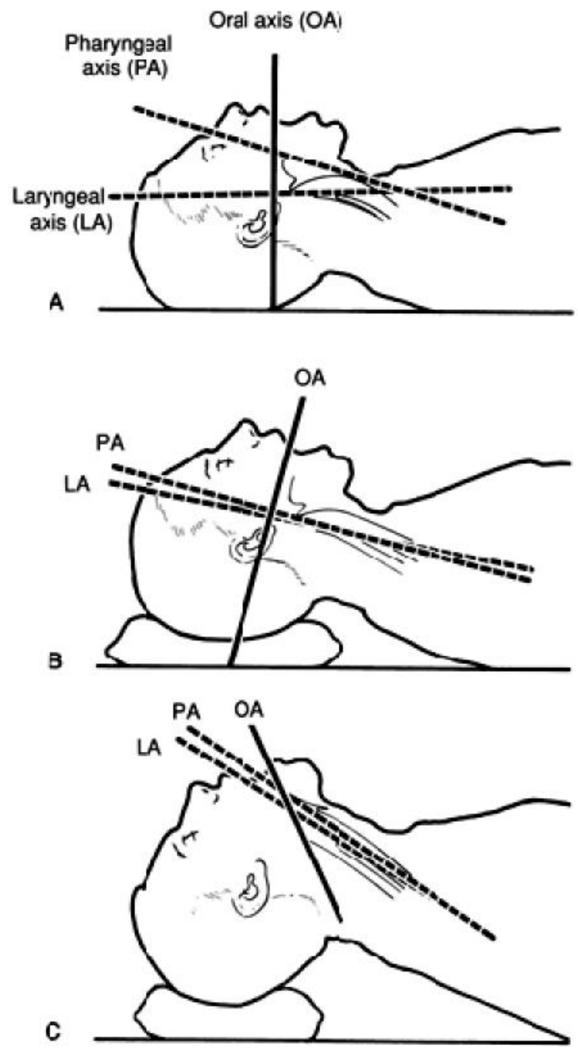


Figure 9

The Sniffing position denoting the three axes, epiglottis and this sits over the glottis. The tip of the blade is advanced to the base of the epiglottis, known as the vallecula, and the entire laryngoscope is lifted upwards and outwards. This flips the epiglottis upward and exposes the glottis below. An opening is seen with two white vocal cords (Figure 8) forming a triangle on each side.

Intubation

The endotracheal tube is inserted into the right side of the mouth and inserted between the open vocal cords under direct vision. The correct position of the tube is confirmed by auscultation or capnography. The tube is secured at this level and the cuff is inflated.

COMPLICATIONS

The complications are usually due to airway trauma, tube malpositioning and physiological responses to airway instrumentation or tube malfunction. These complications can occur during laryngoscopy while intubation, while the tube is in place or following extubation.

Complications during Laryngoscopy and Intubation

1. Malpositioning

- Oesophageal intubation
- Endobronchial intubation

2. Airway Trauma

- Tooth damage
- Lip, tongue or mucosal injury
- Sore throat

3. Physiological reflexes

- Hypertension
- Tachycardia
- Laryngospasm

4. Airway trauma

- Tooth damage
- Lip, tongue or mucosal injury, Sore throat

5. Tube malfunction

6. Cuff perforation

DIFFICULT AIRWAY ALGORITHM

AMERICAN SOCIETY OF ANAESTHESIOLOGISTS

DIFFICULT AIRWAY ALGORITHM

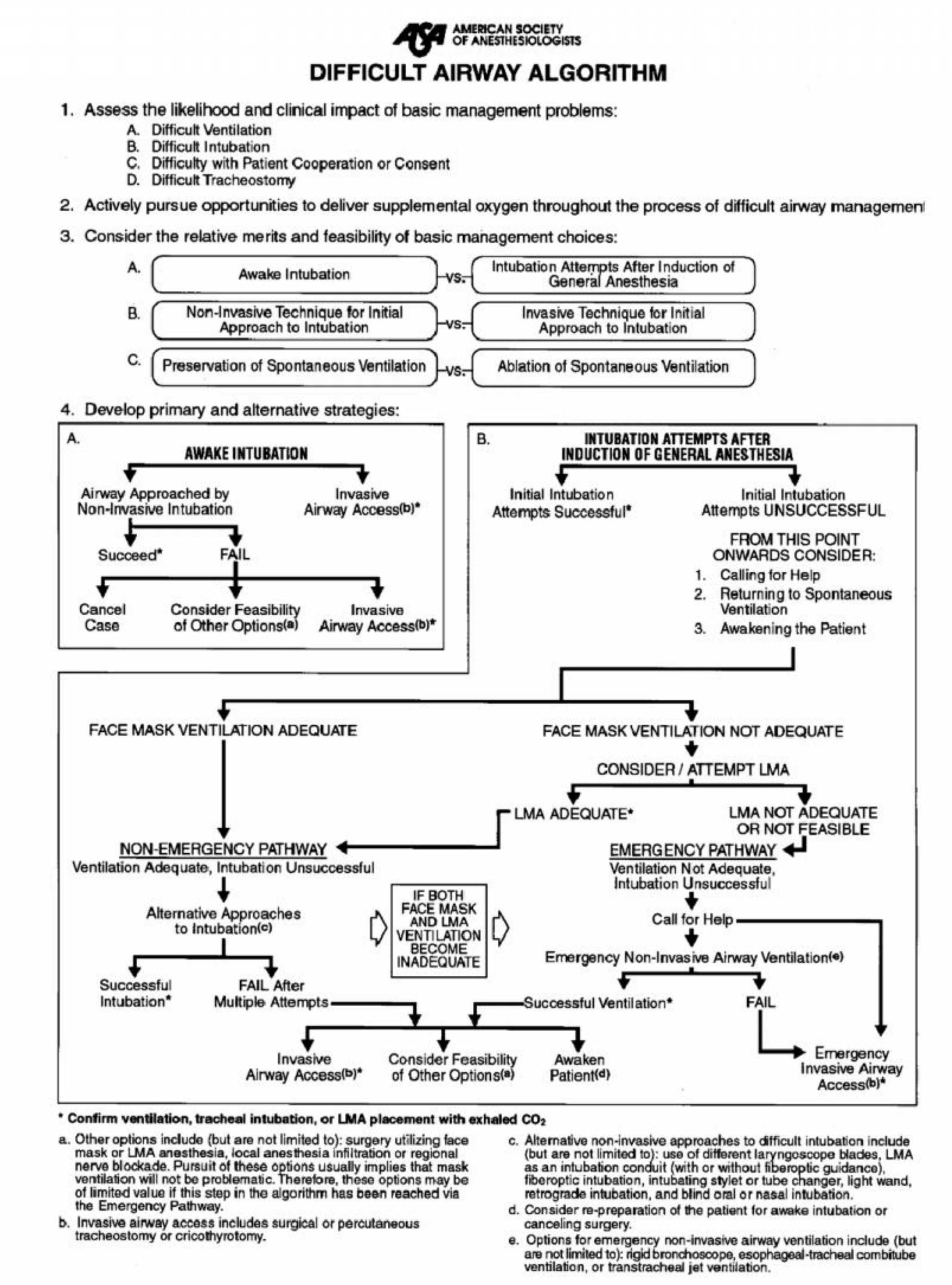


Figure 10

MATERIALS AND METHODS

This study was conducted at Chengalpattu Medical College and Hospital. Two hundred and eight adult patients aged between 15 –75 years of age requiring surgery under GA with endotracheal intubation were enrolled in our current study. Institutional ethical committee clearance and written informed consent from the patients were obtained prior to the proposed surgery.

INCLUSION CRITERIA

1) Any patient undergoing elective surgery requiring general anaesthesia with endotracheal intubation,
2) Age between 15 – 75 years,
3) ASA I to II.

EXCLUSION CRITERIA

1. Edentulous patients and patients without both upper and lower incisors,
2. Patients undergoing emergency surgeries and that requiring rapid sequence intubation,
3. Patients with obvious neck or oral malformations, tumours involving upper airway,
4. Pregnancy

All patients underwent a routine pre anaesthetic assessment prior to surgery. A routine general physical examination was done on all patients along with routine laboratory investigations, ECG and chest X-ray. The enrolled patients were subjected to the following assessments preoperatively:

A. Clinical parameters

1. The modified Mallampati classification[11] (Figure 10 – The revised scoring system by Samsoon and Young was used). Oropharyngeal view was assessed with the patient in the sitting position (The observer's eye and patients mouth was at the same level) with the tongue fully protruded but without any phonation).

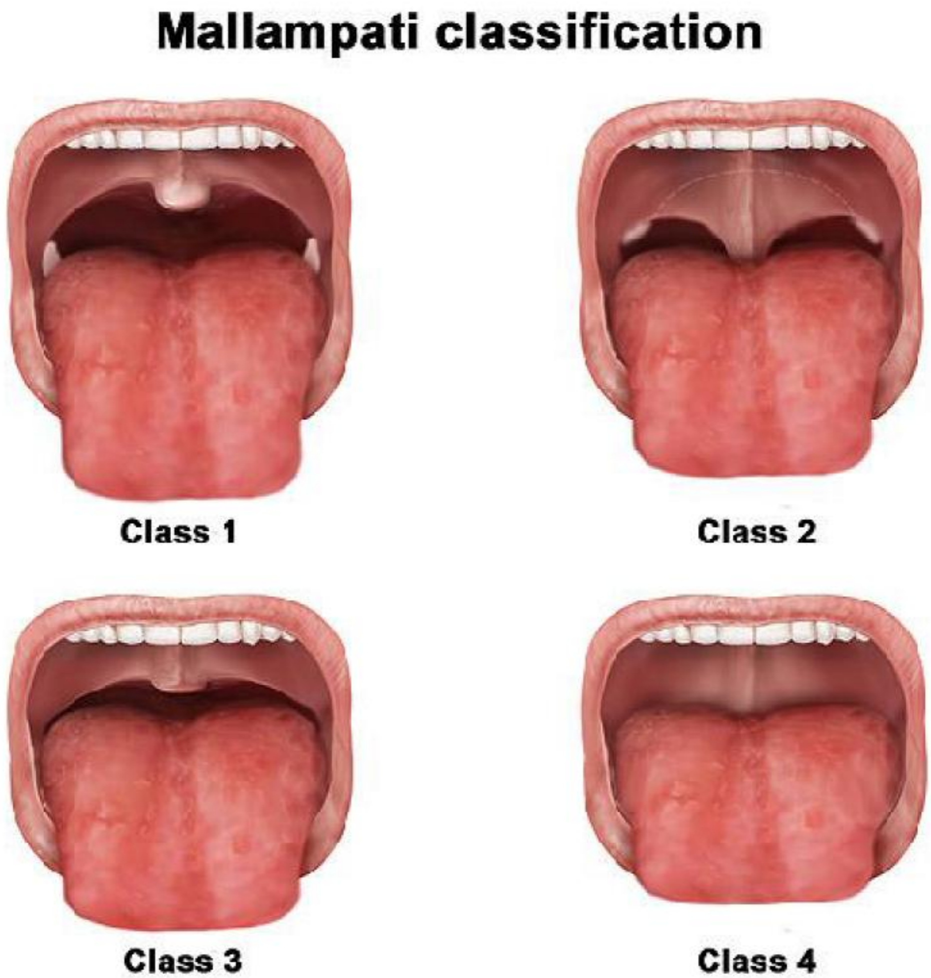
   The classification was as follows -

   Class I- if the soft palate, fauces, uvula, and pillars visible

   Class II- if soft palate, fauces, and uvula visible

   Class III- if only the soft palate and base of the uvula visible

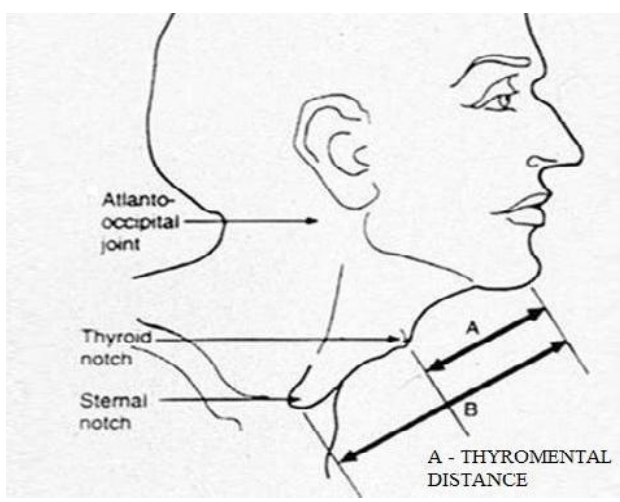
   Class IV- if the soft palate is not visible.



2. Mouth opening was measured as inter- incisor gap by asking the patients to open the mouth as wide as possible. Then, the distance between the upper and lower incisors were measured at the centre of the mouth using a rigid plastic scale. Distances less than 4 cm was classified as difficult intubation.

3. Thyromental distance[12] (Figure 11) was measured between the thyroid notch and the bony mentum using a rigid plastic scale with the neck fully extended was measured and the results were graded into three levels.

TMD > 6.5cms,
TMD 6.0 - 6.5cms,
TMD < 6 cms- difficult intubation



5. Sternomental distance: Sternomental distance (SMD), is measured from the tip of the chin to the sternal notch. It is normally >12.5 cm as reported by Savva. The measurement of < 12 cm on maximal extension of the head predicts difficult intubation.

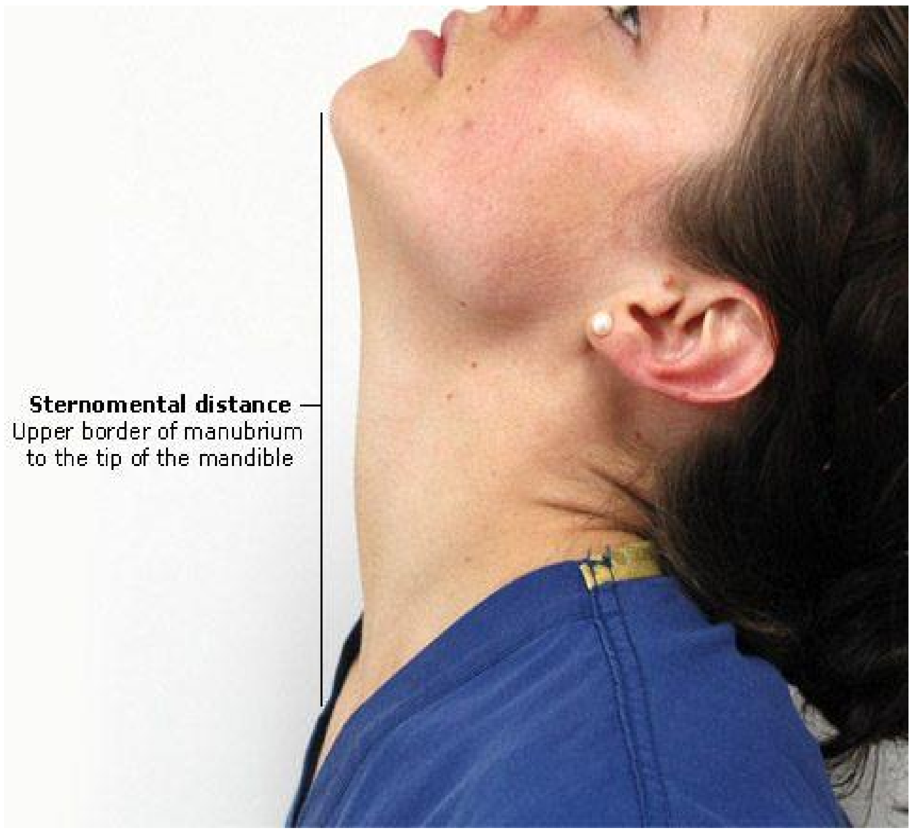


Figure 12

5. Wilson sum risk score[13]:

	Score
Weight	0=<90kg 1=>90kg 2=>110kg
Head and neck movement	0=Above 90degrees 1=About 90degrees 2=Below 90degrees
Jaw movement	0=IG>5cm 1=IG=5cm 2=IG<5cm
Receding - mandible	0=Normal 1=Moderate 2=Severe
Buck- teeth	0=Normal 1=Moderate 2=Severe

B. Radiological parameters

1. Atlanto-occipital gap[52]

Atlanto-occipital distance is the major factor which limits the extension of head on neck. Longer the A-O gap, more space is available for mobility of head at that joint with good axis for laryngoscopy and intubation. Radiologically there is reduced space between

C1 and occiput. It is measured from the tip of the spine of atlas to the occipit.

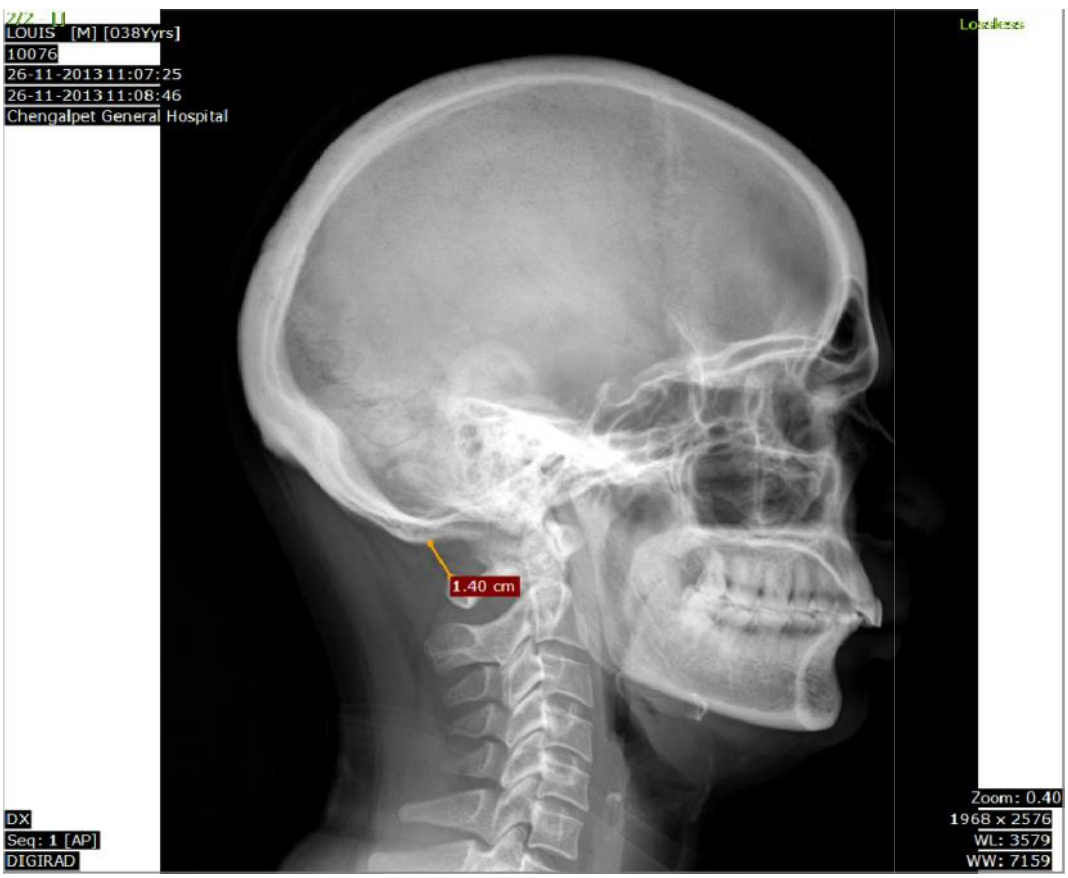


Figure -13 Atlanto occipital distance

2. Anterior depth of the mandible[52]

It is measured from tip of the lower incisor to the lower anterior mandibular bone margin. An increase in the depth denotes significant intubation difficulty.

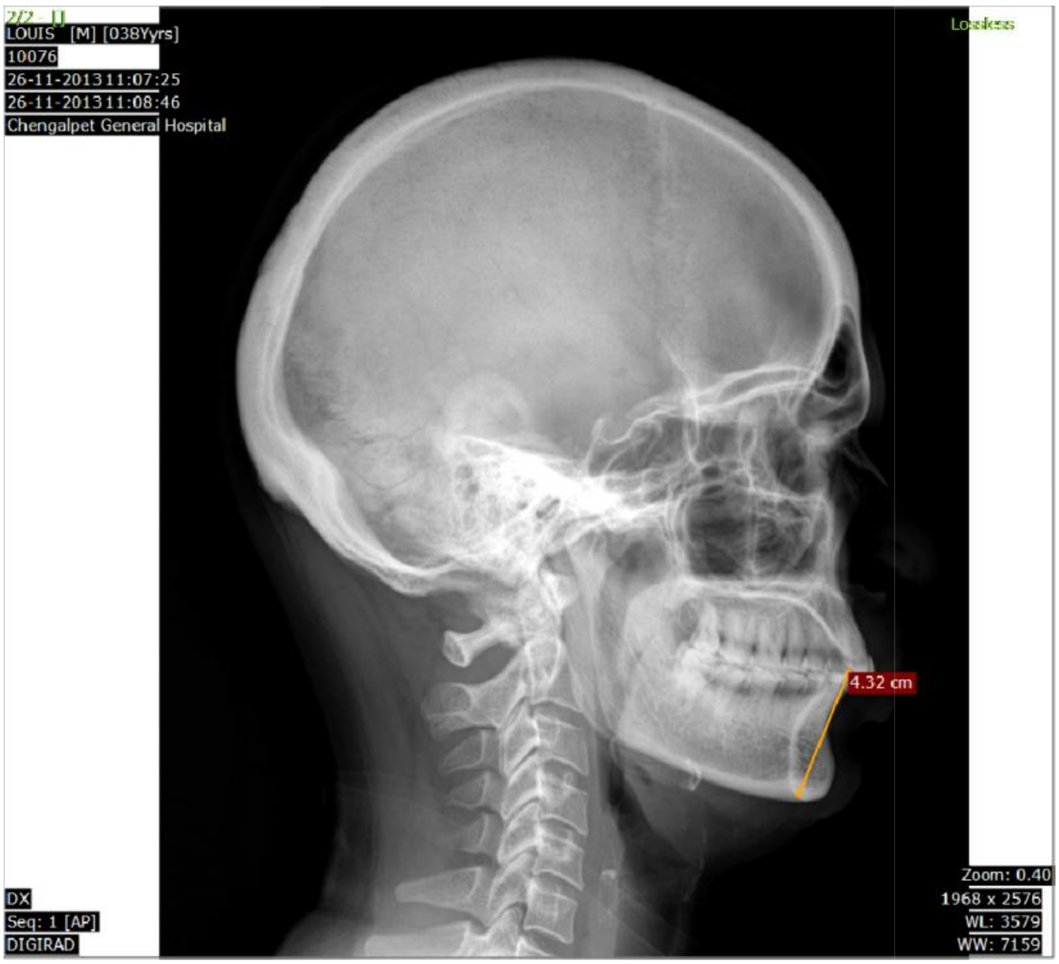


Figure- 14 Anterior mandibular depth

3. Posterior depth of the mandible[52, 53]

White and Kander (1975)[53] reported an important measurement, the depth of the posterior mandible. It is measured between the bony alveolus behind the third lower molar tooth and the lower border of the mandible. An increase in the depth denotes significant intubation difficulty.

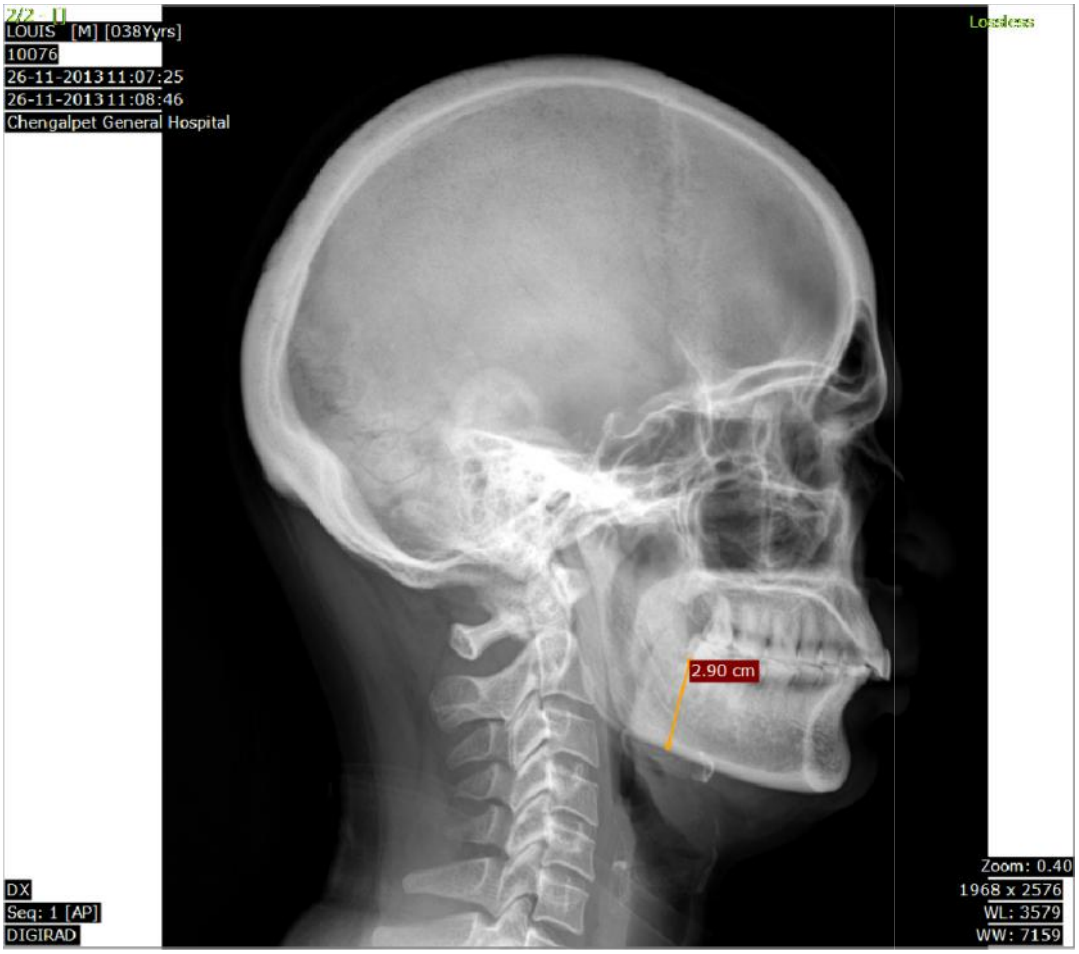


Figure- 15 Posterior mandibular depth

4. Effective mandibular depth[52]

This is measured from the tip of the lower incisor to the tempero-mandibular joint.

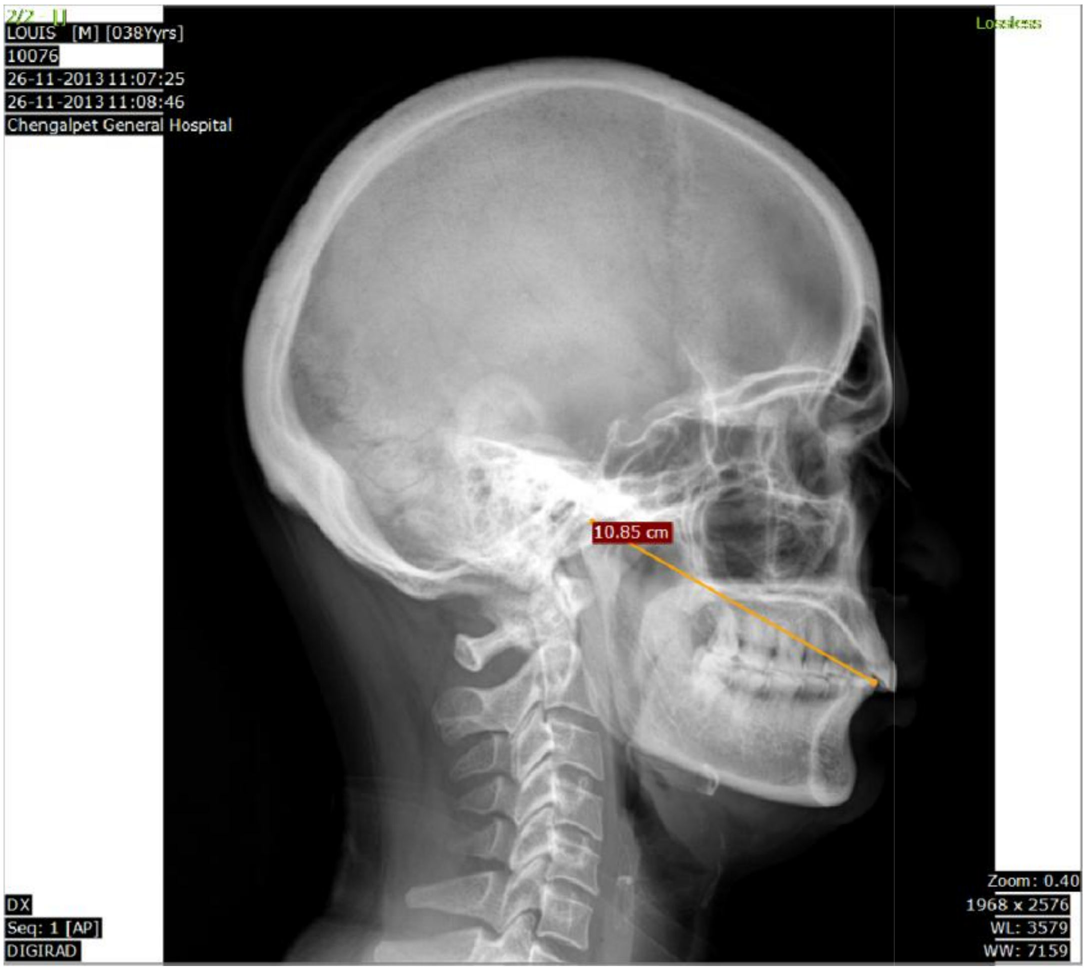


Figure- 16 Effective mandibular depth

5. C2 spine depth[52]

It is measured as width from the upper and the lower border of the second cervical spine. An increase in the depth denotes significant intubation difficulty.

Figure- 17 C_2 spine depth

All the clinical assessments were done by a single Anaesthesia resident and the radiological assessment was done by radiologist with more than two years of experience and was blinded to the study.

Anaesthesia Protocol

All the enrolled patients were given Tab diazepam 0.5mg and Tab ranitidine 150mg and fasted overnight. On the day of surgery, a resident anaesthesiologist checked for whether consent to provide anaesthesia was obtained. An IV line was secured in the pre-operative room. The patient was then shifted to the operation theatre and connected to multipara monitors including electrocardiogram, non-invasive blood pressure and pulse oximetry.

A difficult airway trolley was kept ready before anaesthetising the patient in case of difficulty during intubation consisting of

1. All sizes of Macintosh blades (Sizes 1, 2, 3, 4)
2. McCoy Blade,
3. Stylet,
4. Gum elastic bougie,
5. Guedels airway (All Sizes),
6. All sizes of endotracheal tubes, (5.5-8.5 ID)
7. Laryngeal mask airways (Size 2-4),

8. LMA fastrach,

9. Combitube,

10. Glidescope videolaryngoscope,

11. Fibreoptic bronchoscope,

12. Percutaneous tracheostomy,

13. Retrograde intubation set,

14. Suction apparatus

All sizes of Macintosh blades (Sizes 1, 2, 3, 4) and masks, McCoy Blade, Stylet, Gum elastic bougie, Guedels airway (All Sizes).

Figure 18

All sizes of endotracheal tubes, (5.5-8.5 ID),
Laryngeal mask airways (Size 2-4), LMA fastrach

Figure 19

Combitube, Percutaneous tracheostomy, Cricothyrotomy set, Retrograde intubation set,

Figure 20

Glidescope videolaryngoscope

Figure 21

Fibreoptic bronchoscope

Figure 22

All the enrolled patients were anaesthetized using a standardised anaesthesia technique comprising of premedication with Inj. Glycopyrrolate 0.01 mg/kg, Inj.Midazolam 0.05 mg/kg and Inj. Fentanyl 2 mcg/kg intravenously. After preoxygenation with 100% oxygen for 3 minutes, patients were induced with Inj. Propofol 2 mg/kg and Inj .Succinylcholine 1.5 mg/kg given iv. Laryngoscopy and endotracheal intubation was attempted with the patient's head and neck in optimal intubating position with a pillow under the occiput during intubation (sniffing position), using an appropriate size Macintosh curved blade for all patients by an anaesthesiologist having minimum two years of experience in clinical anaesthesia. The anaesthesiologist who performed the laryngoscopy and intubation was blinded to the study. The glottic view was graded according to the Cormack and Lehane grading as given below.

Grade I – whole of the glottis is viewed

Grade II – Only the posterior commissure is visible

Grade III – Only the tip of the epiglottis is visible

Grade IV - No glottic structure is visible

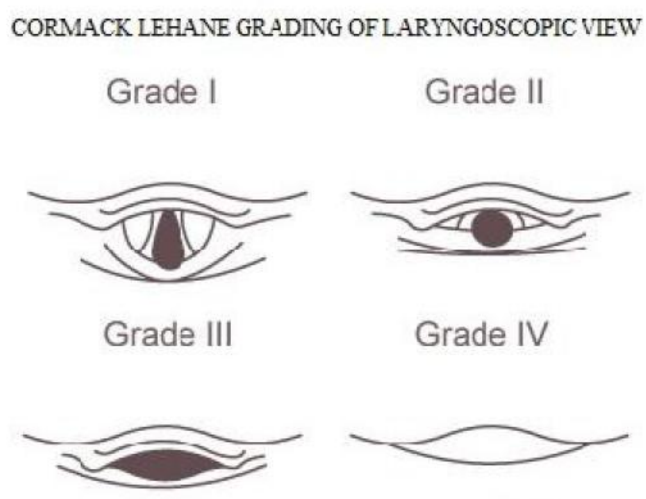


Figure 23

The patient was then intubated. If the intubation was found to be difficult, the anaesthesiologist would first perform an optimal external laryngeal manipulation[46] to improve the glottic exposure. If this failed to improve the glottic view, the size of the blade was changed or a McCoy

Blade used or a gum elastic bougie was employed as preferred by the anaesthesiologist.

Endotracheal intubation was considered difficult, if Cormack and Lehane grading was III and IV[32, 47].

Patient's vital signs were monitored through out the procedure. At the end of surgery patients were adequately reversed with Inj. Glycopyrrolate 0.01 mg/kg and Inj. Neostigmine 0.05 mg/kg and extubated after through oral suctioning. After stabilization, patients were shifted to the post anaesthesia care unit for further monitoring.

STATISTICAL ANALYSIS

Analysis of the preoperative airway assessment data and the findings during intubation were used to determine the sensitivity, specificity, positive and negative predictive value for each test. Cross tabs procedure was employed for association between the airway predictors and difficulty in intubation. Discrimant analysis and ROC curve is used in the statistical analysis.

STATISTICAL TERMS

True positive (TP): A difficult intubation that had been predicted to be difficult.

False positive (FP): An easy intubation that had been predicted to be difficult.

True negative (TN): An easy intubation that had been predicted to be easy.

False negative (FN): A difficult intubation that had been predicted to be easy.

Sensitivity: The percentage of correctly predicted difficult intubations as a proportion of all intubations those were truly difficult.

Specificity: The percentage of correctly predicted easy intubations as a proportion of all predicted difficult intubations.

Positive predictive value (PPV): The percentage of correctly predicted difficult intubations as a proportion of all predicted difficult intubations.

Negative predictive value (NPV): The percentage of correctly predicted easy intubations as a proportion of all predicted easy intubations.

Receiver operating characteristic curves (ROC): This curve helps in finding the best predictive scores. The ROC curve has sensitivity on the y-axis and 1 - specificity on the x-axis. The study model with greatest area below the curve is the better one.

$$\text{Sensitivity} = \frac{TP \times 100}{TP+FN}$$

$$\text{Specificity} = \frac{TN \times 100}{FP+TN}$$

$$\text{Positive Predictive Value} = \frac{TP \times 100}{TP+FP}$$

$$\text{Negative Predictive Value} = \frac{TN \times 100}{FN+TN}$$

OBSERVATIONS & RESULTS

The present study was undertaken to assess the reliability and to compare the commonly used preoperative difficult airway assessment criteria. Two hundred and eight patients of either sex between the ages of 15 and 75 and who are posted for surgery under general anaesthesia with endotracheal intubation were assessed.

The following factors when present either alone or in combination was considered to be predictors of difficult intubation in the present study.

1. Clinical
    a. Samsoon and Young modification of Mallampati grade III&IV
    b. Interincissor gap < 4 cm
    c. Thyromental distance < 6 cm
    d. Sternomental distance < 12cm
    e. Wilson risk sum score > 2
2. Radiological [lateral x-ray] measurements.
    a. Atlanto-occiptital distance
    b. Anterior mandibular length
    c. Posterior mandibular length
    d. Effective mandibular length
    e. C-2 spine depth

Endotracheal intubation was considered difficult, if Cormack and Lehane grade is III and IV[32, 47].

The Demographic profile and Distribution of the all the studies in patients have been given in Tables 1 to 13.

Table 1 : Age Distribution

Age (yrs)	No of Cases
18-30	62
31-40	74
41-50	36
51-75	36
Total	208

Graph 1: Age distribution

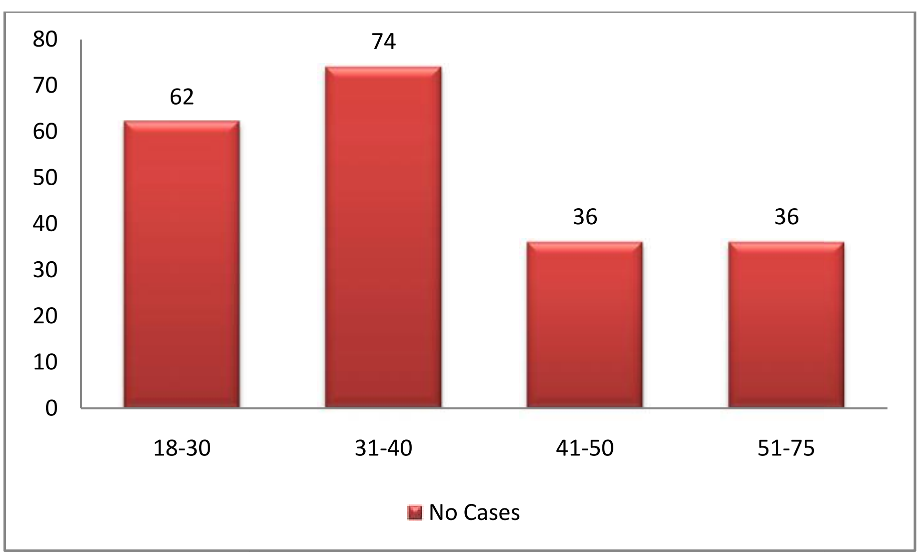


Table 2 : Gender Distribution

Gender	No of Cases
FEMALE	95
MALE	113
Total	208

95 females and 113 males were included in our study.

Graph 2 : Gender distribution

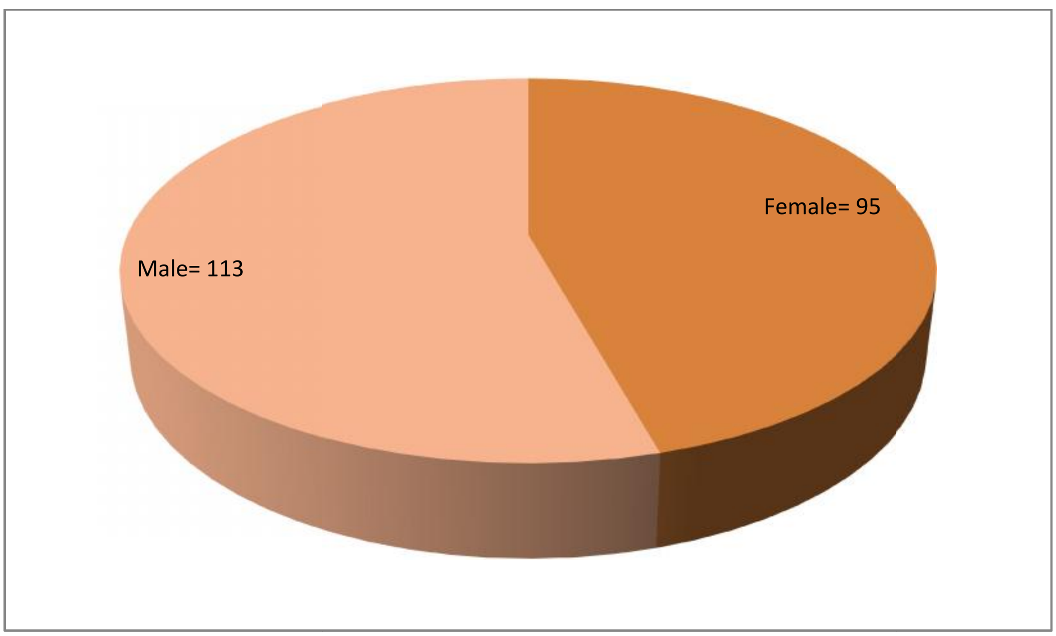
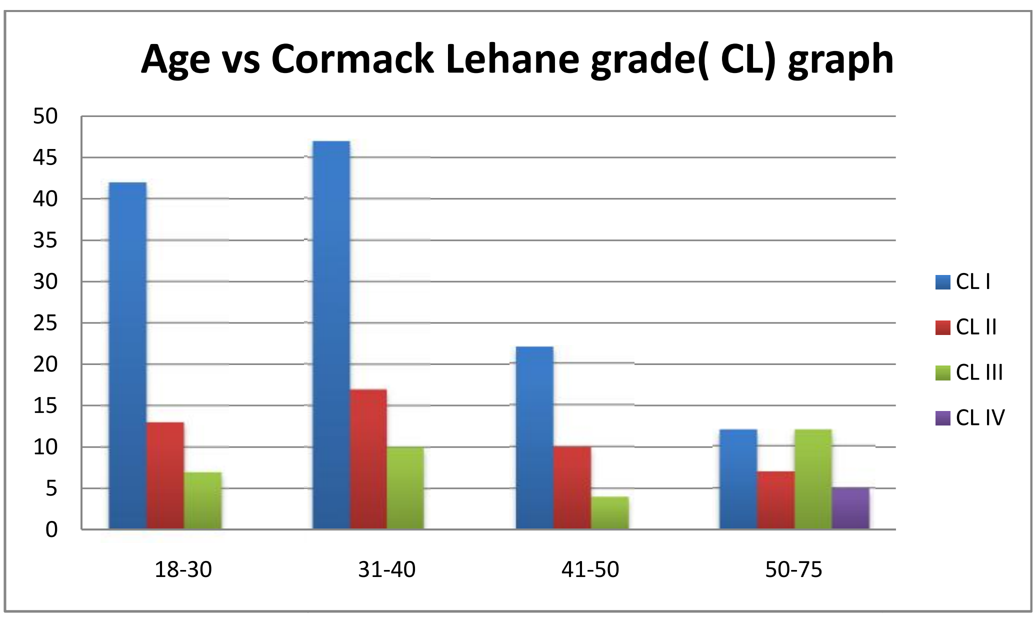


Table 3 : Age vs Difficult Intubation

Age Distribution	Cormack Lehane Grades				Total
	I	**II**	**III**	**IV**	
18-30	42	13	07	00	62
31-40	47	17	10	00	74
41-50	22	10	04	00	36
50-75	12	07	12	05	36
total	123	47	33	05	208

Graph 3 : Age vs Cormack Lehane grade (CL)

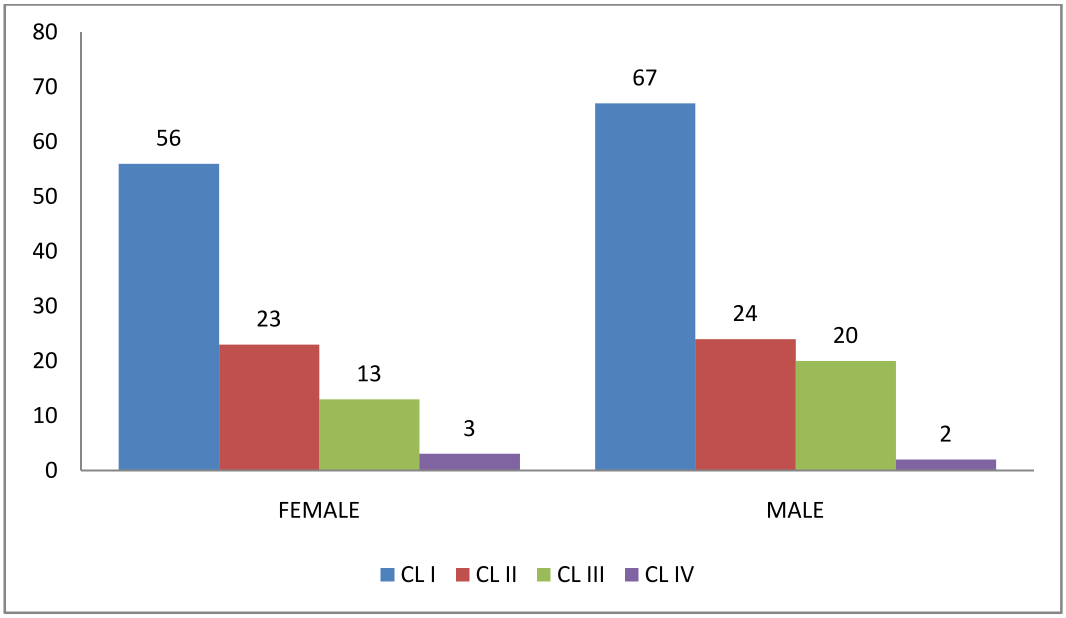


In our study, during laryngoscopy and intubation we observed 38 patients with difficulty in intubation (vide Clause 2). As for distribution of age to difficult intubation is concerned, 17 patients were less than 40 years of age and 21 patients were more than 40 years. This is statistically significant. The mean age of easy intubation group was 36.1 $\pm$ 11.7 yrs and that of difficult intubation group was 43.7 $\pm$ 13.1 yrs. This was found to be statistically significant.

Table 4 : Gender vs Difficult Intubation

Gender	**Cormack Lehane Grade**				**Total**
	I	**II**	**III**	**IV**	
FEMALE	56	23	13	03	95
MALE	67	24	20	02	113
Total	123	47	33	05	208

Graph 4: Gender vs Cormack Lehane Grade (CL)

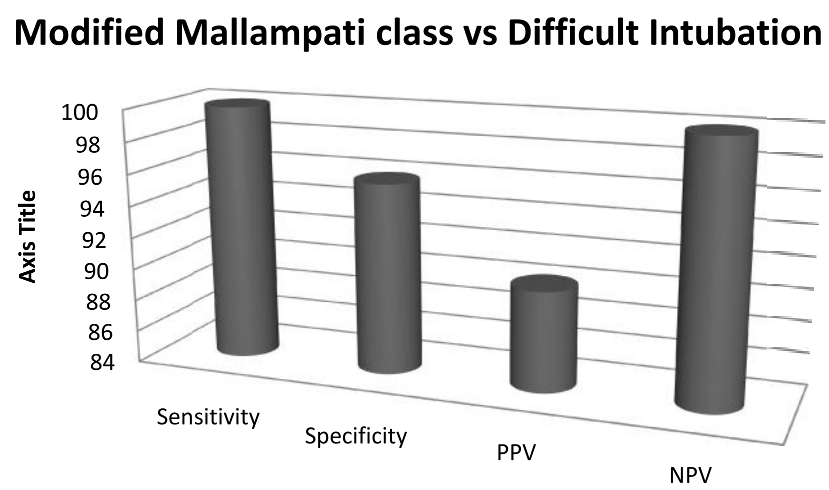


Distribution of gender against difficult intubation showed that 16 patients were females and 22 were males. The means of male and female were not statistically significant.

Table 5 : Modified Mallampati class vs Difficult Intubation

Parameter	Value
• True positive	37
• False positive	7
• True negative	164
• False negative	0
• Sensitivity	100%
• Specificity	95.90%
• Positive predictive value	90.24%
• Negative predictive value	100%

Graph 5 : Modified Mallampati class vs Difficult Intubation graph



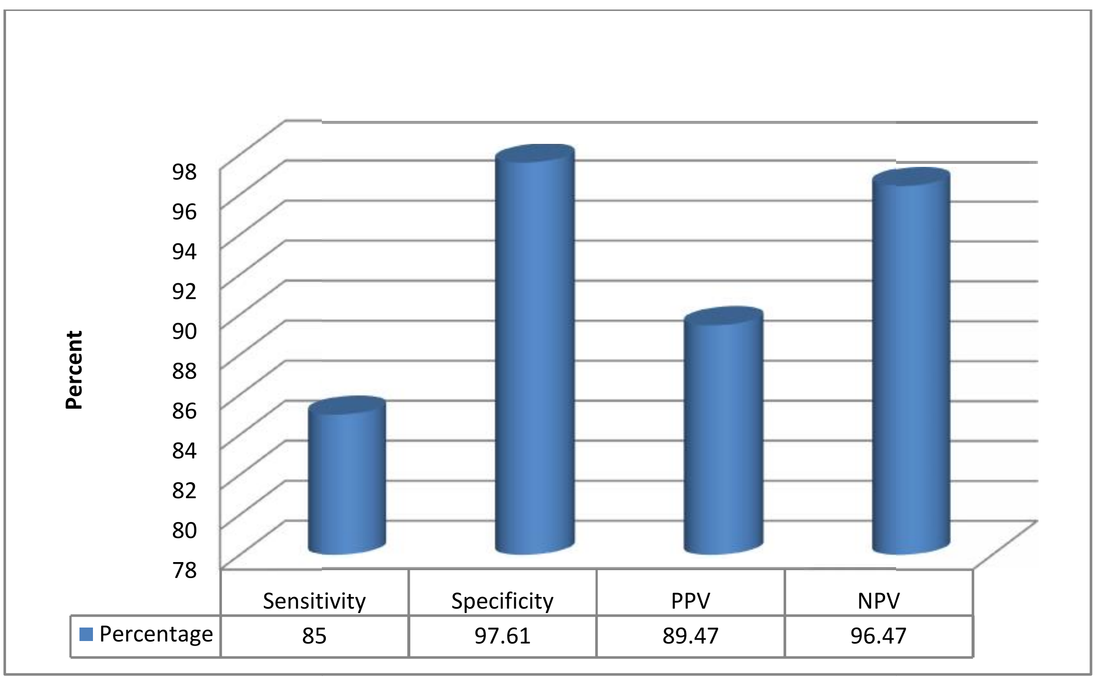
	Sensitivity	Specificity	PPV	NPV
percentage	100	95.9	90.24	100

Among the two hundred and eight patients, modified Mallampati class vs difficult intubation chart [table 5] shows, thirty seven patients are true positive, seven patients are false positive and one hundred and sixty four patients are true negative. The sensitivity and specificity is 100% and 95.90%.The PPV and NPV is 95.90% and 90.24%.

Table 6 : Inter incisor gap vs Difficult Intubation

Parameter	Value
• True positive	34
• False positive	4
• True negative	164
• False negative	6
• Sensitivity	85%
• Specificity	97.61%
• Positive predictive value	89.47%
• Negative predictive value	96.47%

Graph 6 : Inter incisor gap vs Difficult Intubation

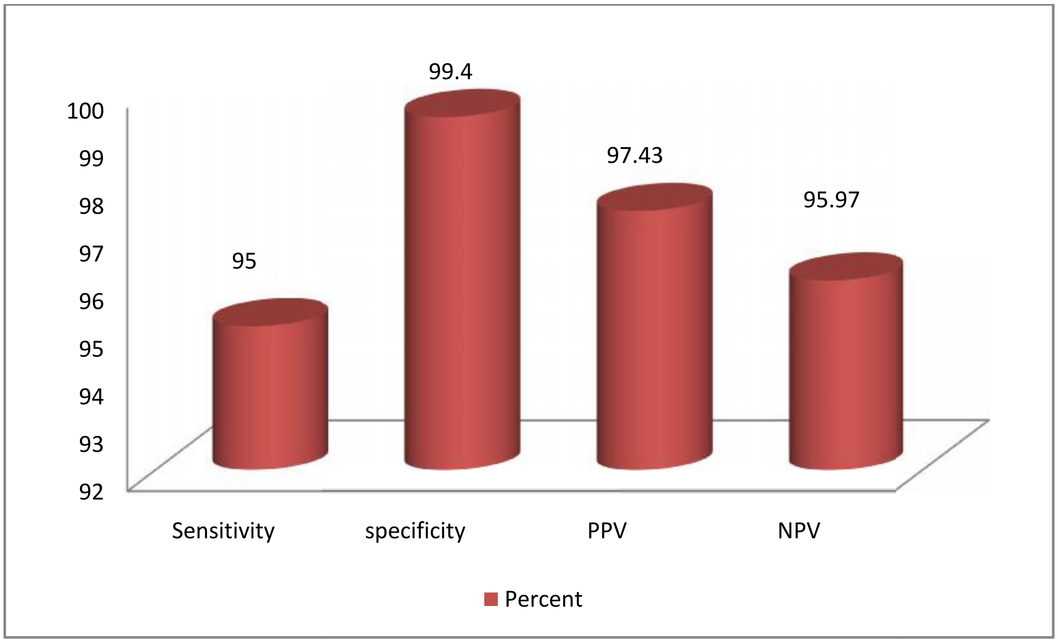


Among the two hundred and eight patients, inter incisor gap vs difficult intubation chart [table 6] shows, thirty four patients are true positive, four patients are false positive, one hundred and sixty four patients are true negative and six patients are false negative. The sensitivity and specificity is 85% and 97.61%.The PPV and NPV is 89.47% and 96.47%.

Table 7 : Thyromental distance vs Difficult Intubation

Parameter	Value
• True positive	38
• False positive	1
• True negative	167
• False negative	2
• Sensitivity	95%
• Specificity	99.4%
• Positive predictive value	97.43%
• Negative predictive value	95.97%

Graph 7: Thyromental distance vs Difficult Intubation

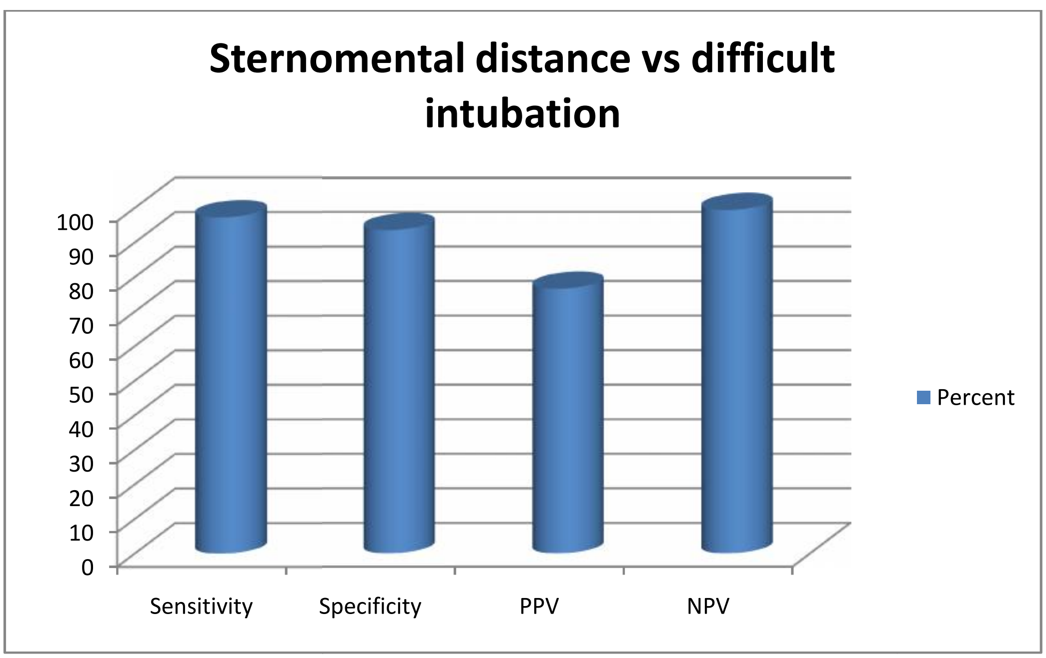


In Thyromental distance vs Difficult Intubation chart [table 7] shows, among the two hundred and eight patients, thirty eight patients are true positive, one patient is false positive, one hundred and sixty seven patients are true negative and two patients are false negative. The sensitivity and specificity is 95% and 99.4%.The PPV and NPV is 97.43% and 95.97%.

Table 8 : Sternomental distance vs difficult intubation

Parameter	Value
• True positive	36
• False positive	11
• True negative	160
• False negative	1
• Sensitivity	97.29%
• Specificity	93.56%
• Positive predictive value	76.59%
• Negative predictive value	99.37%

Graph 8: Sternomental distance vs difficult intubation



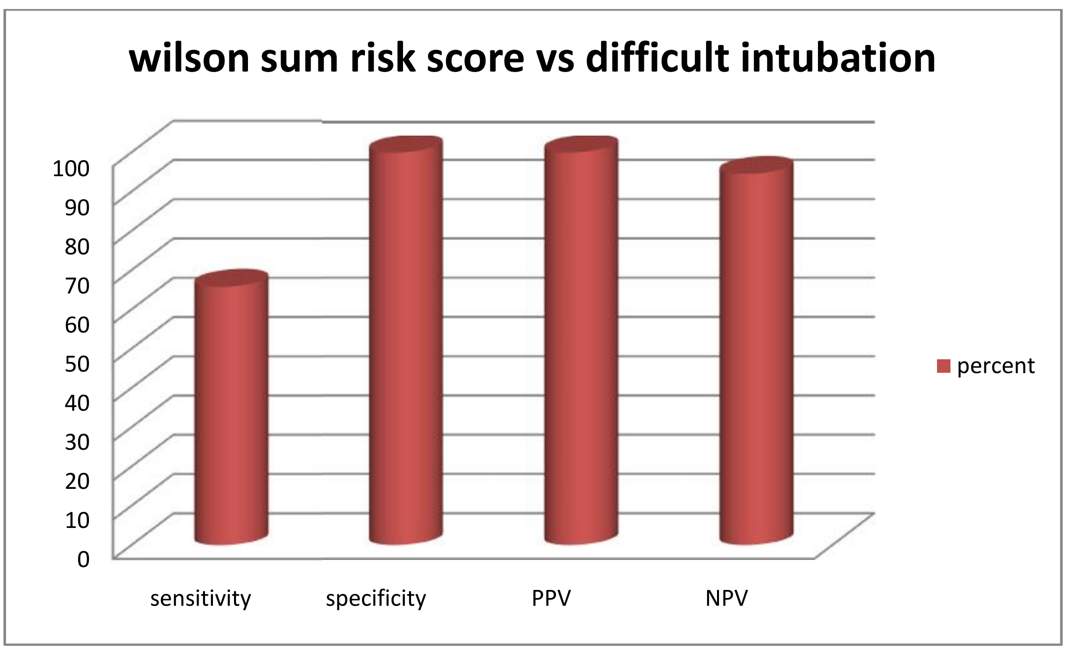
Sternomental distance vs difficult intubation chart [table 8] shows, among the two hundred and eight patients, thirty six patients are true positive, eleven patients are false positive, one hundred and sixty patients are true negative and one patient is false negative. The sensitivity and specificity is 97.29% and 93.56%.The PPV and NPV is 76.59% and 99.37%.

Table 9 : Wilson risk score vs difficult intubation

Wilson risk score	**Cormack Lehane Grade**				**Total**
	I	**II**	**III**	**IV**	
0	121	40	5	01	168
1	00	09	07	00	16
2	00	00	19	04	23
3	00	00	01	00	01
4	00	00	01	00	01
Total	121	49	33	05	208

Table 10: Wilson sum risk score vs difficult intubation

Parameter	Value
• True positive	25
• False positive	00
• True negative	170
• False negative	13
• Sensitivity	65.78%
• Specificity	100%
• Positive predictive value	100%
• Negative predictive value	94.53%

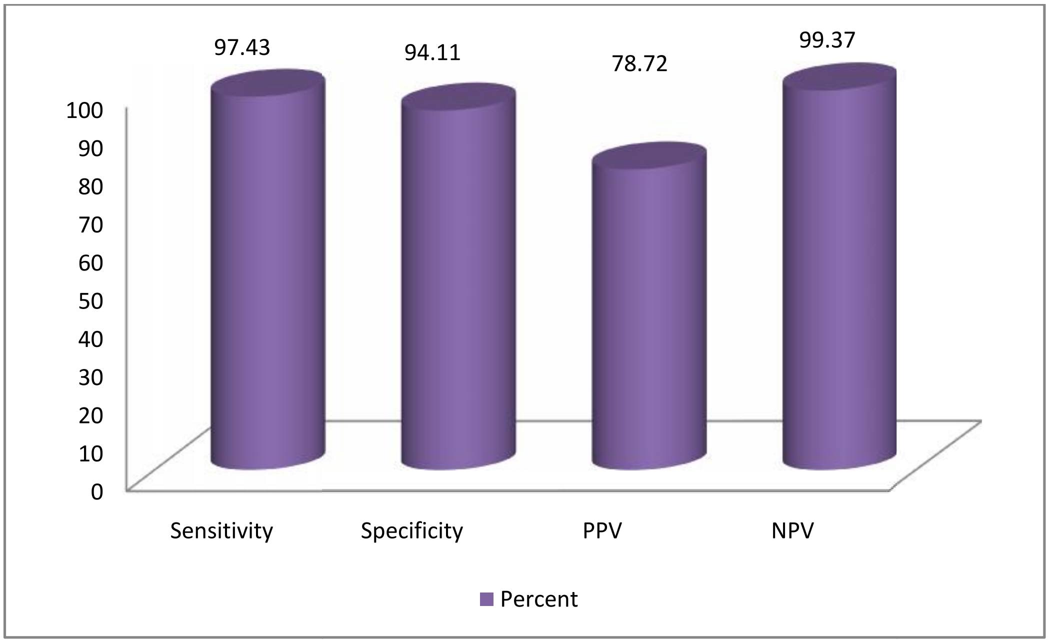


Wilson & colleagues[13] reported study with five risk factors combination with Grade of 0 represents no risk for difficult intubation and a grade of 2 representing the greatest risk for difficult intubation. In our study the Wilson risk sum score suggested a sensitivity of 65.78%, specificity of 100%, positive predictive value of 100% and negative predictive value of 94.53%. This study is in concurrence with the reports of Wilson & colleagues[13] and Oates and colleagues[25].

Table 9 : Atlanto- Occipital distance vs Difficult Intubation

Parameter	**Value**
• True positive	37
• False positive	10
• True negative	160
• False negative	1
• Sensitivity	97.43%
• Specificity	94.11%
• Positive predictive value	78.72%
• Negative predictive value	99.37%

Graph 9 : Atlanto occipital distance vs difficult intubation

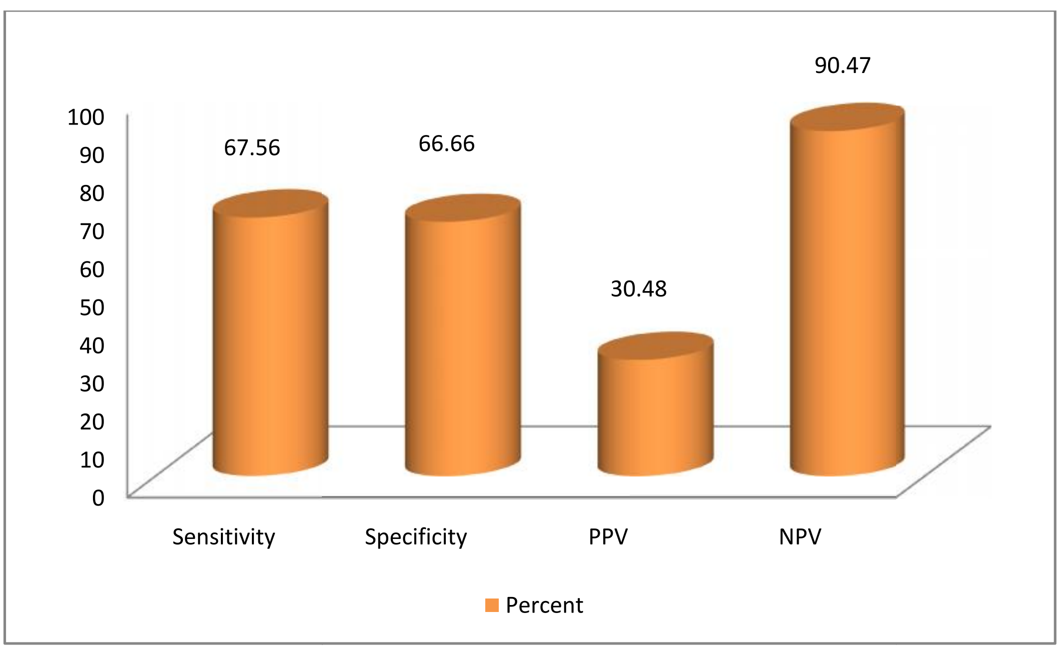


In atlanto- occipital distance vs difficult intubation chart [table 9] shows, among the two hundred and eight patients, thirty seven patients are true positive, ten patients are false positive, one hundred and sixty patients are true negative and one patient is false negative. The sensitivity and specificity is 97.43% and 94.11%.The PPV and NPV is 78.72% and 99.37%.

Table 10 : Effective Mandibular Length vs Difficult Intubation

Parameter	Value
• True positive	25
• False positive	57
• True negative	114
• False negative	12
• Sensitivity	67.56%
• Specificity	66.66%
• Positive predictive value	30.48%
• Negative predictive value	90.47%

Graph : 10 Effective Mandibular Length vs Difficult Intubation

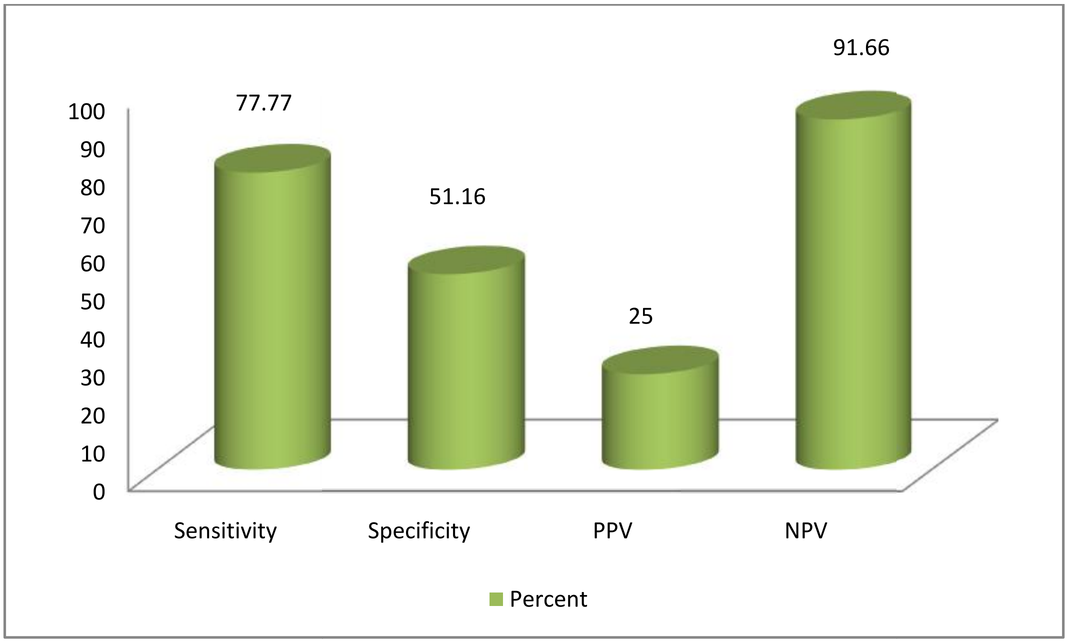


In effective mandibular length vs difficult intubation chart [table 10] shows, among the two hundred and eight patients, twenty five patients are true positive, fifty seven patients are false positive, one hundred and fourteen patients are true negative and twelve patients are false negative. The sensitivity and specificity is 67.56% and 66.66%.The PPV and NPV is 30.48% and 90.47%.

Table 11 : Anterior Mandibular Depth vs Difficult Intubation

Parameter	Value
• True positive	28
• False positive	84
• True negative	88
• False negative	8
• Sensitivity	77.77%
• Specificity	51.16%
• Positive predictive value	25%
• Negative predictive value	91.66%

Graph 11 : Anterior Mandibular Depth vs Difficult Intubation

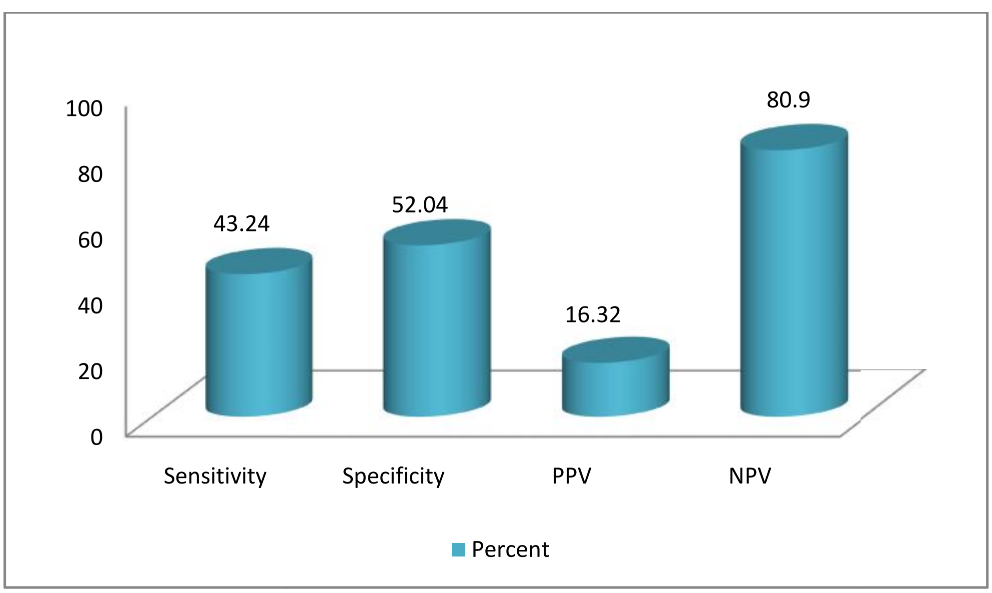


In anterior mandibular depth vs difficult intubation chart [table 11] shows, among the two hundred and eight patients, twenty eight patients are true positive, eighty four patients are false positive, eighty eight patients are true negative and eight patients are false negative. The sensitivity and specificity is 77.77% and 51.16%.The PPV and NPV is 25% and 91.66%.

Table 12 : Posterior Mandibular Depth vs Difficult Intubation

Parameter	Value
• True positive	16
• False positive	82
• True negative	89
• False negative	21
• Sensitivity	43.24%
• Specificity	52.04%
• Positive predictive value	16.32%
• Negative predictive value	80.90%

Graph 12: Posterior Mandibular Depth vs Difficult Intubation

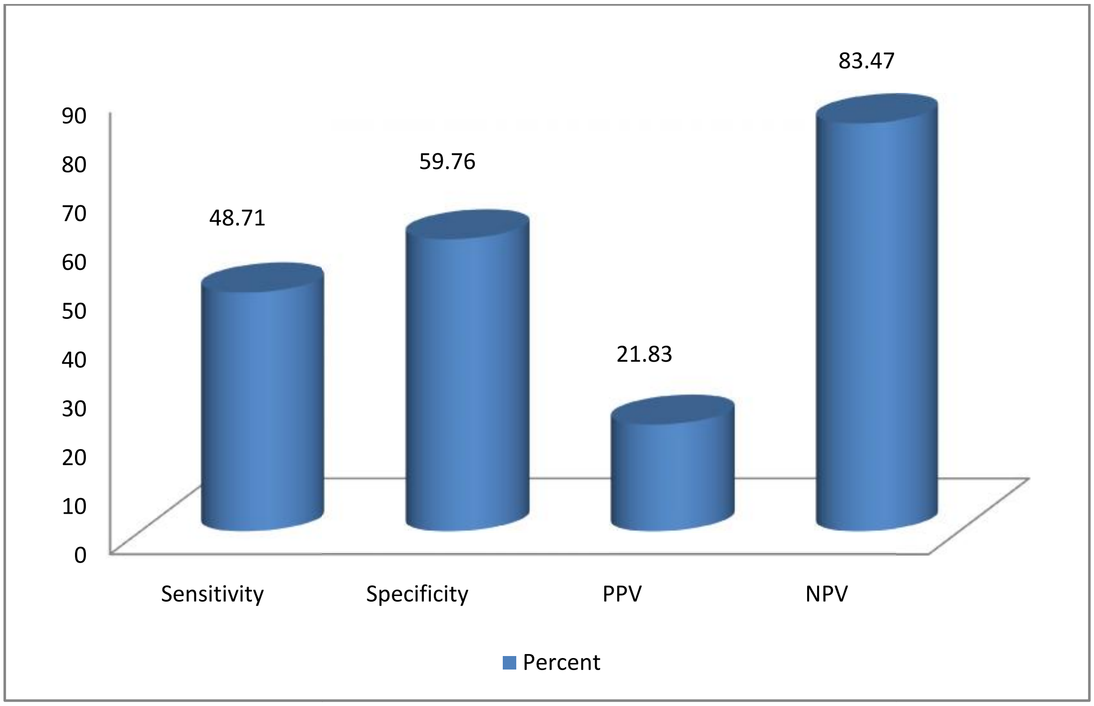


In posterior mandibular depth vs difficult intubation chart [table 12] shows, among the two hundred and eight patients, sixteen patients are true positive, eighty two patients are false positive, eighty nine patients are true negative and twenty one patients are false negative. The sensitivity and specificity is 43.24% and 52.04%.The PPV and NPV is 16.32% and 80.90%.

Table 13 : C_2 Spine Depth vs Difficult Intubation

Parameter	Value
• True positive	19
• False positive	68
• True negative	101
• False negative	20
• Sensitivity	48.71%
• Specificity	59.76%
• Positive predictive value	21.83%
• Negative predictive value	83.47%

Graph : 13 C_2 Spine Depth vs Difficult Intubation graph



In C_2 spine depth vs difficult intubation chart [table 13] shows, among the two hundred and eight patients, ninteen patients are true positive, sixty eight patients are false positive,one hundred and one patients are true negative and twenty patients are false negative. The sensitivity and specificity is 48.71% and 59.76%.The PPV and NPV is 21.83% and 83.47%.

Univariate Analysis of Clinical Data

	Difficult (N=38)	Easy (n=170)	P value
Age	43.7 ± 13.1	36.1 ± 11.7	<0.01
Sex Male	16	79	0.625
Female	22	91	
Interincissor Gap	4.4 ± 0.52	5.4 ± 0.28	<0.01
Thyromental distance	6.27 ± 0.92	8.34 ± 0.76	<0.01
Sternomental distance	12.99 ± 1.91	18.52 ± 2.05	<0.01
Samson and Young modification of Mallampati			
1	1	139	<0.01
2	0	24	
3	27	7	
4	10	0	
Wilson risk sum score	2 (0-4)	0 (0-1)	<0.01

Univariate Analysis of radiological data

	Difficult (N=38)	Easy (n=170)	P value
Occiput - C1 spinous process cm	0.44 ± 0.12	1.03 ± 0.23	<0.01
Posterior mandiblular depth cm	2.66 ± 0.38	2.55 ± 0.37	0.125
Effective mandibular length cm	10.45 ± 0.92	10.42 ± 0.83	0.853
Anterior mandibular depth cm	4.48 ± 0.47	4.45 ± 0.43	0.6369
Depth of C2	1.38 ± 0.39	1.39 ± 0.36	0.827

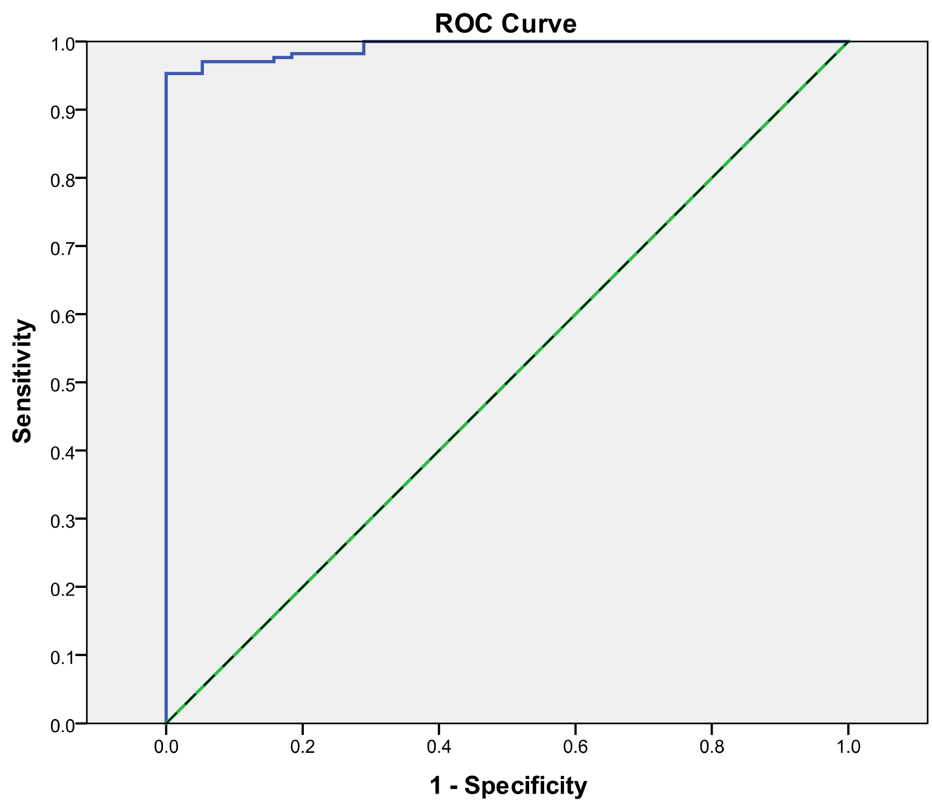
Clinical Data Alone in the Discriminant Analysis using stepwise

Model

Y= -8.425 +(Interincissor gap X 0.931) + (Sternomental distance X 0.156) + (Samson and Young modification of Mallampati X -1.093) + (Thyromrental Distance X 0.327)

The receiver operating characteristic (ROC) curve of the clinical model.

Graph 1.



In the clinical model the sensitivity and specificity were found to be, respectively, 97.2% and 95.3%.

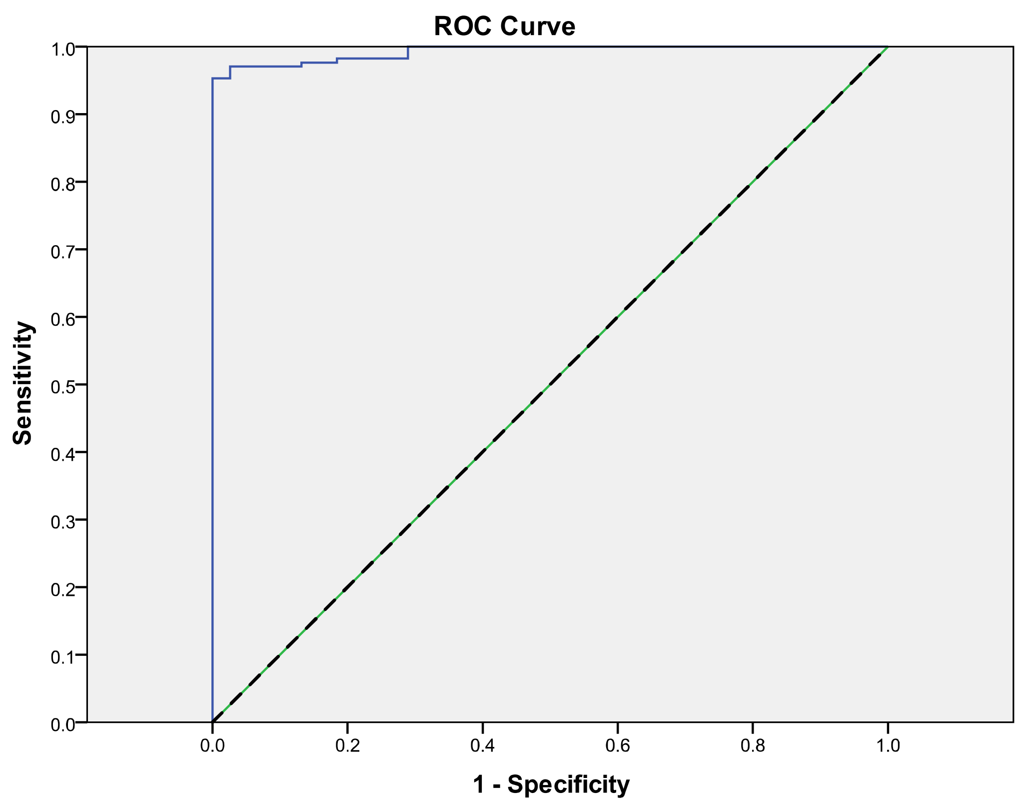
Clinical & radiological

Model

Y= -8.353 + (Interincissor gap X 0.881) + (Sternomental distance X 0.143) + (Samson and Young modification of Mallampati X -0.986) + (Thyromrental Distance X 0.232) + (Occiput C1Spinous Process X 1.079)

The receiver operating characteristic (ROC) curve of the combined (clinical & radiological) model.

Graph 2



In combined clinical and radiological model the sensitivity and specificity were found to be 100% and 95.3%, respectively.

The area below the ROC curves, denotes the probability of correct prediction of the clinical and the combined models. In our study it is 0.992 and 0.993, which means the clinical and combined models are predicted correctly. The outcome of this study for clinical and combined models is with a probability of 99.2% and 99.3%, respectively.

DISCUSSION

Airway management remains an important challenge in the contemporary practice of anaesthesia and preoperative airway assessment facilitates appropriate preparation when difficulty with intubation or ventilation is anticipated prior to induction of anaesthesia.

Direct laryngoscopy is the gold standard for tracheal intubation. There is no single definition of difficult intubation. Difficult glottic view on direct laryngoscopy is the most common cause of difficult intubation.

Difficult laryngoscopy, where in, it is not possible to visualize any portion of the vocal cords after multiple attempts at conventional laryngoscopy.

Difficult tracheal intubation where in it requires multiple attempts, in the presence or absence of tracheal pathology.

We proposed to conduct this study to compare ten airway assessment factors in patients undergoing surgery requiring general anaesthesia and endotracheal intubation in Chengalpattu Medical College Hospital and Hospital with regards to their sensitivity, specificity, positive predictive value and negative predictive value. Two hundred and eight patients between the ages of 15 and 75 were included in our study. The incidence of difficult intubation in our study was 14%, which is comparable to the results obtained by Frerk[14] and Savva[33]. However the incidence of difficult intubation is one percent to fifteen percent has been reported. This wide variation in incidence is due to the criteria that are used to define the difficult intubation and different anthropometric features among populations.

There were no failed intubations in our study. There were no patients with difficult mask ventilation during our study.

In our study we observed a statistical significance in patients having easy intubation compared with patients having difficult intubation with respect to their age, clinical and radiological parameters. This is in concurrence with the study conducted by Hyoung-Yong Moon & his colleagues[43], Rose & Cohen study[32] and Ezri et al[35] reporting that difficult laryngoscopy and intubation increases with age due bone and joint changes and due to poor dental condition. We noted no statistical significance between male and female gender vs difficult intubation in our study. Of the 38 patients with difficult intubat ion, 35 patients were intubated in the first laryngoscopic attempt. These 35 patients were successfully intubated with an optimal external laryngeal manipulation[46], which improves the view of glottis. Of the remaining three patients required one and two laryngoscopic attempts respectively, where in there was no improvement of glottic view on optimal external laryngeal manipulation[46] . One patient required a change of blade size. Gum elastic bougie used for facilitating intubation in Cormac and Lehane grade III and IV and were subsequently intubated without any significant events or difficulty. All intubations were done by a senior anaesthesiologist. There was neither any significant airway trauma nor episode of desaturation noted. All had no difficulty in mask ventilation.

The discriminant analytic study which we applied identified the clinical risk factors [modified mallampati class, inter incisor gap, thyromental distance, sternomental distance and Wilson's risk score] were predictors of difficult laryngoscopy and intubation. In our study the sensitivity and specificity of clinical factors are 97.2% and 95.3%. the combination of clinical and radiological variables have the high sensitivity of 100% and specificity of 95.3%.

In our study the sensitivity, specificity, positive predictive value and negative predictive value of modified mallampatti class were found to be 100%, 95.9%, 90.24% and 100% respectively. These were comparable and better prediction than to El -Ganzouri et al[16], Oates et al[25], and Shiga et al[37] study. Tse et al[15] also reported that a Mallampati score of III, thyromental distance less than seven cm, head and neck movement less than or equal to eighty degree, or a combination of these factors are useful predictors of difficult endotracheal intubation.

In our study the sensitivity, specificity, positive predictive value and negative predictive value of mouth opening were found to be 85%, 97.61%, 89.47% and 96.47% respectively. These were comparable to El - Ganzouri et al[16] and Shiga et al[37]. The low sensitivity can be attributed to less number of patients with restricted mouth opening in our study. This criteria, inter incisor gap, is one of the essential components of temporomandibular joint integrity. Rose DK[32] and colleagues also reported that a reduced inter incisor gap, decreased neck mobility, decreased thyromental distance and the combination of these factors better predicts difficult endotracheal intubation.

In our study the sensitivity, specificity, positive predictive value and negative predictive value of thyromental distance were found as 95%, 99.4%, 97.43% and 95.97% respectively. These were comparable to El - Ganzouri et al[17] and Shiga et al[37]. The low sensitivity can be attributed to less number of patients with a thyromental distance less than 6 cm in our study. Several studies have used various cut off points for thyromental distance demonstrating various results. We chose to evaluate a cut -off point of six cm from which we observed the aforesaid results. Thyromental distance is considered important as it indicates the submandibular space. This submandibular space lodges the tongue that is displaced by the laryngoscope blade and it is influenced by head extension.

In our study the sensitivity, specificity, positive predictive value and negative predictive value of sternomental distance were found to be 97.29%, 93.56%, 76.59% and 99.37% respectively. This study shows an increased sensitivity and specificity than the study reports given by Savva[33], Ramadhani and colleagues[9], Turkan and colleagues[36], and Shiga and colleagues[37].

Wilson & colleagues[13] reported study with five risk factors combination with Grade of 0 represents no risk for difficult intubation and a grade of two representing the greatest risk for difficult intubation. Wilson risk sum score suggested that a score of two could correlate to a sensitivity of seventy five percent and specificity of eighty five percent. Oates and colleagues, in their study reported that the Wilson score have a decreased sensitivity of forty two percent and an increased specificity of ninty five percent, with a PPV of nine percent. They found it to be superior to Mallampati clasification. Yamamoto and colleagues[61] also reported Wilson risk score is superior.

White and Kander[53] reported few radiological measurements. Some of which are measured in this study. They reported that an increase of anterior or the posterior mandibular depth, and a decrease in the atlanto -occipital gap and depth of C_2 spine, results in difficult direct laryngoscopy. In our study only the atlanto -occipital distance have a significant relationship with prediction of difficult intubation. In our study, we were unable to establish a statistical significance between the most radiological [x-ray lateral view] parameters and difficulty in laryngoscopy and intubation. This observation has been reported by other authors also. Bellhouse and Dore also predicted a sensitivity of seventy seven percent with lateral X-rays for difficult intubations.

The receiver operating characteristic [ROC] curve (graph 1 and 2) represents the graphical relationship between sensitivity and specificity. In ROC analysis the advantage is that the area below the ROC curve is independent. A study is ideal when the ROC area is eaual to 1.0, inaccurate when it is less than 0.5, low accuracy if the ROC area is between 0.5 and 0.7, and becomes accurate with an area equal to 0.7. The ROC areas observed in this study were high (0.992 and 0.993,) and it indicates good discrimination with the study model. This also shows reproducibility.

This study demonstrates that the parameters in this study are easy to be applied in the clinical practice.

The large area under ROC noted in this study can be easily reproduced.

The type of equipments required to manage a difficult airway can be chosen according to the airway assessment parameter which is abnormal.

For example in a patient with decreased mandibular space, it may be prudent to choose devices which do not involve displacement of the tongue like Bullard laryngoscope or Fibre -optic laryngoscope. Similarly in patients with decreased head extension, devices like McCoy Laryngoscope blade and or fibreoptic equipment are likely to be more successful.

Wilson[13] concluded in his publications that no single test is sensitive to predict difficult intubation. Bainton also states that combination of airway predictability tests will be more satisfactory.

Thus our study illustrates that combining different clinical or clinical and radiological criteria appears to be sensitive in predicting difficult intubation.

CONCLUSION

From our study we conclude that 1. Clinical models: modified Mallampati classification, sternomental distance, thyromental distance, inter-incissor gap and Wilson sum risk score, are important predictors of difficult intubation. 2. Radological imaging- atlanto-occipital distance is also an important predictor of difficult laryngoscopy and intubation. 3. The other radiological predictors are of value when they are combined with clinical variables, but not as single predictor.

SUMMARY

To summarise, in this study, we analysed the predictability of ten different airway assessment factors. The clinical variables are the modified Mallampati, inter-inscissor gap, thyromental distance, sternomental distance and Wilsons risk score and radiological variables are the atlanto-occipital distance, cervical vertebra C-2 spine depth, effective mandibular length, anterior mandibular depth, posterior mandibular depth. Both clinical and radiological variables are used for the prediction of difficult endotracheal intubation in two hundred and eight patients aged between 15 years to 75 years of either sex, scheduled to undergo elective surgery under general anaesthesia. The study involved preoperative evaluation of airway by the aforesaid ten factors.

Interincissor Gap 4.4 ± 0.52cm, thyromental distance 6.27 ± 0.92cm, sternomental distance 12.99 ± 1.91cm, Wilson risk sum score >2, modified mallampati grade III and IV, occiput - C1 spinous process 0.44 ± 0.12cm, posterior mandiblular depth 2.66 ± 0.38cm, effective mandibular length10.45 ± 0.92cm, anterior mandibular depth 4.48 ± 0.47cm, depth of C2 1.38 ± 0.39cm were considered as predictors of difficult endotracheal intubation. On the day of surgery, patients were anaesthetized using a uniform anaesthesia protocol. Laryngoscopy was done in sniffing position, glottic views were graded according to the Cormack and Lehane classification. Patients of Cormack Lehane class III / IV were considered as difficult to intubate.

From our study we found that 1. Clinical models: modified Mallampati classification, sternomental distance, thyromental distance, inter incissor gap and Wilson sum risk, are important predictor of difficult intubation. 2. Radiological imaging- atlanto-occipital distance is also an important predictor of difficult laryngoscopy and intubation. 3. The other radiological predictors, are of value, when they are combined with clinical variables, but not as single predictor.

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ANNEXURE

ANNEXURE – A

Study Proforma

Demographic details:

1. Name : IP/OP NO:
2. Age : X-ray ID NO:
3. Sex : Male Female
4. Weight : …………… kg

Clinical variables:

1. Modified Mallampati class:…………………..cm
2. Interincissor gap:……………………..cm
3. Thyromental distance:………………..cm
4. Sternomental distance:………………cm
5. Wilson risk sum score:……………….cm

Radiological variables:

1. Occipit - C1 spinous process:…………… cm
2. Depth of C2 spine:……………….. cm
3. Effective mandibular length:……………… cm
4. Anterior mandibular depth:……………….. cm
5. Posterior mandiblular depth:……………… cm

Cormack and Lehane grading: I II III IV

Wilsons risk score

	Score
Weight	**0- < 90 kg** **1- = 90kg** **2- > 90kg**
Head and neck movement	**0- Above 90 degrees** **1- About 90 degrees** **2- Below 90 degrees**
Jaw movement	**0- Interincisor gap >5 cm** **1- Interincisor gap =5 cm** **2- Interincisor gap <5 cm**
Receding mandible	**0- Normal** **1- Moderate** **2- Severe**
Buck teeth	**0- Normal** **1- Moderate** **2- Severe**

ANNEXURE – B

INFORMED CONSENT

1. I ………………………………. ……. aged ….……. years, Wife/ Son/Daughter of ………………………………………residing at………………………..…………. , state that I am admitting / submitting myself to the above study, under the care and supervision of Dr…………………. .……….……. voluntarily without any coercion, misinterpretation, mistake, fraud or under influence.

2. I further say that I have been explained and I fully understood, and know the procedures involved and all possible consequences of the same.

3. I further give consent and agree to the publication of result obtained for medical, scientific or educational purpose provided the pictures or the descriptive texts accompanying them do not reveal my identity.

4. I further say that I have informed the Doctor of all my previous illness, allergies, drug reactions, surgical procedures and all other facts relevant to my health status. I shall not hold the institution,

hospital or the doctor responsible for the consequences, which may arise for the non-disclosure of the same.

5. I have fully understood the procedures of the study and I agree to abide by the same.

6. The above has been explained to me and I have fully understood the same and I am signing this consent cum under taking by my own free will and in a fully alert state of mind.

Participant's Signature Investigator's Signature

ANNEXURE – C

KEY TO MASTER CHART

MMC	-	Modified Mallampati Classificat ion
MO	-	Mouth Opening
IG	-	Interinscissor Gap
TMD	-	Thyromental Distance
WRS	-	Wilson Sum Risk Score
A-O	-	Atlanto Occipital gap
AMD	-	Anterior Mandibular Distance
PMD	-	Posterior Mandibular Distance
EML	-	Effective Mandibular Length
C2-D	-	C2 Spine depth
CL Grade	-	Cormack Lehane Grade
ASA	-	American Society of Anaesthesiologist

MASTER CHART

Sno	Name	Age	Sex	Xray ID	IP no	Samsoon and Young modification of Mallampati	Interincissor gap cm	Thyromental distance cm	Sternomental distance cm	Wilson risk sum score	Occipit - C1 spinous process cm	Posterior mandiblular depth cm	Effective mandibular length cm	anterior mandibular depth cm	Depth of C2 cm	Cormack Lehane
1	Annakli	30	female	8107	5400	2	5.2	7.2	14	0	0.84	2.6	**10.62**	**4.48**	**2.19**	**2**
2	Sathya	29	female	8101	3231	1	5.4	8	19	0	1.02	2.79	**9.16**	**3.64**	**1.06**	**1**
3	Hemamalini	36	female	8049	9104	1	5.3	6.8	14.7	0	0.71	2.71	**11**	**4.43**	**1.02**	**2**
4	Vijayaragavan	24	male	7967	4086	1	5.5	8.6	21	0	1.37	2.36	**10.63**	**4.3**	**1.23**	**1**
5	Selvi	42	female	7864	3792	1	5.3	8	19.6	0	1.19	2.6	**10.55**	**3.84**	**1.23**	**1**
6	Gopi	23	male	7833	2960	1	5.6	7.9	19.8	0	1.08	2.92	**11.63**	**4.9**	**1.56**	**1**
7	Thiruvengadam	60	male	7766	5490	1	5.2	7.5	17	0	0.86	3.03	**9.58**	**4.75**	**1.47**	**1**
8	Ramamoorthy	53	male	7519	3005	1	5.5	8.5	21	0	1.2	2.85	**10.01**	**4.17**	**1.45**	**1**
9	Suganthi	33	female	7455	1503	1	5.4	8.5	20.6	0	1.12	2.66	**10.4**	**4.26**	**1.66**	**1**
10	Tamilarasi	45	female	7298	2947	1	5.7	8.2	19.4	0	1.06	2.37	**9.84**	**3.89**	**1.26**	**1**
11	Usha	36	female	7088	3468	1	5.4	8.4	19	0	0.94	2.51	**12.04**	**4.53**	**1.36**	**1**
12	kamatchi	33	female	6815	3374	1	5.2	7.9	19.6	0	0.99	2.47	**10.23**	**4.02**	**1.21**	**1**
13	Pushpa	30	female	6377	12277	1	5.5	8.3	20	0	0.97	3.06	**10.11**	**4.94**	**1.32**	**1**
14	Ramanujam	64	male	6034	10436	3	4.4	6.2	12.3	2	0.47	2.76	**10.55**	**4.96**	**1.42**	**3**
15	Anusiya	38	female	5649	12560	1	5.4	8	18.8	0	0.9	2.05	**10**	**4.35**	**1.02**	**1**
16	Nagammal	36	female	5532	12528	1	5.6	7.8	19.3	0	0.72	2.51	**11.14**	**4.2**	**1.08**	**2**
17	Amutha	41	female	5176	9104	1	5.2	8.5	21	0	1.09	2.81	**10.34**	**4.42**	**0.84**	**1**
18	Sivamegala	24	female	5132	8826	1	5.4	8.2	18.3	1	0.68	2.86	**10.16**	**4.32**	**1.02**	**2**
19	Muruganntham	49	male	10008	6085	1	5.6	8	19	0	0.94	2.89	**10.18**	**4.61**	**1.14**	**1**
20	Begum	47	female	4921	6773	2	5.2	6.8	12.7	1	0.6	2.86	**10.44**	**4.55**	**1.54**	**2**
21	Palayam	50	female	4844	57597	1	5.5	7	19.3	0	0.87	2.26	**9.41**	**3.99**	**0.96**	**1**
22	kesavan	27	male	4768	52402	1	5.7	7.3	19.5	0	1.04	2.37	**10.55**	**4.05**	**1.27**	**1**
23	Saravanan	27	male	4696	6675	1	5.4	6.9	20.4	0	1.16	3.43	**10.84**	**5.13**	**1.42**	**1**
24	Gayathri	18	female	4698	52536	1	5.7	7.4	19.5	0	1.29	2.66	**10.91**	**4.55**	**1.39**	**1**
25	Saida	22	female	4542	52053	2	5.3	7.1	17.9	0	0.86	2.05	**10.1**	**3.94**	**1.12**	**2**
26	Vasanthi	40	female	4550	56541	2	5.2	6.7	12.8	1	0.65	2.45	**10.31**	**3.87**	**1.34**	**2**
27	Abdhul	50	male	4436	52102	1	5.3	6.8	19.2	0	1.03	2.18	**10.14**	**4.36**	**1.2**	**1**
28	jayakondan	53	male	4413	6827	1	5.9	6.9	19.6	0	0.66	2.95	**10.4**	**4.54**	**1.28**	**2**
29	Sureshkumar	32	male	4320	3234	1	5.1	7.5	20.8	0	1.41	2.65	**10.85**	**4.08**	**1.12**	**1**
30	Muniammal	41	female	4298	55413	1	5.7	7.8	20.5	0	0.76	2.86	**10.1**	**4.33**	**1.21**	**1**
31	Rajeswari	36	female	4279	52786	1	5.2	7.6	19.1	0	0.62	2.56	**8.95**	**3.82**	**0.77**	**2**
32	Surya	35	female	4271	53851	1	5.8	8	18.4	0	1.29	2.32	**9.86**	**4.38**	**1.22**	**1**
33	Vasanthi	40	female	4166	67583	1	5.5	7.9	20.9	0	1.15	2.65	**9.51**	**4**	**1.2**	**1**
34	vasanthakumar	37	male	3198	68164	1	5	8.4	21	0	1.25	2.4	**11.41**	**4.13**	**1.2**	**1**
35	Dasarathan	52	male	2912	25799	1	5.3	7.7	20.1	0	1.28	2.47	**9.75**	**4.56**	**1.45**	**1**
36	kuttiammal	38	female	2706	52786	3	5.7	6.8	12.9	0	0.5	2.42	**10.19**	**4.28**	**0.87**	**3**
37	Sivakumar	17	male	1951	58286	1	5.3	8.1	15.8	0	1.06	2.55	**9.75**	**4.67**	**1.32**	**1**
38	Laxmi	53	female	1282	52269	3	4	6.2	12.4	1	0.5	1.8	**9.46**	**3.06**	**1.1**	**3**
39	Ragini	40	female	553	67719	1	5.7	8.5	16.9	0	0.84	2.48	**10.73**	**4.52**	**1.44**	**1**
40	Kasthuri	59	female	508	52708	1	5.5	7.6	17.5	0	0.75	2.27	**10.61**	**4.13**	**0.95**	**1**
41	Munusamy	60	male	437	52814	1	5.6	8.3	19.4	0	1.35	2.48	**11.9**	**4.71**	**1.17**	**1**

42	jeevarathinam	61	male	436	52783	4	4.2	6.1	18.7	2	0.36	2.4	**10.36**	**3.63**	**0.98**	**3**
43	Ellapan	61	male	401	52823	1	5.8	8	19.4	0	1.43	2.16	**10.86**	**4.48**	**1.73**	**1**
44	sivasakthi	21	female	303	58579	1	5.4	7.4	19.8	0	0.88	2.75	**10.58**	**4.81**	**1.33**	**1**
45	Gnanasekar	45	male	173	52912	1	5.6	8	20.5	1	0.62	2.47	**9.95**	**4.81**	**1.37**	**2**
46	Louis	38	male	10076	6827	1	5	8	18.6	0	1.4	2.9	**10.85**	**4.32**	**1.49**	**1**
47	Sakila	26	female	9974	53851	1	5.2	8.1	15.4	0	0.73	2.43	**9.6**	**4.28**	**1.55**	**2**
48	Gunasekaran	32	male	9909	52914	2	5.7	8.4	19.6	0	0.75	2.87	**10.2**	**4.84**	**1.32**	**2**
49	Jayasankar	38	male	9837	12720	1	5.5	8.6	20.5	0	1.26	2.23	**10.51**	**4.63**	**2.1**	**1**
50	Mohandass	39	male	9807	68478	1	5.3	8.1	20	0	0.87	2.88	**11.26**	**5**	**1.07**	**2**
51	Vasanthi	40	female	9800	65529	1	5.8	7.8	19.4	0	0.96	2.36	**9.52**	**4.1**	**1.23**	**1**
52	Ganesan	55	male	9787	66034	1	5.6	7.5	16.8	0	1.31	3.22	**9.31**	**4.46**	**1.34**	**1**
53	Subbaiah	48	male	9744	92429	3	4.7	5.6	12.4	2	0.5	2.29	**12.02**	**5.02**	**1.38**	**3**
54	Sankar	38	male	9743	52904	3	4.4	6	12.4	2	0.52	2.53	**10**	**4.63**	**1.32**	**3**
55	kalaiarasi	22	female	9734	52961	4	4.4	5.9	12.2	2	0.39	2.31	**9.69**	**4.06**	**0.73**	**3**
56	Mariyappan	54	male	9628	34114	1	5.4	8.4	19.5	0	1.13	2.49	**10.77**	**5.14**	**2.16**	**1**
57	Logu	42	male	9560	56322	1	5.4	8.7	20.4	0	1.14	2.85	**10.32**	**4.45**	**0.89**	**1**
58	Santhakumar	39	male	9559	6535	1	5.7	8.2	19.6	0	1.13	2.23	**10.32**	**4.13**	**1.4**	**1**
59	Prakash	34	male	9557	29713	1	5.6	7.9	15.9	0	1.02	2.37	**10.52**	**5.12**	**2.24**	**1**
60	Vijayalakshimi	36	female	9499	52912	3	5.5	6.6	12.8	1	0.64	3.28	**10.67**	**4.43**	**1.73**	**2**
61	Pachaiappan	60	male	9453	58112	1	5.4	8.4	17.4	0	0.95	2.93	**9.09**	**4.87**	**0.99**	**1**
62	Selvi	34	female	9403	51938	2	5	6.5	20.6	1	0.67	2.15	**9.03**	**3.76**	**1.82**	**2**
63	Gugan	26	male	9383	60345	1	5	8	19.4	0	0.96	3.1	**10.69**	**4.16**	**1.28**	**1**
64	selvam	23	male	9321	55473	1	5.9	8.5	20.7	0	0.92	2.12	**8.44**	**3.97**	**1.09**	**1**
65	Mohan	41	male	9289	48735	1	5.5	8.9	19.8	0	1.05	3.5	**11.18**	**5.44**	**1.16**	**1**
66	Madhanraj	18	male	9188	58291	1	5.8	8.3	20.5	0	1.18	2.29	**11.23**	**4.51**	**1.53**	**1**
67	Mohan	53	male	9118	58184	3	4.2	6.4	12.3	2	0.46	2.96	**10.77**	**4.9**	**1.7**	**3**
68	Govindhammal	40	female	9051	57621	1	5.5	8.4	18.3	0	0.85	2.4	**9.21**	**4.24**	**1.17**	**1**
69	Sowgath Ali	30	male	8931	41764	1	5.6	8.2	17.6	0	1.08	2.47	**11.08**	**5.08**	**2.05**	**1**
70	Sakthi	40	male	8894	48061	4	4.4	5.8	12.1	2	0.31	2.09	**9.4**	**4.54**	**1.17**	**3**
71	Devan	34	male	8877	8846	1	5.3	9	19.6	0	1.42	2.51	**10.61**	**4.19**	**1.04**	**1**
72	Perumal	39	male	8757	60808	3	5.2	6.5	20.1	1	0.66	2.65	**9.47**	**4.09**	**0.97**	**2**
73	Minnala	40	female	8731	60067	1	5.5	8.8	20.2	0	0.96	2.98	**9.61**	**4.29**	**1.97**	**1**
74	Ramakrishnan	18	male	8711	7227	1	5.5	7.9	21	0	1.05	2.55	**9.46**	**4.13**	**1.33**	**1**
75	Thirumal	18	male	8707	51305	2	5.4	8.5	18.5	0	1.1	2.46	**10.48**	**4.87**	**1.47**	**1**
76	Suthakar	22	male	8681	60311	2	5.7	9.2	19.8	0	0.9	2.03	**10.55**	**4.83**	**1.27**	**1**
77	Gopal	39	male	8677	50662	1	5.6	9	17.8	0	1.19	3.29	**10.67**	**5.19**	**1.47**	**1**
78	Mavubasha	55	male	8640	54132	3	4.5	6.1	12.3	2	0.41	3.22	**9.92**	**4.89**	**1.49**	**3**
79	Sivakami	58	female	8570	54719	4	4.6	5	12	2	0.22	1.86	**7.92**	**3.75**	**0.99**	**4**
80	Hemavathi	20	female	8544	52232	1	5.1	8.5	19.5	0	1.41	2.55	**10.71**	**4.11**	**0.97**	**1**
81	Sivamani	34	male	8393	55778	1	5.8	8.9	20	0	1.08	2.15	**12.19**	**4.7**	**1.42**	**1**
82	shankar	30	male	8350	58632	1	5.7	9.3	21	0	1.39	2.93	**10.53**	**4.67**	**1.06**	**1**
83	Kumaresan	21	male	8330	41764	1	5.4	9	19.3	0	1.11	2.4	**10.32**	**4.95**	**1.64**	**1**
84	Sangeetha	16	female	5980	61103	1	5.5	9.2	20.4	0	1.09	1.54	**9.89**	**3.64**	**1.39**	**1**
85	Manjula	37	female	5806	51810	1	5.5	7.8	20.3	0	0.8	2.76	**9.01**	**3.86**	**1.45**	**1**
86	Balaji	34	male	5681	8304	4	4.5	5.6	12.4	2	0.4	2.09	**9.79**	**3.98**	**1.47**	**3**
87	Velangani	30	female	5644	5795	2	5.4	8.7	19.7	0	1.04	2.44	**9.93**	**4.18**	**1.46**	**1**
88	Dhamodharan	62	male	3588	50256	1	5.6	8.9	19.4	0	0.77	2.36	**10.56**	**4.77**	**2.02**	**2**
89	Gunasundari	45	male	3547	52918	1	5.8	7.9	18.8	0	0.82	2.02	**9.53**	**4.03**	**1.27**	**2**
90	Mariyammal	38	female	3499	52900	1	5.2	9.1	20.3	0	1.03	2.46	**10.12**	**5.05**	**1.2**	**1**
91	Ellamalli	40	female	3493	59125	3	4.7	6.3	12.7	1	0.6	2.43	**9.94**	**3.9**	**1.03**	**3**

92	Ramesh	31	male	8753	61296	1	5.5	8.9	20.5	0	1.3	2.78	**11.69**	**4.77**	**1.76**	**1**
93	Chanran	36	male	8443	55775	1	4.7	6	12.3	2	0.48	3.27	**11.06**	**4.59**	**1.45**	**3**
94	Sivagami	45	female	8424	59820	2	5.7	8.7	19.3	0	0.73	2.47	**10.38**	**4.75**	**1.29**	**2**
95	Chandh	22	male	8421	2026	1	5.4	8.9	20.4	0	1.4	2.47	**10.03**	**3.97**	**1.25**	**1**
96	Abdhula	28	male	8342	60064	1	5	9.5	19.8	0	1.13	2.81	**11.22**	**5.11**	**1.42**	**1**
97	Abirami	29	female	8258	5714	3	5.5	6.4	12.8	1	0.59	2.37	**10.1**	**3.98**	**0.89**	**3**
98	Vadivel	60	male	8086	6169	1	5.3	8.6	16.9	0	0.89	2.78	**10.46**	**5.61**	**1.37**	**2**
99	Megala	24	female	7661	57169	1	5.5	8.7	21	0	0.7	2.71	**9.59**	**4.21**	**1.31**	**2**
100	Selvaraj	52	male	7588	59515	4	4.4	5.2	12.1	2	0.33	3.25	**11.5**	**4.79**	**1.95**	**3**
101	Selvi	29	female	7509	2031	3	5	9.2	12.6	0	0.68	2.76	**10.49**	**4.25**	**1.56**	**3**
102	Vijaya	60	female	7444	1037	1	5.8	9	19.4	0	0.74	2.38	**8.08**	**3.74**	**0.82**	**2**
103	Manohar	30	male	7146	1192	1	5.2	8.8	18.6	0	1.37	2.4	**10.26**	**4.66**	**1.75**	**1**
104	Ruth Mary	20	female	7076	52787	3	4.3	6.3	12.3	1	0.55	2.51	**10.32**	**4.32**	**1.79**	**3**
105	Manjula	39	male	7062	52961	2	5.6	8.5	20.3	0	0.79	2.56	**10.51**	**4.18**	**2.56**	**2**
106	Srinivasan	45	male	6695	58849	2	5.5	9.2	20.5	0	1.11	2.47	**10.37**	**4.35**	**1.49**	**1**
107	Vinoth	24	male	6523	41769	3	4.5	6.2	19.8	2	0.44	2.5	**11.5**	**4.81**	**2.23**	**3**
108	Udhayan	18	male	6467	2990	1	5.7	9.6	19.5	0	0.79	2.97	**10.7**	**4.32**	**1.97**	**2**
109	Vennila	35	female	6242	41910	1	5.3	7.4	16.9	0	0.86	2.9	**10.58**	**4.02**	**1.48**	**2**
110	Mahendran	41	male	6104	3285	1	5.5	9	19.2	0	0.94	2.84	**10.51**	**4.69**	**2.06**	**2**
111	Raji	37	female	1597	8342	3	4.3	6.2	12.3	2	0.4	3.06	**12.83**	**5.19**	**1.62**	**3**
112	Andal	38	female	1456	2482	1	5.2	8.3	21	0	1.11	1.93	**8.69**	**3.91**	**1.61**	**1**
113	Sarala	31	female	1165	59088	1	5.6	8	19.7	0	1.42	2.7	**10.61**	**4.34**	**1.91**	**1**
114	Arunkumar	33	male	944	54336	4	3.8	6.2	12.1	4	0.39	2.98	**11.83**	**4.48**	**1.89**	**3**
115	Alamelu	25	female	858	1503	1	5.5	8.5	19.1	0	0.71	2.49	**12.03**	**4.05**	**1.49**	**2**
116	Jagatheeswari	45	female	833	60719	2	5.6	8	20.2	0	1.11	2.02	**10.72**	**4.36**	**1.42**	**1**
117	Nagammal	22	female	781	8833	2	5.4	9.4	20.4	0	1.26	2.68	**10.62**	**4.65**	**1.14**	**1**
118	Kuttiyammal	43	female	777	1034	3	5.5	5.9	15.9	1	0.52	2.29	**9.86**	**4.21**	**1.49**	**3**
119	Raja	32	male	745	1755	1	5.8	8.3	17.6	0	1.09	2.66	**11.09**	**4.09**	**1.19**	**1**
120	sagunthala	60	female	645	56607	1	5	7.5	19.6	0	0.78	3.24	**11.22**	**4.66**	**1.5**	**2**
121	Malarvizhi	23	female	516	2129	1	5	8.6	19	0	0.9	2.38	**9.5**	**3.91**	**1.21**	**1**
122	Muthulakshmi	40	female	503	56607	3	4.3	6.6	12.9	0	0.68	2.24	**9.02**	**3.98**	**1.35**	**2**
123	Dhanasekar	44	male	497	2072	1	5.5	9	17.8	0	1.21	2.16	**11.83**	**5.32**	**1.75**	**1**
124	Kuppamma	44	female	382	51245	1	5.4	9.2	19.5	0	1.31	1.87	**9.05**	**3.68**	**1.52**	**1**
125	kumutha	36	female	305	1062	2	5.3	8	19.7	0	1.2	2.95	**11.33**	**5.09**	**1.16**	**1**
126	Anish	28	male	306	41764	1	5.5	8.7	18.9	0	1.13	2.41	**10.07**	**4.25**	**1.38**	**1**
127	Pradeepan	44	male	199	1137	1	5.2	9.4	20	0	1.02	2.64	**11.63**	**4.98**	**0.96**	**1**
128	Betsy Joe	21	female	139	60317	1	5.2	9	20.4	0	1.15	2.26	**9.68**	**3.91**	**1.34**	**1**
129	Kumar	45	male	129	3222	3	4.3	5.7	12.3	2	0.4	3	**10.04**	**4.74**	**1.52**	**3**
130	Dhanalakshmi	45	female	98	48061	1	5.3	8.8	21.1	0	1.02	1.93	**9.52**	**4.03**	**0.67**	**1**
131	Devika	40	female	63	3592	1	5.3	8	19.6	0	0.82	1.93	**9.6**	**3.96**	**0.92**	**2**
132	Vengatesan	39	male	9897	1096	1	5.2	9.4	19.8	0	1.2	2.68	**9.51**	**4.19**	**1.27**	**1**
133	Illayaraja	39	male	9869	1242	2	5.1	8.3	16.9	0	0.92	2.5	**10.51**	**4.61**	**1.81**	**2**
134	Dilli	24	male	9824	1313	2	5	8.9	17.7	0	1.06	2.26	**10.65**	**4.72**	**1.48**	**1**
135	Parvathy	21	female	9814	59237	3	4.2	9.2	12.1	1	0.55	2.88	**10.23**	**4.27**	**0.86**	**3**
136	Parvathy	33	female	9636	59572	1	5.8	9	18.5	0	1.15	1.92	**8.11**	**3.36**	**1.28**	**1**
137	Piyari	37	female	9616	2917	1	5.3	7.9	19.8	0	0.97	2.56	**10.12**	**4.08**	**1.44**	**2**
138	Gopalakrishnan	22	male	9442	1920	3	5.7	9	12.2	0	0.59	2.91	**10.54**	**4.54**	**1.25**	**3**
139	Mani	50	male	9418	5644	1	5.3	8.8	16.4	0	1.22	3.6	**9.42**	**5.19**	**1.55**	**1**
140	Rani	40	female	4231	1435	1	5.6	8.7	17.9	0	0.83	3.16	**11.22**	**4.45**	**1.03**	**1**
141	Ramya	32	female	3842	3222	1	5.5	9.2	14.8	0	1.14	1.78	**10.32**	**3.85**	**1.5**	**1**

142	Vinothraj	56	male	9950	1597	3	3.9	5.6	12.2	2	0.46	3.13	**11.6**	**4.82**	**1.52**	**3**
143	Kasthuri	21	female	9579	1550	1	5.1	9	19.4	0	1.06	2.06	**10.88**	**4.55**	**1.4**	**1**
144	Agila	25	female	9399	1964	1	5.3	8.6	17.3	0	0.99	2.13	**10.35**	**4.06**	**1.32**	**1**
145	Sudhashini	25	female	9397	58544	2	5.2	8.2	18.6	0	0.83	2.5	**10.13**	**4.29**	**1.12**	**2**
146	Ezhumalai	23	male	9273	3585	1	5.2	7.9	18.4	0	1.21	2.59	**11.29**	**4.88**	**1.85**	**1**
147	vigneshwaran	56	male	8477	6810	1	5.1	9	20.1	0	0.85	2.04	**11**	**4.51**	**2.04**	**1**
148	Sagayam	51	male	7381	3862	3	4.2	6.2	16.5	0	0.47	2.23	**10.7**	**4.65**	**2.23**	**3**
149	Kumaresan	32	male	7368	21207	1	5.4	9.3	15.9	0	0.96	2.73	**10.99**	**4.17**	**2.73**	**1**
150	Kumar	25	male	7367	23636	1	5	8.9	19.2	0	1.04	2.88	**10.98**	**4.8**	**1.55**	**1**
151	Jayagovindan	40	male	7156	22882	1	5.3	9.4	18.6	0	1.8	2.81	**10.26**	**4.2**	**1.66**	**1**
152	Boopalan	33	male	6391	95518	1	5	8.7	19.4	0	0.85	2.45	**10.08**	**4.18**	**1.33**	**2**
153	Jayamani	60	female	5998	18032	3	4.1	6.2	17.2	1	0.51	3.24	**10.19**	**4.64**	**1**	**3**
154	Kanniyammal	33	female	4274	20723	1	5.2	9	15.7	0	1.14	2.56	**10.33**	**4.32**	**1.09**	**1**
155	Kamesh kumar	15	male	4268	12824	1	5	9.1	16.3	0	0.92	3.01	**10.72**	**4.92**	**1.56**	**1**
156	karunakaran	21	male	4247	20070	1	5.1	7.4	18.1	0	0.77	2.45	**12.36**	**4.86**	**1.13**	**2**
157	Anand	45	male	9737	19476	1	5.8	8.7	20	0	0.82	2.89	**11.31**	**4.81**	**1.35**	**2**
158	kamatchi	34	female	24	19195	1	5.3	8.4	19.2	0	1.02	1.96	**10.34**	**4.15**	**1.43**	**1**
159	Mahadevan	40	male	9391	18168	1	5.7	7.8	18.3	0	1.06	2.51	**10.34**	**4.34**	**1.43**	**1**
160	Vijaya	32	female	9075	16136	1	5.1	9.2	14.7	0	1	2.12	**10.55**	**4.56**	**2.12**	**1**
161	Nagappan	23	male	9016	16493	3	4.3	6.8	16.8	1	0.63	2.36	**10.56**	**4.5**	**1.27**	**2**
162	Srinivasalu	54	male	8782	16777	2	5.3	8	19.2	0	1.34	2.78	**10.26**	**5.04**	**1.81**	**1**
163	Soundararajan	43	male	8559	13408	2	5.2	9.4	17.5	0	1.34	3.11	**12.04**	**5.53**	**1.16**	**1**
164	Sneha	46	female	8428	13267	2	5.6	9	18	0	1.73	2.35	**10.24**	**3.96**	**0.96**	**1**
165	Hemachandran	19	male	8216	11305	1	5.5	9.6	18.6	0	0.82	1.73	**9.45**	**4.28**	**1.1**	**2**
166	Murugan	27	male	7880	11209	1	5.3	9	19.1	0	0.75	2.4	**10.39**	**4.28**	**1.27**	**2**
167	Paneerselvam	50	male	7777	10332	3	4.3	6.7	12.9	1	0.6	2.68	**12.08**	**4.8**	**1.71**	**2**
168	Panjalai	60	female	7689	6388	4	3.5	6.2	12.3	2	0.27	2.98	**10.61**	**4.98**	**0.97**	**4**
169	Sujitha	20	female	7478	19971	1	5	8.7	19.3	0	1.09	2.18	**9.48**	**4.26**	**1.08**	**1**
170	Ravi	57	male	7457	20683	1	5.4	9.2	17.8	0	0.92	2.89	**10.71**	**4.77**	**1.67**	**2**
171	Kamachi	33	female	7396	20810	1	5	9.1	19.4	0	1.08	2.35	**9.75**	**3.87**	**1.16**	**1**
172	Vinodh	21	male	7067	20390	1	5.2	8.5	18.4	0	1.28	2.66	**10.79**	**4.25**	**1.32**	**1**
173	Leelavinothan	19	male	6777	20857	1	5.5	9	19.3	0	1.35	2.34	**11.81**	**4.55**	**2.49**	**1**
174	Rani	50	female	5961	18760	1	5.3	9.5	17.8	0	0.91	2.76	**9.43**	**4.2**	**1.08**	**2**
175	Karpagam	42	female	5951	88496	1	5.2	9.7	18.3	0	1.23	2.57	**10.08**	**4.21**	**1.53**	**1**
176	Rajammal	57	female	5408	16954	3	4.3	6.4	12.4	0	0.59	2.33	**8.91**	**4.24**	**1.57**	**3**
177	Venkatesan	60	male	5340	16489	4	4.2	6.3	12.2	0	0.27	2.76	**10.39**	**4.28**	**1.17**	**4**
178	Dhakshina moorthy	75	male	5151	19433	3	4.3	6.7	12.8	0	0.69	2.85	**11.98**	**4.74**	**1.27**	**2**
179	Vijaya	39	female	5093	15073	1	5.5	7.5	16.8	0	1.01	2.64	**10.42**	**4.59**	**1.04**	**1**
180	Malliga	40	female	4401	14377	3	5.4	8.8	17.9	0	0.65	2	**9.58**	**4**	**1.22**	**2**
181	Karunanithi	41	male	4236	13419	4	4.5	5.6	12	2	0.3	2.82	**9.98**	**4.57**	**2.05**	**3**
182	Ettiappan	45	male	4207	13711	1	5.3	9.7	19.3	0	0.99	2.86	**10.62**	**4.69**	**2.86**	**2**
183	Suganthi	33	female	4133	13397	1	5.1	9	21	0	1.04	2.55	**10.47**	**4.39**	**1.87**	**1**
184	Paulraj	36	male	4124	3376	2	5.3	8.6	19.6	0	1.24	2.74	**11.49**	**5.07**	**1.34**	**1**
185	Mahalingam	45	male	3900	13023	1	5.2	9	18.1	0	1.53	2.34	**10.27**	**4.02**	**1.34**	**1**
186	Rajini	31	male	3528	10809	3	3.8	6.1	12.3	3	0.4	2.65	**10.25**	**4.62**	**1.09**	**3**
187	Mangaiyarthilagam	45	female	3292	4160	2	5	8	17.4	0	0.88	2.69	**10.9**	**4.49**	**0.87**	**1**
188	Devaraj	36	male	2687	34196	1	5.5	8.7	14.5	0	1.65	2.87	**12.49**	**5.98**	**1.25**	**1**
189	Selvam	55	male	2680	24251	3	4.2	6.3	12.2	2	0.48	2.78	**11.39**	**5.56**	**1.52**	**3**
190	Anjalai	36	female	2482	21207	1	5.3	9	19.3	0	0.91	2.2	**8.2**	**4.3**	**2.2**	**1**
191	Mariyammal	46	female	2307	14039	1	5.2	9.6	18.6	0	0.99	2.77	**9.76**	**4.28**	**1.36**	**1**

192	Jayamkondan	32	male	2312	5163	1	5	7.8	19.4	0	1.04	2.92	**11.56**	**4.8**	**1.46**	**1**
193	Shankar	36	male	1736	5676	1	5.4	8.2	20	0	1.09	2.54	**11**	**4.77**	**1.06**	**1**
194	Sadasivam	53	male	1690	10933	1	5	9	18	0	0.81	3.7	**11.79**	**5.54**	**1.47**	**1**
195	Jancy	29	female	2752	12462	1	5.3	9.7	16.5	0	0.92	2.67	**9.89**	**3.78**	**1.39**	**1**
196	Selvi	32	female	2384	77208	1	5.1	8.4	13.4	0	1.2	2.48	**11.66**	**4.49**	**1.46**	**1**
197	Shiva	15	male	2215	13374	1	5.3	9.2	15	0	1.36	2.3	**10.34**	**4.06**	**1.13**	**1**
198	Valarmathy	28	female	1442	10322	1	5.5	9.3	14.5	0	1.01	2.61	**10.71**	**4.49**	**1.07**	**1**
199	Sekar	50	male	3168	19503	3	3.6	5.9	12	2	0.28	2.75	**11.05**	**4.45**	**1.33**	**4**
200	Jegatha	50	female	2794	14622	3	3.8	5.7	11.9	2	0.17	2.62	**9.67**	**4.14**	**0.79**	**4**
201	Narayana	56	male	2564	14902	3	4	5.9	12.1	2	0.36	2.59	**11.53**	**4.59**	**1.37**	**3**
202	Sivagami	40	female	2474	15545	3	4.2	6.4	12.5	2	0.53	3.07	**10.32**	**5.1**	**1.77**	**3**
203	Sankar	40	male	2084	17739	1	5.1	8	15.2	0	0.77	2.8	**11.15**	**4.67**	**1.49**	**2**
204	Priya	33	female	1802	88686	1	5.3	7.9	20	0	1.12	2.4	**10.74**	**4.77**	**1.22**	**1**
205	Dinesh	43	male	1797	20035	1	5.5	8.1	16	0	1.21	2.43	**11.4**	**4.9**	**1.32**	**1**
206	Kottiswaran	26	male	1587	20393	1	5.4	8.2	14.3	0	1.09	2.56	**10.47**	**4.49**	**1.4**	**1**
207	Vedhagiri	24	male	1309	21721	2	5.4	7.5	13.8	0	0.89	1.12	**10.63**	**4.75**	**1.16**	**2**
208	Nijindran	18	female	433	20868	1	5.2	8	14	0	1.19	2.13	**10.57**	**4.49**	**1.09**	**1**