PREOPERATIVE ASSESSMENT TO PREDICT DIFFICULT AIRWAY USING MULTIPLE SCREENING TESTS

By

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Dissertation submitted to the

BLDE (DEEMED TO BE UNIVERSITY) VIJAYAPUR, KARNATAKA

In partial fulfillment of the requirements for the degree of

DOCTOR OF MEDICINE

IN

ANAESTHESIOLOGY

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2019

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ACKNOWLEDGEMENT

On completion of my post graduation journey and this scientific document, I would like to acknowledge the immense help received from my mentors in the department of anaesthesia. With privilege and respect I would like to express my gratitude and indebtedness to my Guide, Dr.R. R. Kusugal, Associate Professor, Department of Anaesthesiology for his constant inspiration, extensive encouragement and loving support, which he rendered in pursuit of my post-graduate studies and in preparing this dissertation.

I am forever grateful to our HOD Dr. D. G. Talikoki, and all Professors Dr.Vidya Patil and Dr.Vijayakumar T. K.. Dr. Vijay Katti, Dr. Sridevi Mulimani, Dr. Renuka H, Dr.Nirmala Devi, Dr. Shivanand L K, Dr. Basavaraj Patil, Dr. Prathiba S D, Dr. Ramesh S, Dr. Santosh K, Dr. Lalitha, Dr.Geetha H, Dr.Sunil K, Dr. Mala N, Dr Santoshkumar A and Dr. Sharath C for their great help.

I am extremely thankful to Professor Dr. S. P. Guggarigoudar, Principal, of B.L.D.E.U'S Shri. B.M. Patil Medical College, Hospital and Research Centre, Vijayapur, for permitting me to utilize resources in completion of my work.

My thanks to one and all staff of Library, Anaesthesia Department and Hospital for their co-operation in my study.

I thank my colleagues Dr Savita, Dr Vinuta, Dr Neha, Dr Chandrima, Dr Adil, Dr Muzzamil, Dr Raghu, Dr Shreyas who have helped me through my dissertation work.

I am thankful to the members of ethical committee BLDEU‘s Shri. B. M. Patil Medical College Hospital and Research Centre Vijayapur for permitting me to carry out this study.

I am thankful Mohd Shannawaz for his help in statistical analysis. I would also like to thank all my juniors for their help and co-operation.

I am deeply indebted to my son Advik and husband Dr Ishwar Kanabur for being my inner strength. I am thankful for the support of my parents, brother, sister and in-laws for their blessings which helped me to complete this dissertation.

I thank Dr Rashmi Hullalli for her help in preparing dissertation.

Last but not the least; I convey my heartfelt gratitude to all my patients, without whose co-operation, this study would be incomplete.

Dr. RASHMI. B. PATIL.

LIST OF ABBREVATIONS USED

AOJE	:Atlanto Occipital Joint Extension
ASA	: American Society of Anaesthesiologist
BURP	: Backward, Upward and Rightward Pressure
C & L Grading	: Cormack and Lehane Grading
Cms	: Centimeters
C_6	:6^{th} cervical vertebra
ECG	: Electrocardiogram
ETT	: Endotracheal Tube
Fig	: Figure
FN	: False Negative
FP	: False Positive
H & N Movement	: Head and Neck Movement
IIG	: Inter-incisor Gap
L/Lt	: Left
LMA	: Laryngeal Mask Airway
Max	: Maximum
Mg	: Milligram
Min	: Minimum
MMT	: Modified Mallampatti Test
N	: Normal
NPV	: Negative Predictive Value
O2	: Oxygen
PBC	: Post Burn Contracture

PPV	: Positive Predictive Value
R/Rt	: Right
RHTMD	: Ratio of Height to thyromental Distance
RR	: Relative Risk
SD	: Standard Deviation
SENS	: Sensitivity
SMD	:Sternomental Distance
SPEC	: Specificity
TMD	: Thyromental Distance
TMJ	: Temporomandibular Joint
TN	: True Negative
TP	: True Positive
Yrs	: Years
≥	: Greater than or equal to
≤	: Less than or equal to

ABSTRACT

Backgrounds and objectives

In the present study, preoperative assessment of 120 patients posted for surgery under general anaesthesia was carried out to evaluate the usefulness of both the individual as well as multiple screening tests in predicting the ease or difficulty of tracheal intubation.

Methods

The preoperative airway assessment was conducted using multiple screening tests like Modified Mallampatti test, Thyromental Distance, Head and Neck Movement and Inter Incisor Gap. Modified Mallampatti test grade III or IV, Thyromental distance <6 cms, Head and Neck movement <80º and Inter Incisor gap <3.5 cms were considered as predictors of difficult intubation. Intubation was considered difficult if the view on laryngoscopy was Cormack and Lehane grade III or IV, three attempts at tracheal intubation, duration longer than 10 minutes, failure to intubate or if special maneuvers were required to facilitate intubation. The results were evaluated on the basis of sensitivity, specificity, positive and negative predictive value of these tests.

Results

When individual factors were taken into consideration, the false negative result was 0.83% and false positive results ranged from 0-2.5%. Modified Mallampatti test had higher sensitivity of 100%, Head and Neck movement and IIG had 100% specificity

and positive predictive value. When multiple predictors were taken into consideration false negative and false positive results were 0.83% and 1.67% respectively.

Interpretation and Conclusion

When multiple predictors were taken into consideration there was a considerable reduction in false positives with significant improvement in positive predictive value. Application of multiple predictors can reduce the frequency of unanticipated difficulty and unnecessary interventions related to over prediction of difficult airway.

Keywords

Intubation; airway; anaesthesia; modified Mallampatti test; Thyromental distance; inter incisor gap; predictors; Head and Neck Movement.

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Introduction

INTRODUCTION

The management of the airway with induction of anesthesia is the primary and unique responsibility of the anesthesiologist. From the time of introduction of endotracheal intubation, several problems have occurred due to failed intubation. An unusual and unanticipated situation is one of "Cannot ventilate and cannot intubate". Closed claims analysis has found that vast majority (85%) of airway related events involve brain damage and one third of mortality was attributable solely to anesthesia. This was related to inability to maintain a patent airway in these cases[1].

Many methods have been introduced in the past to overcome these problems and identify the patient who will be difficult to intubate. Important among those is the preoperative assessment of the airway in the patients posted for surgery.

Initially the airway assessment was carried out by single factors like Mallampatti's oropharyngeal classification[2,3], Thyromental distance[4], Head and neck movement, 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[5,6,7,8,9]. These include modified Mallampatti test, thyromental distance, inter-incisor gap, head and neck movement etc. 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

With the application of multivariate factors one can identify, true positives (those who were predicted to have difficult intubation and had difficult intubation), false positives (those who were predicted to have difficult 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.

In the present study preoperative airway assessment of 120 patients posted for surgery under general anesthesia was carried out to evaluate the usefulness of both the individual and multiple screening tests in predicting the ease or difficulty of tracheal intubation taking into consideration the sensitivity, specificity, positive and negative predictive values of these tests.

OBJECTIVES

OBJECTIVES

The objective of this study is to determine :

1) The single predictor, which is more sensitive, specific and has higher positive predictive value.

2) Whether multiple predictors are associated with less false negative and false positive predictions when compared to single factor i.e., more specific and have higher positive predictive value,

3) The number of false negative cases seen with normal airway prediction using single and multiple predictors.

4) The number of cases, which require special techniques and additional aids to facilitate intubation.

REVIEW OF

LITERATURE

ANATOMY OF RESPIRATORY TRACT

The term airway refers to the upper airway which is the extrapulmonary air passage consisting of the nasal and oral cavities, pharynx, larynx, trachea and large bronchi. The normal airway in the awake state and in health performs a variety of functions including filtration of ambient air, air conditioning, humidification and conduction of air to and from the lungs for gaseous exchange between pulmonary alveoli and capillaries. The airway is converted into a passive state during induction and maintenance of general anesthesia due to the suppression of nervous system which regulates the vital respiratory functions. The anesthesiologist should be able to ventilate the patient during this state by either bag mask or via endotracheal tube. He should be well versed with the anatomy of the airway, its application and various methods of assessment of the airway like mouth opening, nasal patency, head and neck movement, thyromental distance and sternomental distance which will help him to evaluate and anticipate the difficulty of airway maintenance and formulate a plan for safety of the patient.

Mouth

Mouth is made up of the vestibule and the mouth cavity, the former communicating with the latter through the angle of mouth. The vestibule is formed by the lips and cheeks om the outside and by the gums and teeth within.

The cavity of the mouth is bounded by the alveolar arch and teeth in front, the hard and soft palate above, anterior two thirds of the tongue and the reflection of its mucosa forward onto the mandible below and the oropharyngeal isthmus behind.

The palate

Hard palate : is made up of palatine processes of maxilla and the horizontal plates of the palatine bones.

Soft palate : This hangs like a curtain suspended from the posterior edge of the hard palate. Its free border bears the uvula centrally and blends on either side with the pharyngeal wall. The anterior aspect of soft palate faces the mouth cavity and the posterior aspect faces the nasopharynx. The muscles of the soft palate are five in number the tensor palati, the levator palati, the palatoglossus, the palatopharyngeus and the muscular uvulae. These help to close off the nasopharynx from the mouth in deglutition and phonation.

The nose is divided anatomically into the external nose and the nasal cavity.

The external nose is formed by a framework of bones consisting of nasal bones, the nasal part of frontal bone and the frontal processes of maxillae, a series of cartilages in the lower part and a small zone of fibrofatty tissue that forms the lateral margin of the nostril. The cartilage of the nasal septum comprises the central support of this framework.

The nasal cavity is subdivided by the nasal septum into two separate compartments that open to the exterior by the nares and into the nasopharynx by the posterior nasal apertures or choanae. Each side of the nose presents a roof, floor, a medial and lateral wall.

The roof is formed by the nasal and frontal bones, cribriform plate of ethmoid and body of the sphenoid.

The floor is formed by the palatine process of the maxilla and the horizontal plate of the palatine bone.

The medial wall is the nasal septum, formed by the septal cartilage, the perpendicular plate of the ethmoid and the vomer. The lateral wall is formed by the nasal aspect of the ethmoidal labyrinth above, the nasal surface of the maxilla below and in front and the perpendicular plate of the palatine bone behind. Onto the lateral wall opens the orifices of the paranasal sinuses and the nasolacrimal duct.

Blood supply : The upper part of the nasal cavity receives its arterial supply from the anterior and posterior ethmoidal- branches of the ophthalmic artery and the lower part by the sphenopalatine branch of maxillary artery and septal branch of superior labial branch of the facial artery. The venous drainage occurs through the sphenopalatine, facial and ophthalmic veins.

Nerve supply : The olfactory nerve supplies the specialized olfactory zone of the nose. Nerve supply to other areas is by 1st and 2^{nd} division of trigeminal nerve.

Pharynx

The pharynx is a wide muscular tube that forms a common upper pathway of respiratory and alimentary tracts. Anteriorly it is in free communication with the nasal cavity, the mouth and the larynx, which divides into three parts the nasopharynx, oropharynx and laryngopharynx respectively.

In extent, it reaches from the skull (the basilar part of the occipital bone) to the origin of esophagus at the level of C_6. Posteriorly it rests against cervical vertebrae and prevertebral fascia.

Nasopharynx : The nasopharynx lies behind the nasal cavity and the soft palate. It communicates with the oropharynx through the pharyngeal isthmus. On the lateral wall of the nasopharynx, 1 cm behind and below the inferior nasal concha lies the pharyngeal opening of Eustachian tube. A bulge immediately behind its opening, termed the tubal elevation with a small depression in turn, which is named Fossa of Rosenmuller. The nasopharyngeal tonsil (adenoids) lies on the roof and posterior wall of nasopharynx. Postero-superiorly to the nasopharynx lies the sphenoid sinus that separates the pharynx from sella turcica containing the pituitary gland.

Oropharynx : The mouth cavity leads into oropharynx through the oropharyngeal isthmus, which is bounded by the palatoglossal arches, the soft palate and the dorsum of the tongue. The oropharynx extends its height from the soft palate to the tip of the epiglottis. It consists of palatine tonsils, which are collections of lymphoid tissue which lie on each side in the triangle formed by the palatoglossal and palatopharyngeal arches (the pillars of the fauces) connected across the base by the dorsum of the tongue.

Laryngopharynx : The third part of the pharynx extends from the tip of the epiglottis to the lower border of the cricoid at the level of C6. Its anterior aspect faces first the laryngeal inlet, bounded by the aryepiglottic folds, then below this the posterior aspect of the arytenoids and finally the cricoid cartilage. The larynx bulges back into the centre of laryngopharynx, leaving a recess on either side termed the pyriform fossa.

The muscles of the pharynx

The muscles of the pharynx are superior, middle and inferior constrictors, the stylopharyngeus, salpingopharyngeus and palatopharyngeus.

Larynx

Larynx is situated anterior to the bodies of C4, C5, C6 vertebra and commands the entrance to the pulmonary system. It is a strong muscular organ that is primarily a valve of the respiratory tract. The development of larynx as organ of speech was much later and is popularly known as voice box. Structurally the larynx is in the form of a box composed of nine cartilages, connected by ligaments and moved by nine muscles[10].

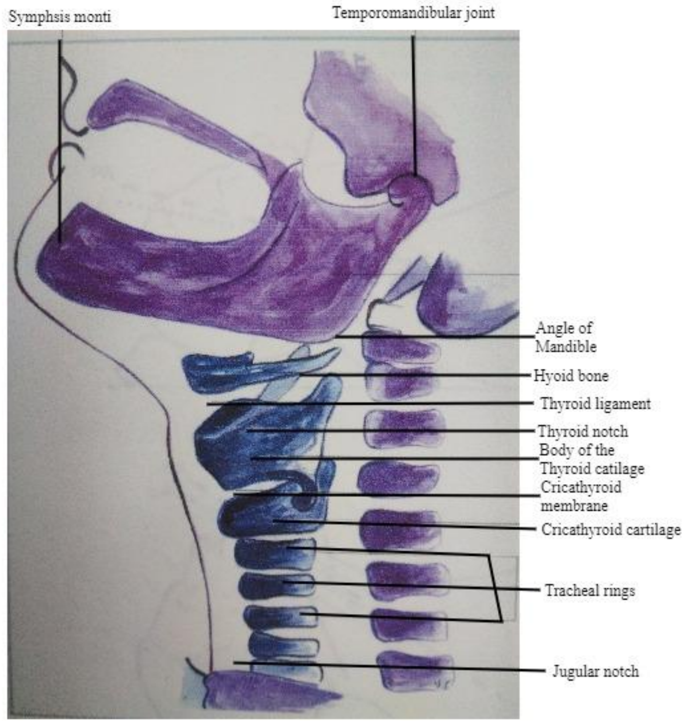

Fig 1: Lateral view of Head and Neck

Laryngoscopic anatomy

To view the larynx by direct laryngoscopy and then to pass on endotracheal tube depends on getting the mouth, the oropharynx and the larynx into one plane. Elevation of the head about 10 cms with pads under the occiput with shoulders remaining on the table aligns the laryngeal and pharyngeal axis. Flexion of the neck and extension at the atlantooccipital joint creates the shortest distance and most nearly straight line from the incisor teeth to glottic opening. This position is termed the sniffing position[11].

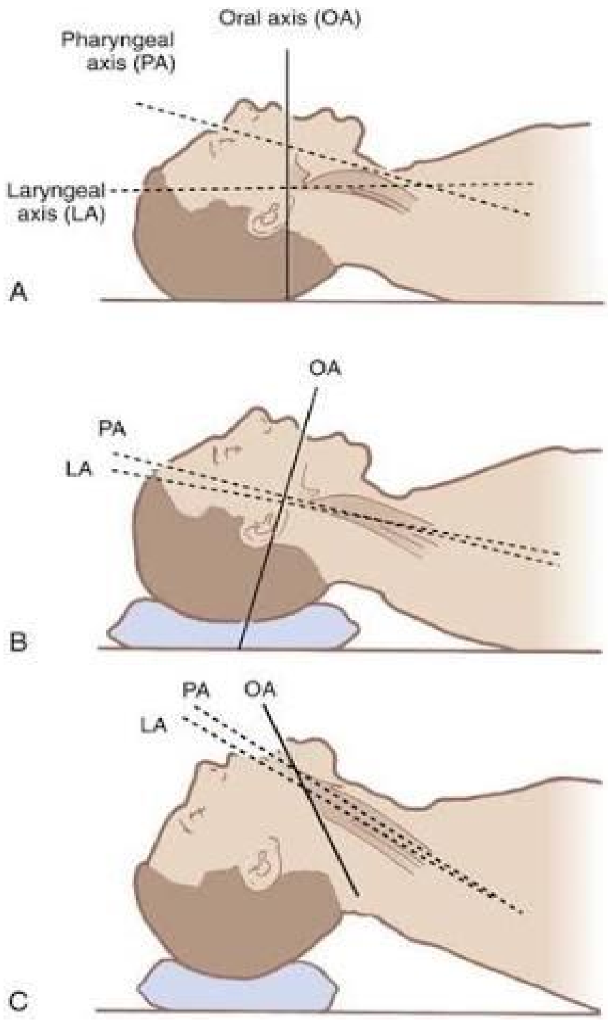

Fig. 2 : Sniffing (Magill's) position for intubation

At laryngoscopy, the anesthetist first views the base of the tongue, the valecula and the anterior surface of the epiglottis. The laryngeal aditus then comes into view bounded in front by the posterior aspect of the epiglottis with its prominent epiglottic tubercle. The aryepiglottic folds are seen on either side running postero-medially from the lateral aspect of the epiglottis. They are thin in front and become thicker as they pass backwards where they contain cuneiform and corniculate cartilages. The vocal cords appear as pale, glistening ribbons that extend from the angle of the thyroid cartilage backwards to the vocal process of the arytenoids. Between the cords is the triangular opening of the rima glottidis through which can be seen the upper two or three rings of the trachea[l0,12].

Fig 3: Larngoscopic view of larynx

Laryngeal cartilages : The laryngeal cartilages comprise the single cricoid, thyroid and epiglottic cartilages and the paired arytenoid, cuneiform and corniculate cartilages.

1. Arytenoid cartilages

These are three sided pyramids that sit one on either side of the supero-lateral aspect of the lamina of the cricoid. Each has a lateral muscular process into which are inserted the posterior and lateral cricoarytenoid muscles and an anterior vocal process, which is the posterior attachment of the vocal ligament. The apex articulates medially with the corniculate cartilage.

2. Corniculate cartilages

The corniculate cartilage are two conical nodules of elastic fibrocartilage which articulate with the apices of the arytenoid cartilages and are sometimes fused with the arytenoid cartilages.

3. Cuneiform cartilages

These are two small elongated club like nodules of elastic fibrocartilage, one in each aryepiglottic fold, anterosuperior to the corniculate cartilages.

4. Cricoid cartilage

Cricoid cartilage can be regarded as the skeletal foundation of the larynx, attached below to the trachea and articulated by synovial joints to the thyroid cartilage and the two arytenoids. It forms a complete ring around the airway and is the only laryngeal cartilage to do so. Cricoid is smaller but thicker and stronger than thyroid cartilage and is shaped like a signet ring with a narrow curved anterior arch and a broad flatter posterior lamina. Together these form the inferior parts of the anterior and lateral walls of larynx and most of its posterior wall.

Cricoid lamina : is quadrilateral in outline, 2-3cm in vertical dimension.

Cricoid arch : Vertically narrow in front, 5-7 mm in height and widens posteriorly towards the lamina[13].

On each side of the cricoid, at the junction of lamina and arch is a circular synovial facet that articulates with inferior thyroid cornu. The inferior border of cricoid is horizontal and joined to first tracheal cartilage by cricotracheal ligament. The superior border is oblique and gives attachment to cricothyroid ligament.

5. Thyroid cartilage

The thyroid cartilage is the largest of laryngeal cartilages. It consists of two quadrilateral laminae whose anterior borders face along their inferior two-thirds at a median angle forming the subcutaneous laryngeal prominence (Adam's apple). Above this a V-shaped superior thyroid notch separates the laminae and posteriorly they diverge, the posterior borders of each being prolonged as slender horns, the superior and inferior cornua. Superior cornua is long and narrow and curved upwards, backwards and medially to which lateral thyrohyoid ligament is attached. The inferior cornua is short and thick and articulates with the side of cricoid cartilage.

6. Epiglottic cartilage

The epiglottic cartilage is a thin leaf like plate of elastic fibrocartilage projecting obliquely upwards behind the tongue, hyoid body and in front of the laryngeal inlet. Its free end, which is broad and round, is directed upwards. Its attached part or stalk is long and narrow and is connected by the elastic thyro-epiglottic ligament to the back of laryngeal prominence just below the thyroid notch. Its sides are attached to the arytenoid cartilages by aryepiglottic folds. Its free upper surface is covered by mucosa and is reflected on the pharyngeal aspect of the tongue and the lateral pharyngeal walls as a median glosso-epiglottic and two lateral glosso-epiglottic folds. On each side of the median fold is a depression called vallecula. The lower part of the anterior surface is behind the hyoid bone and thyrohyoid membrane and connected to it by hyo-epiglottic ligament. The lower projecting part of smooth posterior surface is called epiglottic tubercle.

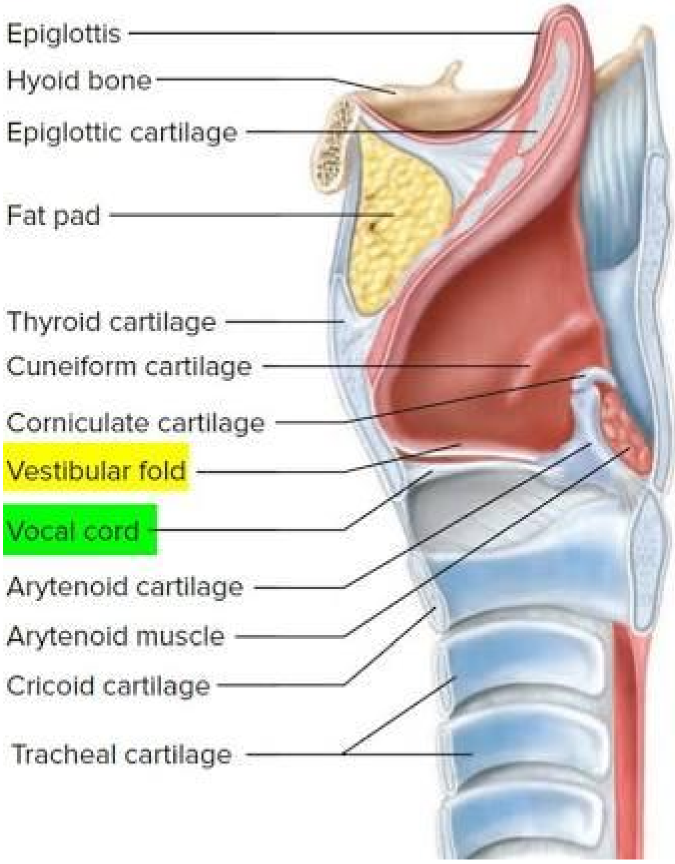

Fig. 4 : Lateral view of laryngeal cartilages

Laryngeal ligaments : The ligaments of the larynx can be divided into the extrinsic and the intrinsic which link together the laryngeal cartilages

Extrinsic

1. Thyrohyoid membrane

It is a broad fibroelastic membrane attached below to the superior border of the lamina of thyroid cartilage and its superior cornua and above to the superior margin of the body of hyoid bone and greater cornua. Its thicker part is the median thyrohyoid ligament and thinner lateral part is the lateral thyrohyoid ligament. The membrane is pierced by internal branch of superior laryngeal nerve and superior laryngeal vessels.

2.Cricotracheal ligament

It unites the lower cricoid border to first tracheal cartilage

3. Hyoepiglottic ligament

It connects the epiglottis to the back of the body of thyroid

4.Cricothyroid ligament

It comprises the inferior larger part of laryngeal membrane and is comprised of anterior and lateral parts. The single thick anterior (median) cricothyroid ligament is broad below and narrow above. It connects adjacent margins of cricoid and thyroid cartilages. An anastomoses between the cricothyroid arteries crosses it and supply perforating branches to the larynx. The paired smaller lateral cricothyroid ligaments are thinner. It is an easily identified gap in the anterior surface of laryngeal skeleton through which intratracheal injections are administered. It is also the recommended site for emergency laryngotomy in case of laryngeal obstruction.

The intrinsic ligament comprises the capsules of the tiny synovial joints between arytenoid and cricoid cartilages and between the thyroid and cricoid cartilages.

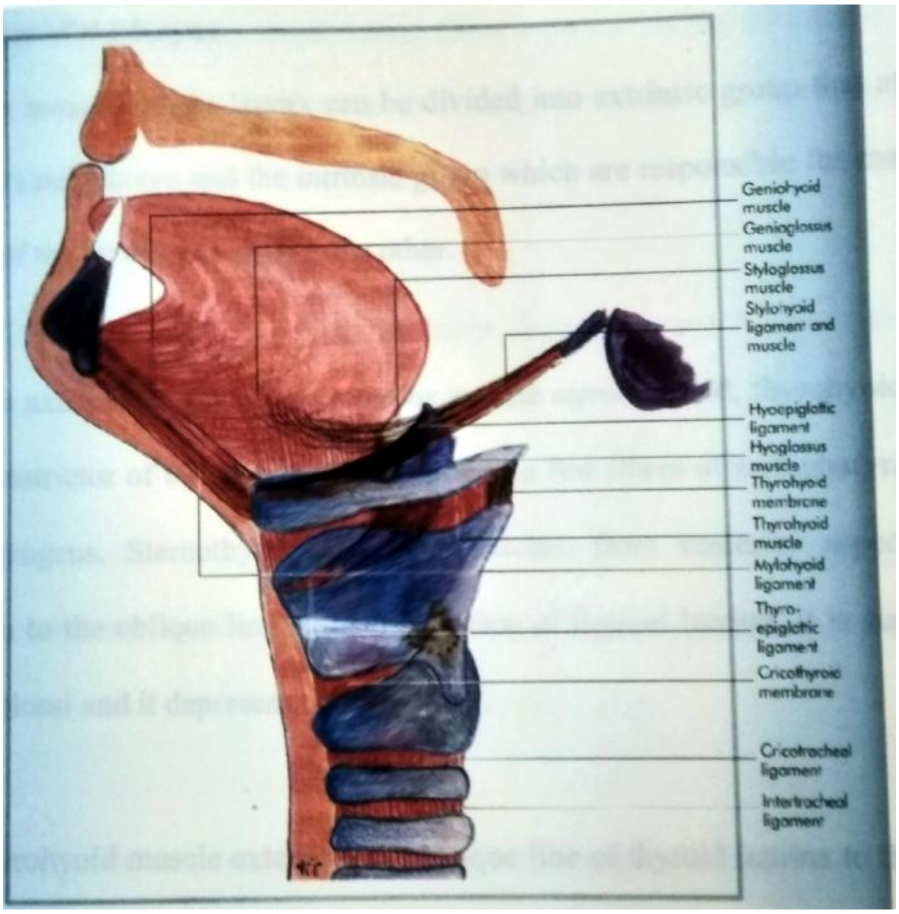

Fig 5: Ligaments, Muscles, Membranes connecting airway framework

Laryngeal cavity

This space extends from the laryngeal inlet, from the pharynx, down to the lower border of cricoid cartilage where it continues into the trachea.

It is partially divided into upper and lower parts by paired upper and lower mucosal folds, with a middle part between the two sets of folds.

Upper folds are vestibular folds, median aperture that they guard is Rima vestibuli and the lower pair are vocal folds and the fissure between the latter are Rima glottidis or glottis.

The muscles of the larynx

The muscles of the larynx can be divided into extrinsic group that attach the larynx to its neighbours and the intrinsic group which are responsible for moving the cartilages of the larynx one against the other.

The extrinsic muscles of the larynx are the sternothyroid, thyrohyoid and the inferior constrictor of the pharynx in addition to a few fibers of stylopharyngeus and palatopharyngeus. Sternothyroid muscles stretches from posterior aspect of the manubrium to the oblique line on lateral surface of thyroid lamina. It is supplied by ansa hypoglossi and it depresses the larynx.

Thyrohyoid muscle extends from oblique line of thyroid lamina to the inferior border of the greater horn of hyoid. It elevates the larynx. The inferior constrictor acts solely as a constrictor of the pharynx.

The intrinsic muscles of the larynx function in :

1. Opening the cords in inspiration
2. Close the cords and laryngeal inlet during deglutition
3. Alter the tension of the cords during speech[14]

They comprise the posterior and lateral cricoarytenoids, interarytenoids, aryepiglottic, thyroarytenoid, thyroepiglottic, vocalis and the cricothyroid muscles.

The posterior cricoarytenoid arises from posterior surface of cricoid lamina and inserted into posterior aspect of arytenoid. It abducts the vocal cords by external rotation of arytenoid and opens the glottis.

The lateral cricoarytenoid arises from superior border of cricoid arch and inserted into lateral aspect of arytenoid. It adducts the cord by internally rotating arytenoid cartilage and closes the glottis.

The interarytenoid muscle, the only unpaired muscle runs between two arytenoid cartilages and helps to close the glottis.

The thyroarytenoid muscle arises from the posterior aspect of the junction of laminae of thyroid cartilages and inserted into anterolateral aspect of arytenoid cartilage. It serves to shorten and thus relax the vocal cord.

The cricothyroid muscle, the only intrinsic muscle outside the cartilaginous framework, arises from anterior part of outer aspect of cricoid cartilages and inserted into inferior border of the lamina of thyroid cartilage. Contraction of this muscle lengthens the anteroposterior diameter of the glottis, putting the vocal cords to stretch and thus functions as the tensor of the cord.

The trachea

The trachea extends from its attachment to the lower end of the cricoid cartilage, at the level of the sixth cervical vertebrae, to its termination at the bronchial bifurcation. In the living subject in erect position, the lower end of trachea can be seen to extend to the level of the 5th or in full inspiration, the 6th thoracic vertebrae.

In the adult the trachea is 15cm long of which 5 cm lie above the suprasternal notch. The patency of trachea is due to a series of 16-20 C-shaped cartilages joined vertically by fibroelastic tissue and closed posteriorly by the tracheal muscle. The cartilage at the tracheal bifurcation is the keel shaped carina.

The trachea lies exactly in the midline in the cervical part of its course, but within the thorax it is deviated slightly, to the right by the arch of the aorta.

In the neck, trachea is covered anteriorly by the skin, superficial and deep fascia. The isthmus of thyroid covers the 2^{nd} to 4^{th} rings. In the lower part of the neck, the edges of sternohyoid and sternothyroid muscles overlap the trachea. On either side are the lateral lobes of the thyroid gland which intervene between trachea and the carotid sheath and its contents (common carotid artery, internal jugular vein and the vagus nerve. Posteriorly trachea rests on the oesophagus with both the recurrent laryngeal nerves lying on either side in a groove between the two.

The thoracic part of the trachea descends through the superior mediastinum. Anteriorly it is related to from above downwards the inferior thyroid veins, sternothyroid muscles, thymus, brachiocephalic and left common carotid artery and posteriorly it is related to the oesophagus. To the right trachea is in contact with the mediastinal pleura and to the left are the left common carotid artery, left subclavian artery and left vagus nerve which intervene between trachea and pleura.

The arterial supply to the trachea is derived from the inferior thyroid arteries and the venous drainage via the inferior thyroid veins. Lymphatic drainage is through the deep cervical, pre-tracheal and para-tracheal nodes. The trachea is innervated by the recurrent laryngeal branch of the vagus nerve with a sympathetic supply from the middle cervical ganglion.

The Main Bronchi

The trachea bifurcates into the right and left bronchi at the level of T6 vertebra. The right main bronchus is shorter, wider and more vertically placed than the left. Shorter because it gives off its upper lobe bronchus after a course of only 2.5cm, wider because it supplies the larger lung and more vertically placed (at 25° to the vertical compared with 45° on the left) because the left bronchus has to extend laterally behind the aortic arch to reach its lung hilum.

The left main bronchus is 5 cm longer. It passes under the aortic arch, in front of the oesophagus, thoracic duct and descending aorta.

REVIEW OF LITERATURE

Maintenance of a patent airway is the primary responsibility of anesthesiologists. Interruption of gas exchange for even a few minutes can result in catastrophic outcomes. The difficulty of achieving a patent airway varies with anatomic and other individual patient factors. Identification of the patient with a difficult airway is vital in planning anesthetic management so that endotracheal intubation and positive pressure ventilation can be safely achieved. The need to predict a potentially difficult intubation has received great importance as it plays a vital role in bringing down morbidity and mortality.

Bannister and Macbeth in 1944 stressed the importance of position of the head and neck in direct laryngoscopy in order to achieve proper alignment of the axis of the mouth, pharynx and larynx[15] . Gillespie in 1950 suggested the ideal position for axis alignment and intubation that can be achieved by raising the head, flexing the neck and extending the head at the atlanto-occipital joint[16].

Cass, James and Lines in 1956 described five cases of difficult laryngoscopy and analysed the anatomic features that make visualization of glottis difficult. These include:

1. A short muscular neck with a full set of teeth,
2. A receding mandible with obtuse mandibular angles,
3. Protruding maxillary incisor teeth due to relative overgrowth of maxilla
4. Poor mobility of mandible associated with temporomandibular joint arthritis and trismus.

5. Long high arched palate with a long narrow mouth.
6. Increased alveolo-mental distance necessitating wider opening of mouth'.

White and Kander in 1975 studied radiographs of the mandible, upper jaw and cervical spine in thirteen patients in whom direct laryngoscopy was difficult. They found that posterior depth of mandible was the most important factor for determining the ease of direct laryngoscopy and an increase in this distance hinders the displacement of soft tissues by larygoscope blade[18].

Jones and Pelton in 1976 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[19].

In 1976, Tunstall pointed out that proper airway management consists of more than a collection of techniques for achieving intubation. 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[20].

Nichole and Zuck in 1983 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[21].

Vander Linde, Roelofse and Steenkamp in 1983 suggested that no single anatomical factor determined the ease of direct laryngoscopy, but rather a combination of them[22].

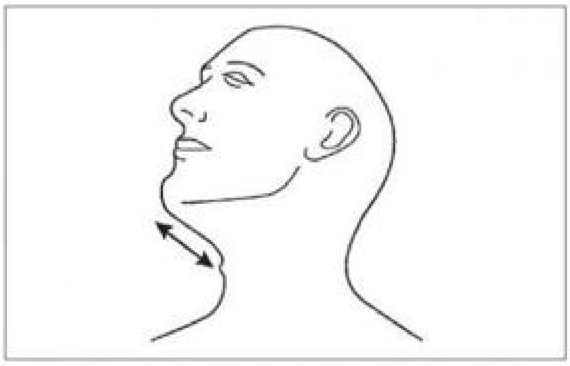

Fig. 6: Showing thyromental distance

Patil, Stehling and Zander (1983) suggested that if during the initial clinical examination existing signs of a potentially difficult intubation supplement a distance less than 6.0cms between the lower border of chin and the thyroid notch, then intubation is going to be difficult and fibreoptic laryngoscopy is indicated[4].

In 1983, Mallampatti SR hypothesized that concealment of faucial pillars and uvula by the base of the tongue rendered the exposure of larynx by direct laryngoscopy difficult. He developed a simple grading system that involves preoperative ability to visualize faucial pillars, soft palate and base of uvula as a means of predicting the degree of difficulty in laryngeal exposure[23]. He evaluated his hypothesis on 210 adult patients. The patient's airway was assessed at the time of preoperative interview by the individual scheduled to administer anesthesia. Visibility of oropharyngeal structures (faucial pillars, soft palate and base of uvula) was noted by instructing the patient to open his / her mouth and protrude the tongue maximally while in the sitting posture. Each patient was directed to perform this maneuver twice to minimize the chances of erroneous observation. The patients were divided into 3 classes.

Class 1 : Faucial pillars, soft palate and uvula could be seen.

Class 2 : Faucial pillars and soft palate could be seen but uvula masked by the base of the tongue.

Class 3 - Only soft palate could be visualised

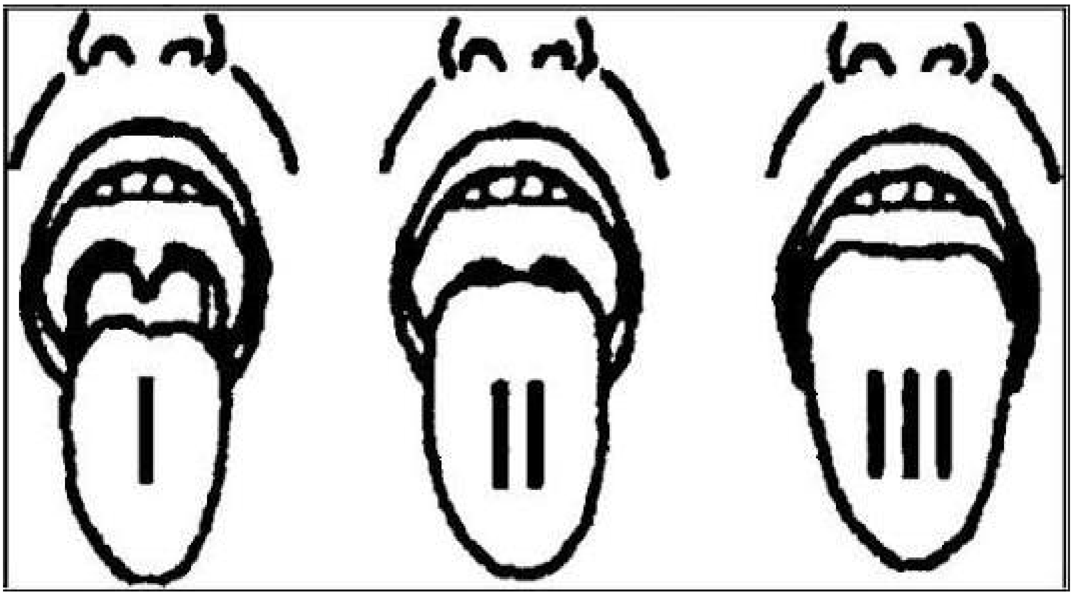

Fig 7 : Mallampatti Grades.

He also graded the extent of exposure of glottis during laryngoscopy and expressed on a scale of 1 to 4 as-follows:

Grade 1 : Glottis (including anterior and posterior commissure)
could be fully visualised

Grade 2 : Glottis could be partly exposed (Anterior commissure
not visualized)

Grade 3 : Glottis could not be exposed (only corniculate
cartilage seen)

Grade 4 : Glottis including corniculate cartilages couldn't be
exposed.

Grade 1 and 2 were considered adequate exposure and grade 3 and 4 inadequate exposure.

He evaluated his hypothesis on 210 adult patients and showed significant correlation between ability to visualize pharyngeal structures and ease of laryngoscopy[2,23].

In 155 patients with class I exposure, all had easy visualization at laryngoscopy (100%). In 40 patients with class 2 exposure, laryngoscopy was easy in 126 patients and difficult in 14 patients. In 15 patients with class 3 exposure, only one patient had easy laryngoscopy and in all other patients laryngoscopy was difficult.

Even edentulous/obese patients had laryngeal exposure consistent with visibility of faucial pillars and uvula.

Using single factor of Mallampatti classification, the author concludes that his results were highly significant and difficult laryngeal visualization can be predicted in most cases by eliciting the visibility of faucial pillar and uvula. If all three pharyngeal structures are visible, one can expect adequate exposure of larynx in direct laryngoscopy. If faucial pillars and uvula are masked by the base of the tongue and only soft palate is visible, one should expect difficult intubation secondary to inadequate exposure of larynx on direct laryngoscopy.

Cormack and Lehane in 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 : Whole of the vocal cords visible.

Grade II : Only posterior commissure visible.

Grade III : Only epiglottis visible.

Grade IV : None of the above visible.

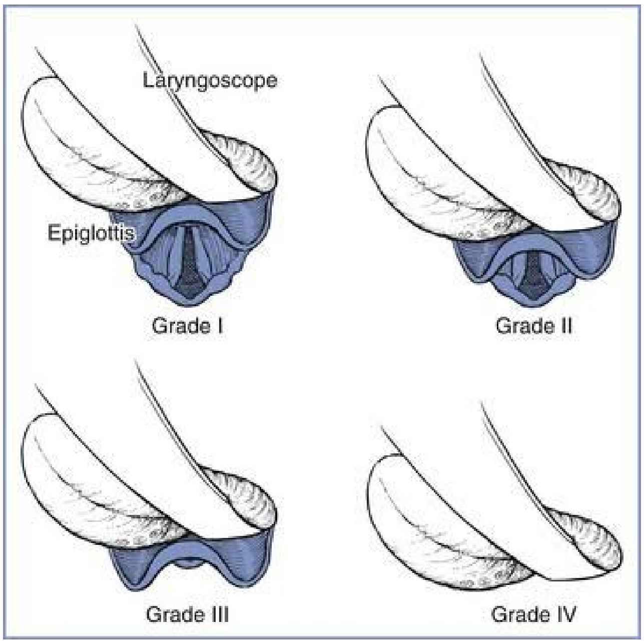

Fig. 8: Cormack and Lehane's classification of laryngoscopic view

They felt that grade III and IV cases are often not recognized preoperatively. So most anesthesiologists 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 performed with difficulty which will help at the time of real difficulty — the concept of simulated difficult intubation[24].

In 1987, Samsoon and Young modified Mallampatti classification into four classes, the fourth class represents an extreme form of class 3 in which only hard palate could be visualized but not the soft palate. As it is not physically possible to measure the size of the posterior part of the tongue relative to the capacity of oropharyngeal cavity, this method of assessment gives an indirect means of evaluating their relative proportionality. 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 observer looks from the patient eye level and inspects the pharyngeal structures with a pen torch. It is important while 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.

Fig. 9: Samsoon and Young's modification of Mallampatti classification.

They found significant associations of class I and II with Cormack and Lehane's laryngeal view of grade I/II and class III and IV with Cormack and Lehane's grade III/IV[3].

Cook in 2000 felt that Cormack and Lehane's classification of laryngeal view is applied inaccurately by many anesthetists and that its sensitivity being too low in delineating increasing difficulty with intubation. He modified the classification of laryngeal view and subdivided grade II into IIa and IIb, grade III into IIIa and IIIb[26].

Grade I : Most of the vocal cords visible
Grade IIa : Posterior cord visible
} Easy view

Grade IIb : Only arytenoids visible.
Grade IIIa : Epiglottis visible and liftable
} Restricted view

Grade IIIb : Epiglottis adherent to pharynx and not liftable.
Grade IV : No laryngeal structure seen
} Difficult view

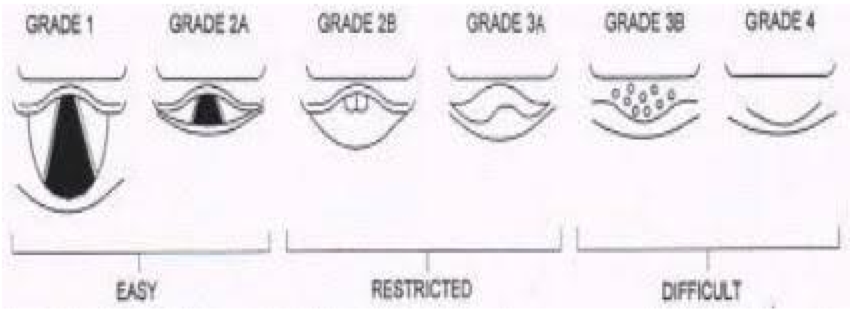

Fig. 10 : Cook's classification of laryngeal view

They evaluated their classification in 500 patients and compared its efficiency with that of Cormack and Lehane's grading. They found that easy view predicted easy intubation with a sensitivity of 96.2%, specificity of 70.1% and PPV of 92.7%. Difficult view predicted difficult intubation with a sensitivity of 100%, specificity of 99.6% and PPV of 77%. Their results were highly superior to that of Cormack and Lehane's classification and they suggest it to be routinely used for better prediction of difficult intubation.

Caplan, Ponies, Ward *et al* in 1990 found that 35% of 1541 liability claims were for adverse respiratory events in ASA closed claims study and approximately 75% of these undesirable events were due to 3 factors — Inadequate ventilation (38%), esophageal intubation (18%) and difficult tracheal intubation (17%). The remaining adverse respiratory events were produced by airway obstruction, bronchospasm, aspiration, premature and unintentional extubation and endobronchial intubation. Anesthetic care was rarely considered appropriate in cases of inadequate ventilation and esophageal intubation and was considered appropriate in difficult tracheal intubation. They also felt that better monitoring would have prevented adverse outcome in 72% of 522 claims for adverse respiratory events. All claims for inadequate ventilation and esophageal intubation was considered preventable with better monitoring which included pulse oximetry, capnometry or both[1].

Benumof JL in 1991 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 larygoscope blade, optimal sniff position, multiple attempts, external laryngeal pressure to push the larynx more posteriorly and cephalad for better view. He has defined an infinite difficult intubation is when trachea cannot be intubated under direct vision despite optimal head and neck positioning, very forceful anterior elevation of the laryngoscope blade, use of multiple attempts, laryngoscope blades, laryngoscopists, external laryngeal pressure and full paralysis. This means tracheal intubation through a non-visualized larynx is impossible[25].

Chou and Wu in 1993, conducted retrospective study on radiograph of 11 patients in whom direct laryngoscopy proved difficult. They evaluated the vertical distance between the mandible and hyoid bone — Mandibulo-hyoid distance. They found it to be substantially longer in patients in whom trachea was difficult to intubate. Mandibulo-hyoid distance indicates the relative rostro-caudal position of mandible and hyoid bone. A more rostral mandibular angle, a more caudal hyoid bone or both contribute to longer mandibulo-hyoid distance. Rostral mandibular angle is also associated with short mandibular ramus which raises floor of oral cavity towards the skull. The caudal hyoid bone due to short ramus results in large portion of the tongue to be situated in hypopharynx rather than oral cavity which comes in the way during direct laryngoscopy, resulting in anterior and caudal larynx associated with difficult intubation in patients with no other indicators of difficult laryngoscopy[29].

Several prospective studies have identified various individual clinical symptoms possessing a significant association with laryngoscopy or intubation difficulties. Sensitivity and positive predictive value of these individuals signs are low ranging from 33%-71% for sensitivity[2,3,29,30]. Five studies have challenged the multifactorial prediction indices of difficult tracheal intubation or difficult view of glottis or both[5,6,7,8,9]. They include weight, head and neck movement, jaw movement, receding mandible, buck teeth, modified Mallampatti test, thyromental distance, history of difficult intubation, pathologies associated with difficult intubation, clinical symptoms of airway pathology, etc. Four studies found a decrease in falsely predictive larnygoscopy or intubation difficulty[5,6,8,9]. One study found no improvement in sensitivity[7].

Mathew M, Hanna LS, Aldrette JA in 1989 studied the correlation between thyromental distance and the horizontal length of mandible with modified Mallampatti test in 44 patients who were divided into two equal groups.

- Group A consisting of 22 patients who presented difficulty in intubation but were not anticipated so in the preoperative examination.
- Group B consisting of 22 patients whose intubations were performed in the first attempt without any difficulty.
- In group A —› Mean Thyromental distance was 5.6 cms
    - Mean horizontal length of mandible was 8.5 cms.
    - Nine patients had MMT grade III and
    - Thirteen patients had MMT grade IV
- In group B-→ Mean TMD was 8 cms.
    - Mean horizontal length of mandible was 10.8 cms
    - Fourteen patients had MMT grade I and
    - Eight patients had MMT grade II.

The study demonstrated that patients with Thyromental distance of <6cms and horizontal length of mandible <9cms showed good correlation with MMT grade III and IV and had a higher probability of difficult intubation. On the other hand, those with thyromental distance of < 6cms and horizontal length of mandible > 9 cms correlated well with MMT grade I and II with a lesser possibility of difficult intubation[31].

Frerk C.M. in 1991 conducted airway evaluation of 244 patients using modified Mallampatti test and Thyromental distance. MMT grade III and IV and TMD. <7cms were considered to predict difficult intubation. The view on laryngoscopy was graded according to Cormack and Lehane's. Difficult intubation was defined as laryngoscopic view of grade 3 or 4 or if a gum elastic bougie was required for intubation. Of 244 patients, 11 proved to be difficult to intubate.

Based on modified Mallampatti test, 52 patients were predicted to have difficult intubation, but only 9 turned out to have difficult intubation [True positive] and so it had a high false positivity of 43 and sensitivity of 81%, specificity of 81.5%.

Based on Thyromental distance. 53 patients were predicted to have difficult intubation, but only 10 had difficult intubation [True positive]. So thyromental distance had a sensitivity of 90.9% specificity of 81.5% and a low positive predictive value of 18%.

When usefulness of these two tests were assessed, both had very high false positive results and were not specific for routine use. However if both the tests were combined, only 14 patients were predicted to have difficult intubation and they could identify 9 patients who had difficult intubation. The combination of two tests retained the same sensitivity of 81.5%, but had a good specificity of 97.8% with less false positive results[6].

Savva D. **in 1994** studied 350 patients before operation using modified Mallampatti test (MMT), Thyromental distance (TMD), sternomental distance (SMD), forward protrusion of mandible and interincisor gap. MMT grade III or IV TMD cms SMD protrusion of mandible B OR C were considered as difficult intubation. Tracheal intubation was considered difficult if view on laryngoscopy was grade III or IV or if a gum elastic bougie was required for tracheal intubation after failing twice. 17 patients provided difficulty at tracheal intubation[30].

Modified Mallampatti test identified 11 of 17 patients who had difficult intubation [True positive] but had a very high false positivity [113]. Its sensitivity

(64.7%) and specificity (66.1%) was average, but positive predictive value was too low (89%).

Thyromental distance 556.5 cms had similar sensitivity (64.7%) but more specific (81.4%) than modified Mallampatti test. Sternomental distance .12.5cms identified 14 patients who had difficult intubation [true positive] with 38 false positive results. It had fairly good sensitivity (82.4%) and specificity (88.6%). But even it had poor positive predictive value. Protrusion of mandible and interincisor gap had very low sensitivity and PPV and hence are poor predictors of difficult intubation.

This study has evaluated the usefulness of individual predictors of difficult intubation but has not evaluated the combination of factors in predicting difficult intubation[30].

Tse JC, Rimm EB, Hussain A in 1995 conducted preoperative airway evaluation of 471 adults presenting for elective surgery under general anesthesia using Mallampatti classification, Thyromental distance and Head extension. Assignment to Mallampatti class 3, Thyromental distance <7cm and head extension 580° were selected as indicators of difficult intubation. During intubation, the best laryngeal view was graded according to Cormack and Lehane's. The sensitivity, specificity, positive and negative predictive values of these tests when used alone and together in various combinations were calculated.

Sixty two patients were found at laryngoscopy to have airways that were difficult to intubate (Laryngoscopy grade III or IV). There were no failed intubations.

Of sixty two patients who had difficult laryngoscopy, Mallampatti class 3 identified 41 patients-66% [True positive]. In 21 patients it could not identify difficult intubation-34% [false negative]. It had a sensitivity of 66%. It predicted 186 patients to have difficult intubation, but in fact 145 patients had easy intubation-77% [false positive] and hence its positive predictive value was too low-22%. Of the 285 patients, predicted to have easy intubation, 264 patients actually had easy intubation-92% [true negative]. It had a specificity of 65% with very good negative predictive value (93%).

Thyromental distance 5.7cm identified only 20 out of 62 patients who had difficult intubation with a sensitivity of 32%. In 102 patients predicted to have difficult intubation, 82 patients had easy intubation. It had a low positive predictive value (20%). Out of 369 patients who were identified as candidates for easy intubation 327 patients had easy intubation. It had a specificity of 80% and negative predictive value of 89%.

Head extension _80° identified only 6 patients who had difficult intubation with a very poor sensitivity of 10%. In 33 patients predicted to have difficult intubation, 27 patients had easy intubation with a positive predictive value of 18%. In 439 patients predicted to have easy intubation, 82 patients had easy intubation with a specificity of 93% and negative predictive value of 87%.

When combination of these tests were used. It could identify only 3 patients who had difficult intubation and hence sensitivity was too low [5%]. In 463 patients predicted to have easy intubation, 404 patients had easy intubation with a specificity of 99% and negative predictive value of 87%.

The authors came to a conclusion that the above tests did not predict difficult intubation reliably as they had low sensitivity and positive predictive valves although each test when used alone had a higher sensitivity than the combination tests. However the tests had 'high specificities and negative predictive values and suggest that negative results indicate truly easy intubation[7].

Modified Mallampatti Test could detect 63 of 77 (TP + FN) difficult cases with a sensitivity of 81.8%. 39 of 102 (TP+FP) cases predicted difficult had easy intubation and hence it had a PPV of 61.76%. 118 of 132 (TN + FN) cases predicted easy had easy intubation and hence it had a specificity of 75.15%. The high sensitivity 81.8% was due to high incidence of MMT grade III and IV which was due to decreased mouth opening, increase in size of tongue and decrease in mobility of tongue in patients with facio-oro-maxillary and neck malignancy.

Thyromental distance had a sensitivity of 66.23%, specificity of 75.79% and PPV of 57.3%. The improved sensitivity of thyromental distance in their study was due to the reduction in thyromental distance caused by the tumour itself with surrounding inflammation and fibrosis all of which contributing to its increased association with difficult intubation.

IIG had a sensitivity of 29.87 specificity of 99.36 and PPV of 95.83%. AOJE had a poor sensitivity of 2.5%, but 100% specificity and PPV. Both IG and AOJE predicted easy intubation better. Among the two groups, group I had better specificity and PPV. When these were evaluated in subsequent 134 patients, all the three groups had equal sensitivity, but group I had better specificity and PPV.

They concluded that modified Mallampatti Test predicts difficult intubation more accurately than others among independent predictors. Among the three groups of multiple predictors, group I consisting of MMT, TMD, AOJE and IG was better than the other two groups[33].

Chou and Wu in 2003 found the role of thyromental distance as a predictive test to identify difficult airway as controversial and have made strong suggestion in favour of abandoning the routine use of TMD in predicting difficult airway[34].

However TMD is still a part of preoperative airway physical examination as pointed out in the latest practice guidelines for management of the difficult airway[35].

Schumitt, Kirmse and Troger in 2002 have demonstrated that the ratio of patient's height to TMD (RHTMD) has better predictive value than TMD alone in the Caucasian population[36].

This was subsequently evaluated in Indian population by **Krishna, Agarwal and Rali *et al*., (2005)** in their study on 200 adult patients to determine the usefulness of RHTMD in predicting difficult laryngoscopy and compare it with Wilson Risk-sum score, Modified Mallampatti test and TMD.

MMT grade III and IV, Wilson risk sum score of 2, TMD < 7 cms and RHTMD < 25 were predicted to be indicators of difficult laryngoscopy. The best view on laryngoscopy was graded using Cormack and Lehane's classification. Grade 3 or 4 laryngoscopic view was considered as difficult laryngoscopy. The sensitivity, specificity, NPV and PPV were calculated. The incidence of difficult laryngoscopy in their study was 8.5% - 17 out of 200 cases

Wilson Risk sum score could predict 15 out of 17 difficult cases with a sensitivity of 88.24%. Only 15 out of 25 cases predicted to be difficult had actually difficulty in laryngoscopy. Hence it had a PPV of 60% 173 out of 183 cases predicted easy had easy laryngoscopy. Hence it had a specificity of 94.54%.

MMT could predict 13 out of 17 difficult cases with a sensitivity of 76.47%. It had a PPV of 23.64 which is much less than that of Wilson risk sum score. 141 out of 183 cases predicted easy had easy laryngoscopy and hence it had a specificity of 77.05%.

TMD had similar sensitivity (76.47%) to MMT, but lower specificity (50.64%) than MMT. More over it had poor PPV (13.54%).

RHTMD had better PPV (29.41%) than TMD but lower sensitivity (29.41%) than TMD.

The study confirmed the multifactorial etiology of difficult laryngoscopy as it showed the presence of more than one predictor in most of the cases of difficult laryngoscopy. The authors felt that though TMD still remains the simple popular bedside list, it will vary with the patient size and a single cut off value may not be logical. RHTMD can account for the patient size as well and can be used as predictor of difficult laryngoscopy.

They also conclude that Wilson Risk sum score and MMT are better •predictive tests than TMD or RHTMD for predicting difficult laryngoscopy[37].

METHODOLOGY

METHODOLOGY

MATERIALS AND METHODS.

SOURCE OF DATA: This study was carried out in the Department of Anaesthesiology, B.LD.E.(DEEMED TO BE UNIVERSITY) Shri B.M.Patil Medical College, Hospital and Research centre, Vijayapur. Study was conducted from Dec 2016 to August 2018.

METHOD OF COLLECTION OF DATA:

Study Design: One and half year prospective randomized clinical trial.

Study Period: One and half year from December 2016 to August 2018.

Sample Size: 120 patients undergoing elective surgeries under general anaesthesia were selected

Sample size

Using expected incidence of difficult airway as 11.5%, expected specificity 99%, and desired precision as 20%, the minimum sample size was 115.

This sample size gave the precision of $\leq$20% for both sensitivity and specificity.

Formula used:

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

Where: z = value of two static at 5% level of significance

d = margin of error

p = expected incidence rate.

STATISTICAL ANALYSIS

All characteristics were summarized descriptively. For continuous variables, the summary statistics of mean, standard deviation (SD) were used. For categorical data, the number and percentage were used in the data summaries. Chi-square (χ^2)/ Freeman-Halton Fisher exact test was employed to determine the significance of differences between groups for categorical data. The difference of the means of analysis variables between two independent groups were tested by unpaired t test. The t test (also called Student's T Test) compares two averages (means) and tells you if they are different from each other. Sensitivity- specificity analysis was done to check relative efficiency. If the p-value was < 0.05, then the results were considered to be statistically significant otherwise it was considered as not statistically significant. Data were analyzed using SPSS software v.23.0. and Microsoft office.

PATIENT SELECTION:

INCLUSION CRITERIA

- Patients who were scheduled to undergo surgery under general anaesthesia
- patients posted for elective surgical procedures in different surgical specialities.
- Age group of 18-50 years inclusive of both sexes.
- ASA Grade I & II patients.

EXCLUSION CRITERIA

- Patients who were scheduled to undergo surgery under regional anaesthesia.
- Patients posted for emergency surgical procedures.
- Patients below 18 years and those above the age of 50 years.
- Head and neck tumours.
- Post burn contractures of head and neck.
- ASA Grade III & IV patients.

METHODOLOGY

In all the patients selected for the study a detailed history and general examination was performed. Preoperative airway examination was performed as per proforma using multiple screening tests to predict difficult airway. The following screening tests were used in present study.

a) Recording of patient's - Height in cms,

   Weight in kilogram which was graded into III groups

   < 90kg, 90-110kg, >110kg

b) Modified Mallampatti Test [MMT] similar to that used by Samsoon and Young which 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[3]. 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 :

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

   Grade II : Soft palate, fauces and uvula seen

   Grade III : Soft palate and base of uvula seen.

   Grade IV : soft palate not visible.

c) Maximum range of Head and Neck - by asking the patient to extend fully the head and neck while a straw was placed vertically on the forehead. The patient was made to stand in-front of a chart in which all the angles were marked from 0^o-180^o. Then angle measurement was made depending on the range of head and neck movement.($<80^o$, 80^o-100^o, $>100^o$).

d) Inter-incisor gap [IIG] : The patient was asked to open the mouth as far as possible and the distance between the upper and lower incisor teeth was measured. The results were graded into three levels. IIG <3.5cms, IIG 3.5- 5cms and IIG->5cms.

e) Thyromental distance [TMD][4] : The distance between the prominence of the thyroid cartilage and the bony point of the chin with the head fully extended on the neck was measured and the results were graded into three levels. TMD > 6.5cms, TMD 6.0-6.5cms, TMD < 6 cms

All the measurements were recorded on a form and evaluated.

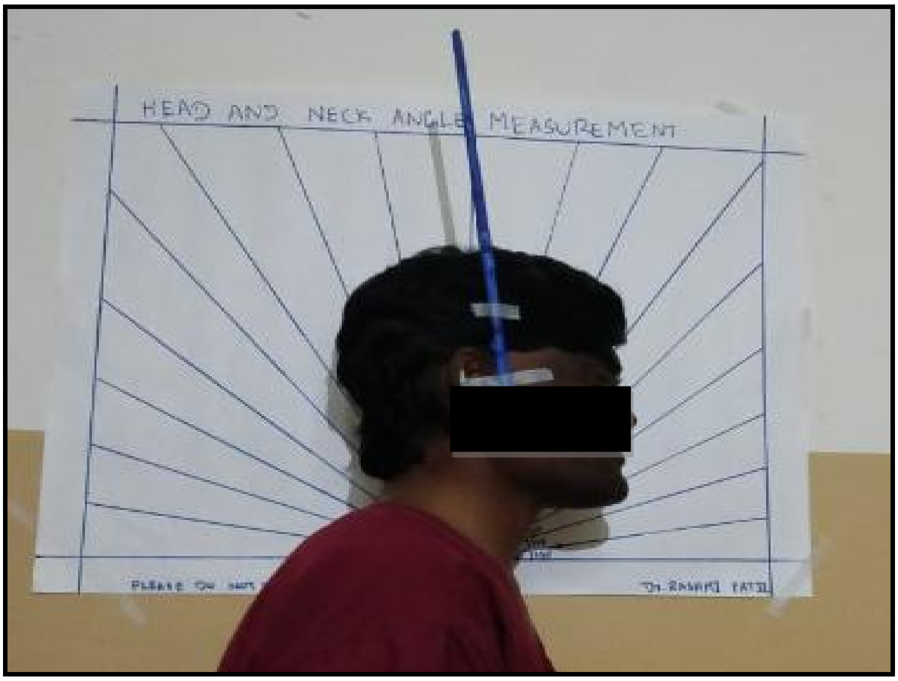

Fig 11 : Head and Neck angle measurement

The following factors when present alone (single predictor) or in combination (multiple predictors) were considered to be predictors of difficult intubation in present study.

a) Weight > 110kgs

b) Modified Mallampatti Test — grading III and IV

c) Maximum range of Head and neck movement < 80°.

d) Inter incisor gap of < 3.5cms

e) Thyromental distance of <6 cms

The rest were predicted to have easy intubation.

checklist :

- Anesthesia machine and circuits checked and following instruments kept ready.
- Endotracheal tubes —> cuffed portex and red rubber tubes of appropriate size and one size lower than required.
- Macintosh laryngoscope —> with medium and large sized blade.
- Airway : oral and Nasopharyngeal airway
- Laryngeal mask airway of appropriate size
- Functioning suction apparatus
- Malleable stylet / Magill's forceps / bougie
- Monitors ---> ECG Monitor, Pulse oximeter, Capnography and sphygmomanometer.
- Emergency drugs —> Atropine, adrenaline, Dopamine, Lignocaine 2% and 4%.

In case of anticipated difficulty in intubation, fibreoptic equipment was kept ready.

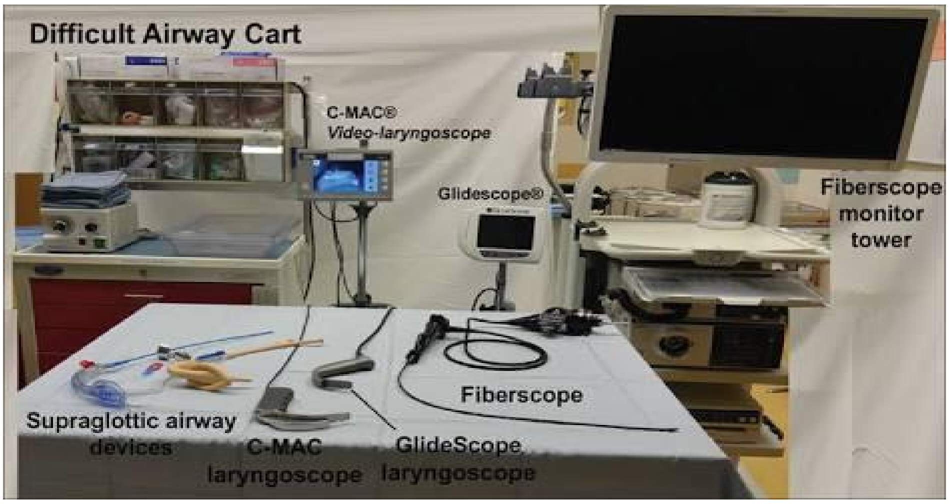

Fig. 12: Difficult Airway Cart

Fig 13 : Drugs and equipments required for fiberoptic intubation

All the patients were preoxygenated with 100% 0_2 for 3 minutes and induced with injection Propofol 2mg/kg body weight. Injection Succinylcholine 1 mg/kg was given to facilitate intubation. Laryngoscopy was performed using Macintosh blade. The best view obtained on laryngoscopy was noted. View on laryngoscopy was graded using the classification of Cormack and Lehane[24].

Grade I : Whole of the vocal cords visible.

Grade II : Only posterior commissure visible

Grade III : Only epiglottis visible.

Grade IV : None of the above visible

A note was also made of whether, or not intubation was difficult that is if the view at laryngoscopy was grade III or IV even in patients who were predicted to have easy intubation using multiple screening tests. If difficulty was experienced in tracheal intubation, backward, upward and rightward pressure on thyroid cartilage-BURP was applied as it improved visualization of glottis on direct laryngoscopy[38]. Subsequently if required laryngoscopy was repeated and additional aids such as stylets/bougie were used if necessary to facilitate tracheal intubation. Number of attempts in intubating the trachea was noted. Failure to intubate the trachea was also noted.

Even in patients having single abnormal factor and predicted to be difficult intubation, the same anesthetic technique was employed wherever possible and view on laryngoscopy was graded using Cormack and Lehane. Intubation whether easy or difficult in these cases was noted.

Endotracheal intubation was considered truly difficult (observed difficult), if any of the following were positive[3,6].

1) Cormack and Lehane grade III and IV.
2) Three attempts at tracheal intubation or duration longer than ten minutes
3) If special maneuvers were used to facilitate tracheal intubation which in our study was usage of bougie..
4) Failure to intubate.

Rest of the patients were considered to have truly easy. [Observed easy] endotracheal intubation.

Definition of terms

True positive (TP) : A difficult endotracheal 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 that were truly difficult.

$$\text{Sensitivity} = \frac{\text{True Positives}}{\text{True Positives} + \text{False negatives}} \times 100$$

Specificity : The percentage of correctly predicted easy intubations as a proportion of all intubations that were truly easy.

$$\text{Specificity} = \frac{\text{True Negatives}}{\text{True Negatives} + \text{False Positives}} \times 100$$

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

$$\text{PPV} = \frac{\text{True Positives}}{\text{True positives} + \text{False Positives}} \times 100$$

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

$$\mathrm{NPV} = \frac{\text{True negatives}}{\text{True negatives} + \text{False negatives}} \times 100$$

OBSERVATION AND RESULTS

OBSERVATION AND RESULTS

Table 1 : GENERAL CHARACTERISTICS OF STUDY PARTICIPANTS.

Age (yrs)	**N**	**%**
≤20	14	11.7
21-30	51	42.5
31-40	31	25.8
41-50	24	20
Total	**120**	**100**
MEAN±SD	31.1±8.8	

Sex	**N**	**%**
Male	56	46.7
Female	64	53.3
Total	**120**	**100**
M/F RATIO	0.875:1	

The above tables shows that half (42.5%) of the study participants belong to 21-30 age group, followed by the age group 31-40 which had 25.8% of the participants and 41-50 age group had 20% of the participants. In my study, 53.3% were females and 46.7% were males.

GRAPH 1 : DISTRIBUTION OF CASES ACCORDING TO AGE AND SEX

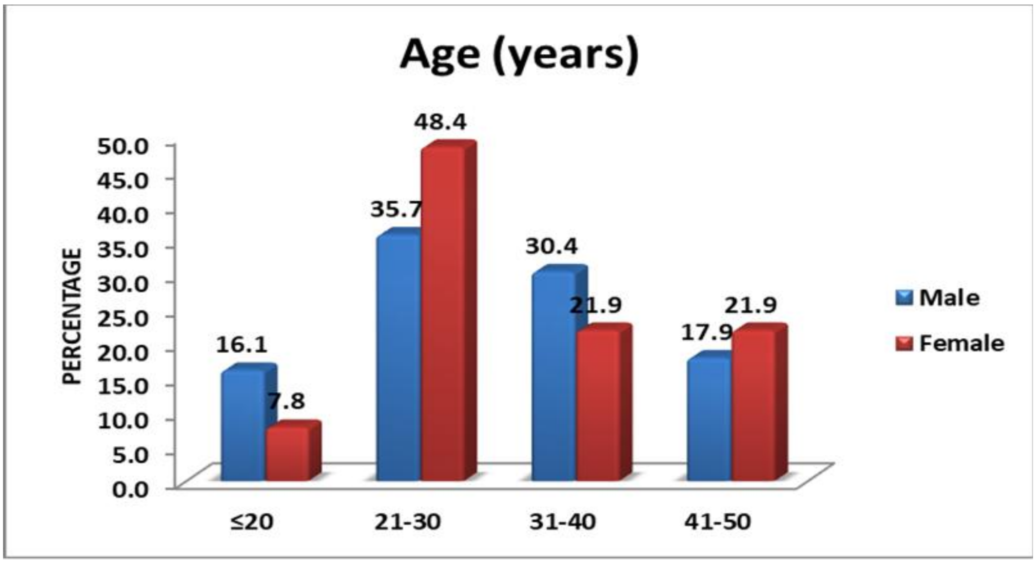

TABLE 2 : COMPARISON OF MEAN AGE BETWEEN SEXES

PARAMETERS	Male		Female		p value
	MEAN	SD	MEAN	SD	
Age (yrs)	30.8	8.8	31.3	8.9	0.738

When the mean age between males and females was compared, mean age of male participants was 30.8 years (SD 8.8) and that of female participants was 31.3 years (SD 8.9). This comparison was not statistically significant (p value 0.738).

GRAPH 2 : COMPARISON OF MEAN AGE BETWEEN SEXES

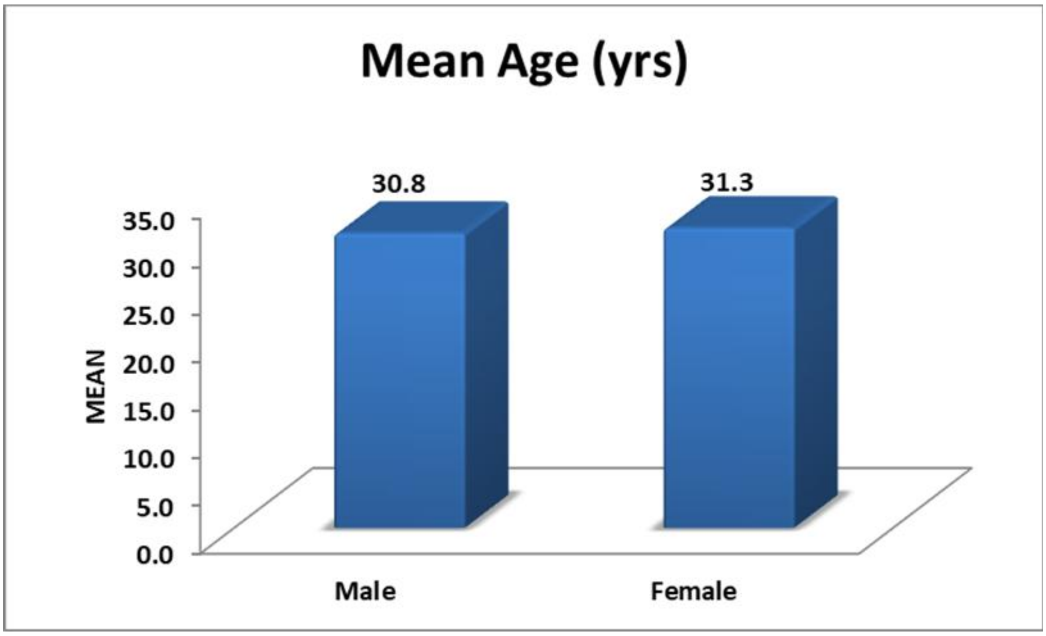

TABLE 3 : COMPARISON OF MEAN HEIGHT BETWEEN SEXES

PARAMETERS	Male		Female		TOTAL		p value
	MEAN	SD	MEAN	SD	MEAN	SD	
Height(cm)	166.6	5.5	157.7	3.6	161.8	6.4	<0.001*

Note: * significant at 5% level of significance (p<0.05)

When mean height of the cases was compared between males and females, it was found statistically significant (p value <0.001).

GRAPH 3 : COMPARISON OF MEAN HEIGHT BETWEEN SEXES

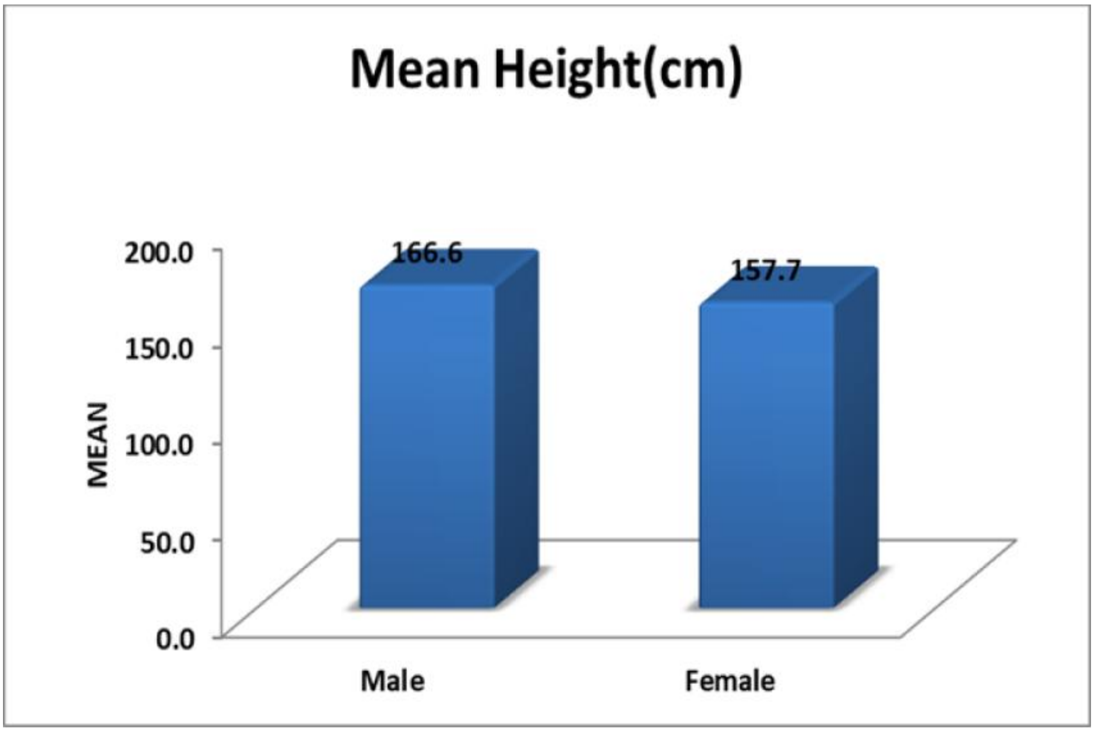

TABLE 4 : DISTRIBUTION OF CASES ACCORDING TO CORMACK & LEHANE GRADING

Cormack & Lehane grading	N	%
I	108	90
II	10	8.3
III	2	1.7
IV	0	0
Total	**120**	**100**

Above table shows that majority of the cases i.e., 108 (90%) belonged to Cormack & Lehane grade I, 8.3% of the cases to grade II, and only 1.7% belonged to grade III.

GRAPH 4 : DISTRIBUTION OF CASES ACCORDING TO CORMACK & LEHANE GRADING

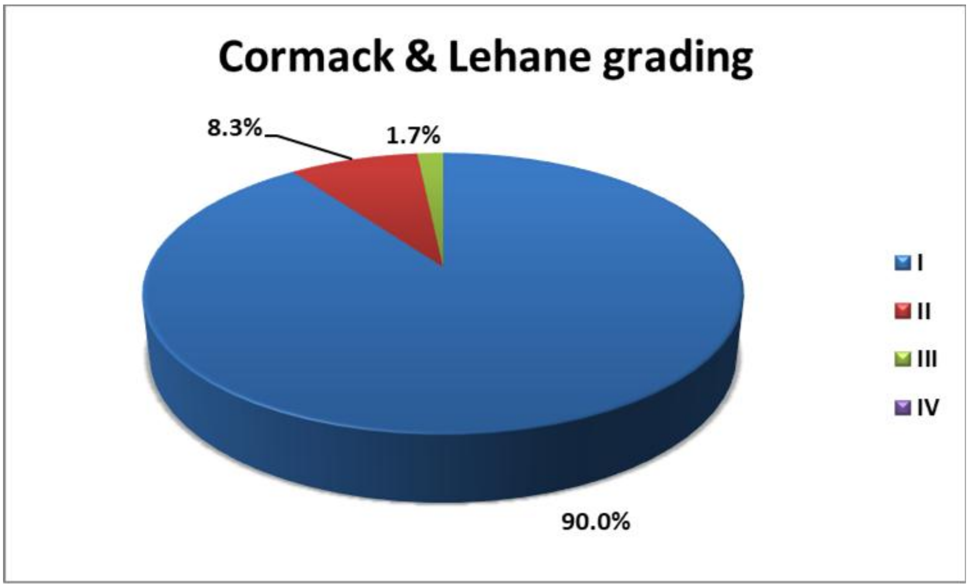

TABLE 5 : DISTRIBUTION OF CASES ACCORDING TO MODIFIED MALLAMPATTI TEST

Modified Mallampatti test	N	%
I	29	24.2
II	86	71.7
III	5	4.2
IV	0	0
Total	**120**	**100**

29 cases belonged to MMT grade-I (24.2%), 86 cases belonged to MMT grade-II (71.7%), 5 cases belonged to MMT grade-III (4.2%).

GRAPH 5 : DISTRIBUTION OF CASES ACCORDING TO MODIFIED MALLAMPATTI TEST

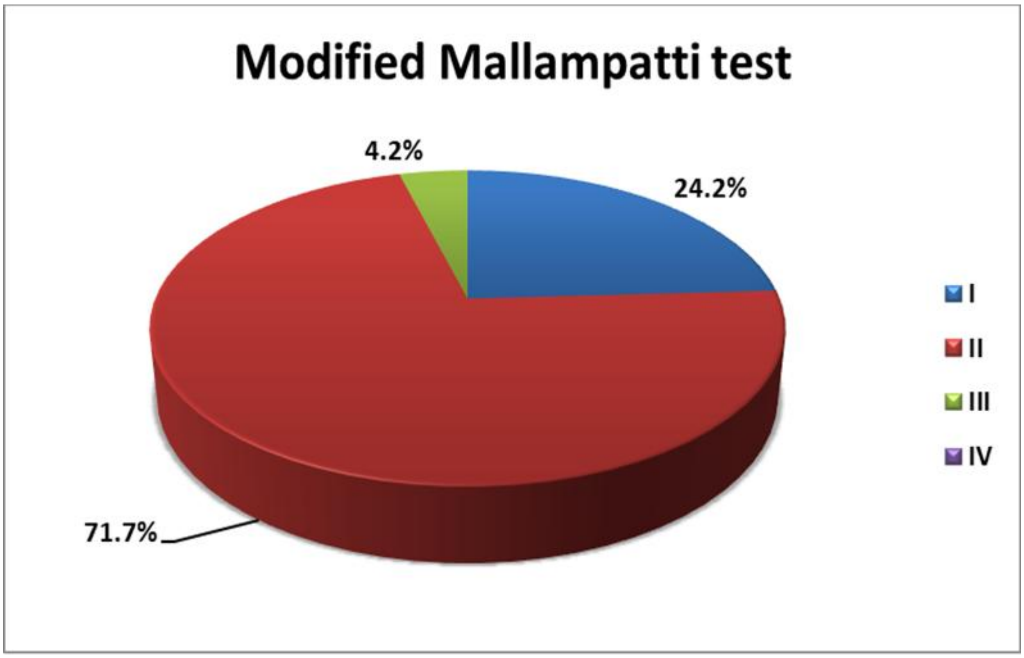

TABLE 6 : ASSOCIATION BETWEEN MODIFIED MALLAMPATTI TEST AND CORMACK & LEHANE GRADING

Modified Mallampatti test	Cormack & Lehane grading				Total	p value
	I	II	III	IV		
I	27	2	0	0	29	<0.001*
II	80	6	1	0	88	
III	1	2	1	0	3	
IV	0	0	0	0	0	
Total	**108**	**10**	**2**	**0**	**120**	

Note: * significant at 5% level of significance (p<0.05)

A significant association was observed between MMT and Cormack & Lehane Grading of laryngoscopic view with p value <0.001. So there was positive association between MMT and Cormack & Lehane grading.

GRAPH 6 : ASSOCIATION BETWEEN MODIFIED MALLAMPATTI TEST AND CORMACK & LEHANE GRADING

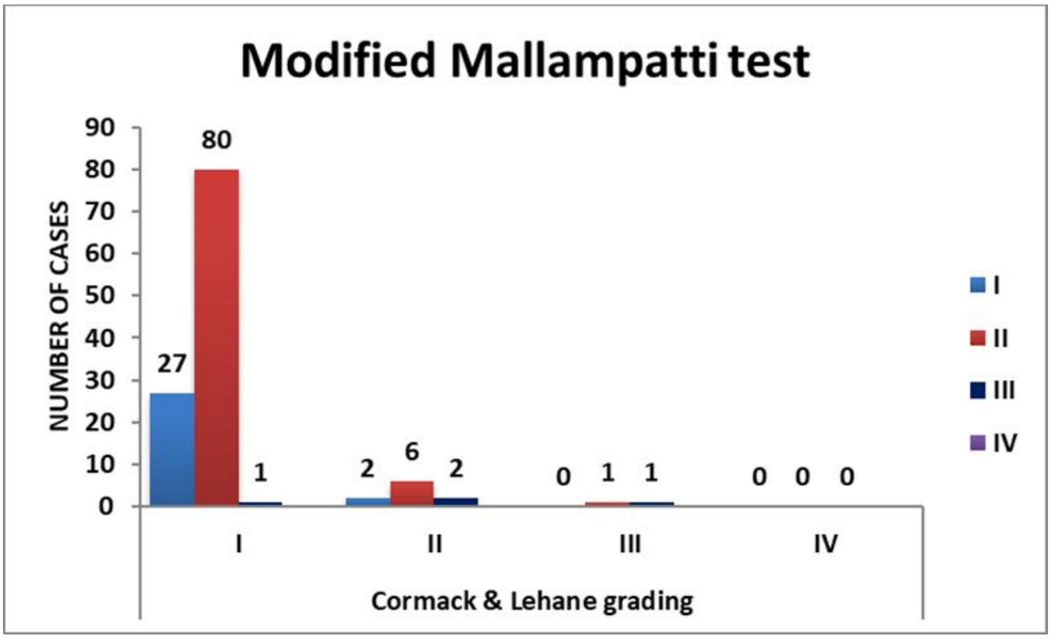

TABLE 7 : SENSTIVITY ANALYSIS OF MODIFIED MALLAMPATTI TEST

TP (true positive)	1
FN (false negative)	1
FP (false positive)	3
TN (true negative)	115

	Modified Mallampatti test
Sensitivity	100.00%
Specificity	97.46%
PPV	40.00%
NPV	100.00%
Accuracy	97.50%

Out of 120 cases, according to MMT 115 cases were true negatives, 3 were false positives , 1 was false negative and only 1 case was true positive. MMT had sensitivity of 100%, specificity 97.46%, PPV 40%, NPV 100%

TABLE 8 : DISTRIBUTION OF CASES ACCORDING TO RANGE OF HEAD & NECK MOVEMENT

Head & Neck Movement	N	%
>100˚	116	96.7
80˚-100˚	3	2.5
<80˚	1	0.8
Total	**120**	**100**

Out of 120 cases, 116 cases had head and neck movement >100^{o} (96.7%), 3 cases had head and neck movement 80^{o}-100^{o} (2.5%), 1 case had head and neck movement <80^{o} (0.8%).

GRAPH 7 : DISTRIBUTION OF CASES ACCORDING TO RANGE OF HEAD & NECK MOVEMENT

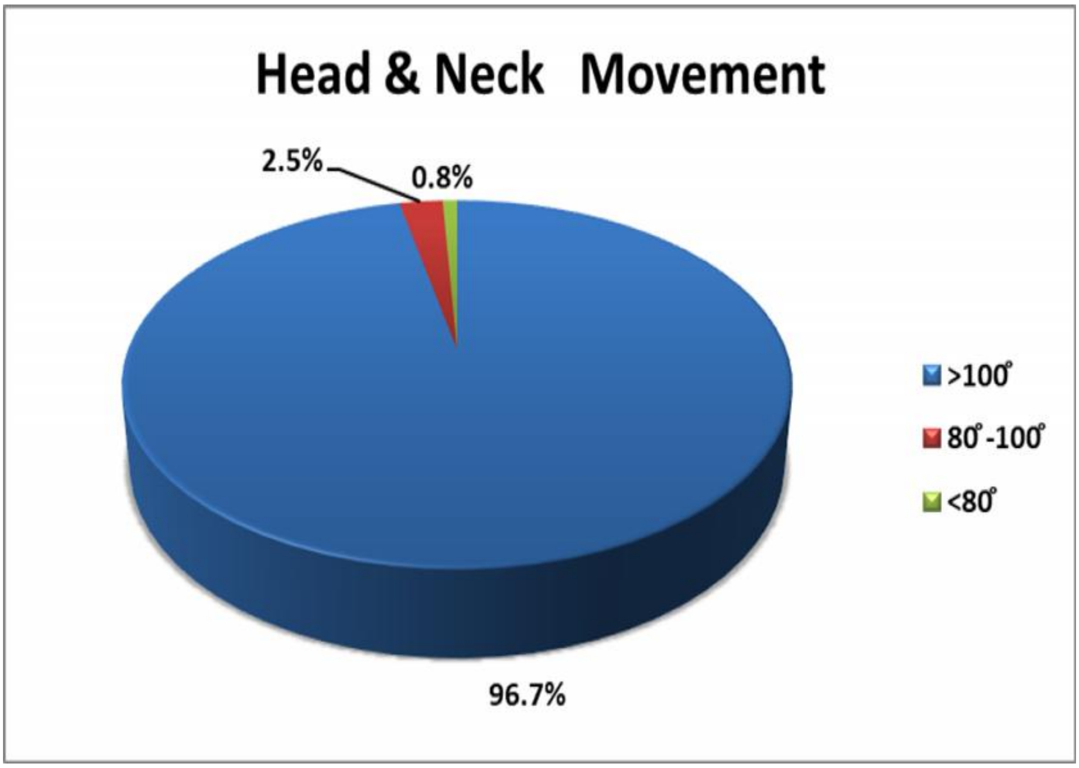

TABLE 9 : ASSOCIATION BETWEEN HEAD & NECK MOVEMENT AND CORMACK & LEHANE GRADING

Head & Neck Movement	Cormack & Lehane grading				Total	p value
	I	II	III	IV		
>100˚	106	9	1	0	117	<0.001*
80˚-100˚	2	1	0	0	3	
<80˚	0	0	1	0	0	
Total	**108**	**10**	**2**	**0**	**120**	

Note: * significant at 5% level of significance (p<0.05)

A significant association was observed between head and neck movement and Cormack & Lehane grading of laryngoscopic view with p value <0.001

GRAPH 8 : ASSOCIATION BETWEEN HEAD & NECK MOVEMENT AND CORMACK & LEHANE GRADING

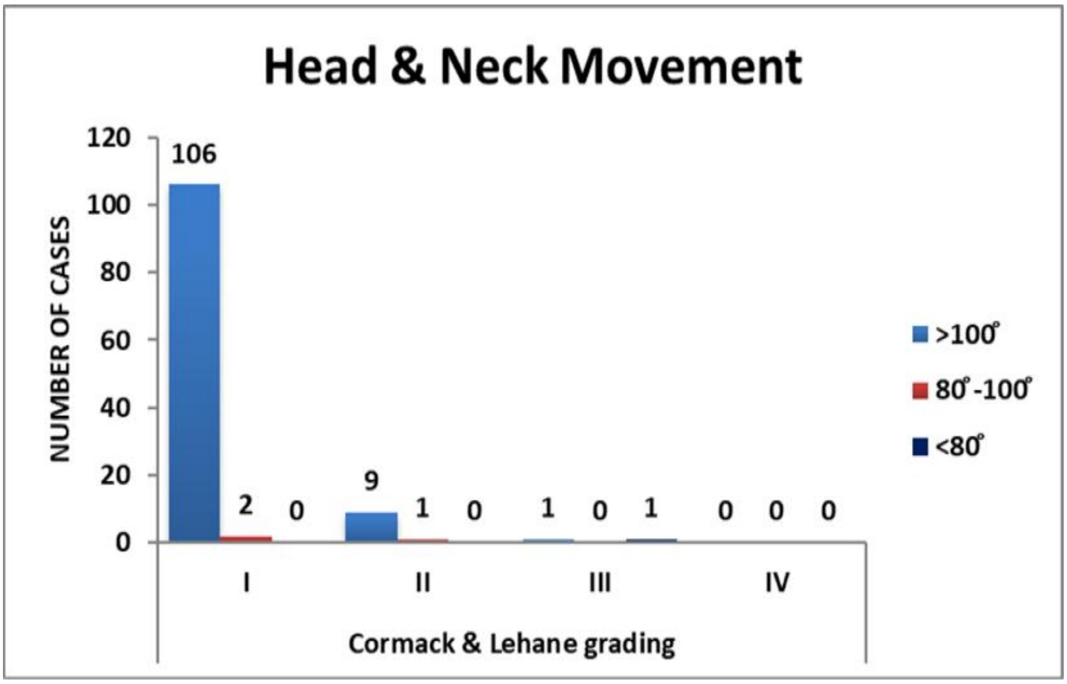

TABLE 10 : SENSTIVITY ANALYSIS OF HEAD & NECK MOVEMENT TEST

TP (true positive)	1
FN (false negative)	1
FP (false positive)	0
TN (true negative)	118

	Head & Neck Movement
Sensitivity	50.00%
Specificity	100.00%
PPV	100.00%
NPV	99.16%
Accuracy	99.17%

Out of 120 cases, according to head and neck movement, 118 cases were true negatives, 1 was false negative and only 1 case was true positive. Head and neck movement had sensitivity of 50%, specificity 100%, PPV 100%, NPV 99.16%.

TABLE 11 : DISTRIBUTION OF CASES ACCORDING TO INTER INCISOR GAP

Inter incisor gap (cm)	N	%
>5	106	88.3
3.5-5	13	10.8
<3.5	1	0.8
Total	**120**	**100**

106 cases had IIG >5cm (88.3%), 13 cases had IIG 3.5-5cm (10.8%), 1 case had IIG <3.5cm (0.8%).

GRAPH 9 : DISTRIBUTION OF CASES ACCORDING TO INTER INCISOR GAP

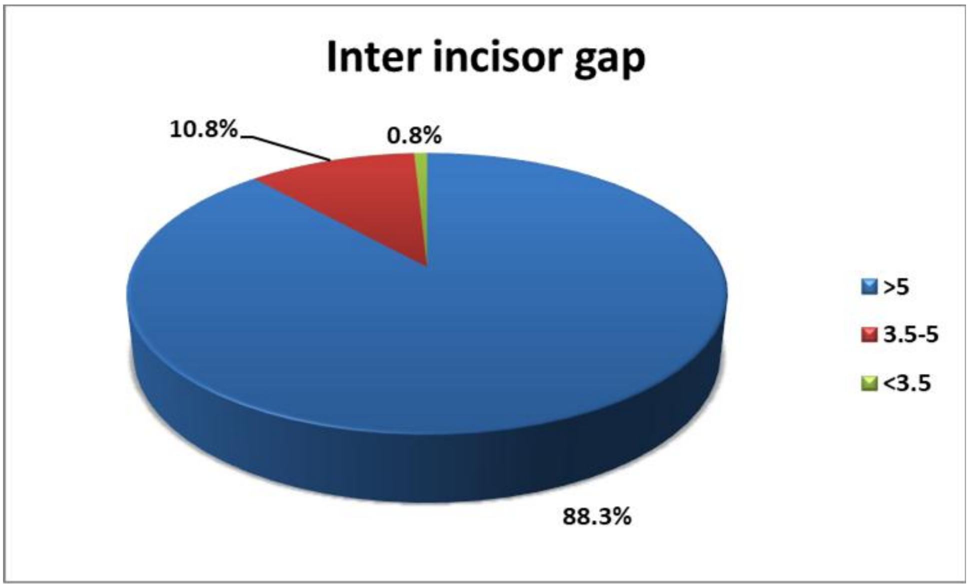

TABLE 12 : ASSOCIATION OF INTER INCISOR GAP RESULTS WITH CORMACK & LEHANE GRADING

Inter incisor gap (cm)	Cormack & Lehane grading				Total	p value
	I	II	III	IV		
>5	98	7	1	0	107	<0.001*
3.5-5	10	3	0	0	13	
<3.5	0	0	1	0	0	
Total	**108**	**10**	**2**	**0**	**120**	

Note: * significant at 5% level of significance (p<0.05)

A significant association was observed between IIG and Cormack & Lehane grading of laryngoscopic view with p value <0.001.

GRAPH 10 : ASSOCIATION BETWEEN INTER INCISOR GAP AND CORMACK & LEHANE GRADING

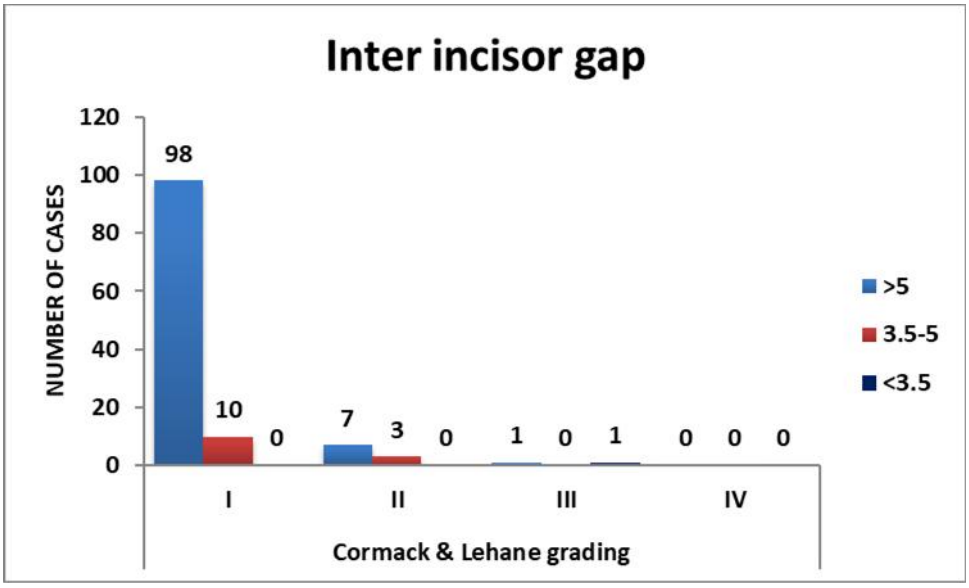

TABLE 13 : SENSTIVITY ANALYSIS OF INTER INCISOR GAP TEST

TP (true positive)	1
FN (false negative)	1
FP (false positive)	0
TN (true negative)	118

	Inter incisor gap
Sensitivity	50.00%
Specificity	100.00%
PPV	100.00%
NPV	99.16%
Accuracy	99.17%

Out of 120 cases, according to IIG, 118 cases were true negatives, 1 was false negative and only 1 case was true positive. IIG had sensitivity of 50%, specificity 100%, PPV 100%, NPV 99.16%.

TABLE 14 : DISTRIBUTION OF CASES ACCORDING TO THYROMENTAL DISTANCE

Thyromental distance (cm)	N	%
>6.5	109	90.8
6.0-6.6	8	6.7
<6.0	3	2.5
Total	**120**	**100**

109 cases had TMD >6.5cms (90.8%), 8 cases had TMD 6.0-6.5cms (6.7%), 3 cases had TMD <6cm (2.5%).

GRAPH 11 : DISTRIBUTION OF CASES ACCORDING TO THYROMENTAL DISTANCE

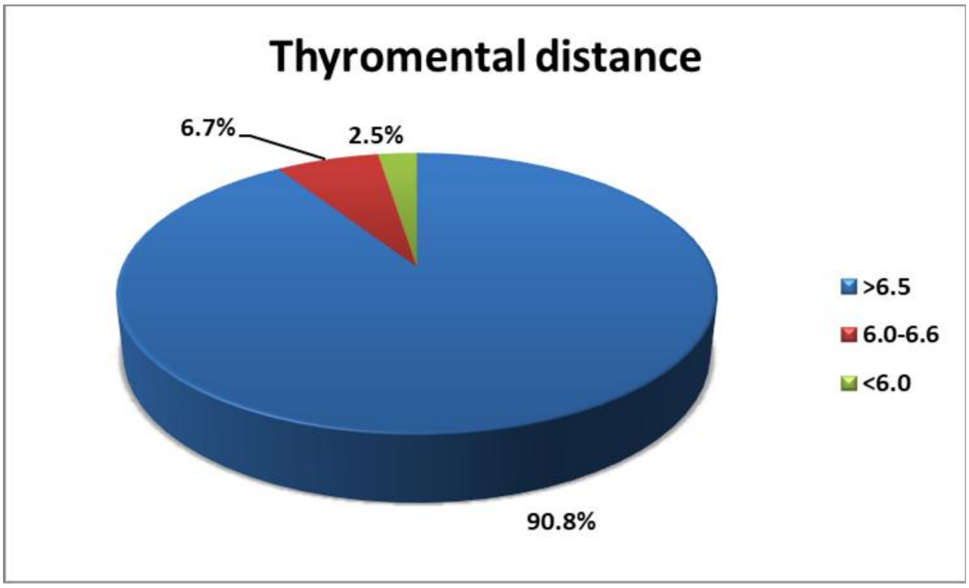

TABLE 15 : ASSOCIATION BETWEEN THYROMENTAL DISTANCE AND CORMACK & LEHANE GRADING

Thyromental distance (cm)	Cormack & Lehane grading				Total	p value
	I	II	III	IV		
>6.5	100	8	1	0	110	<0.001*
6.0-6.6	7	1	0	0	8	
<6.0	1	1	1	0	2	
Total	**108**	**10**	**2**	**0**	**120**	

Note: * significant at 5% level of significance (p<0.05)

A significant association was observed between TMD and Cormack & Lehane grading of laryngoscopic view with p value <0.001.

GRAPH 12 : ASSOCIATION BETWEEN THYROMENTAL DISTANCE AND CORMACK & LEHANE GRADING

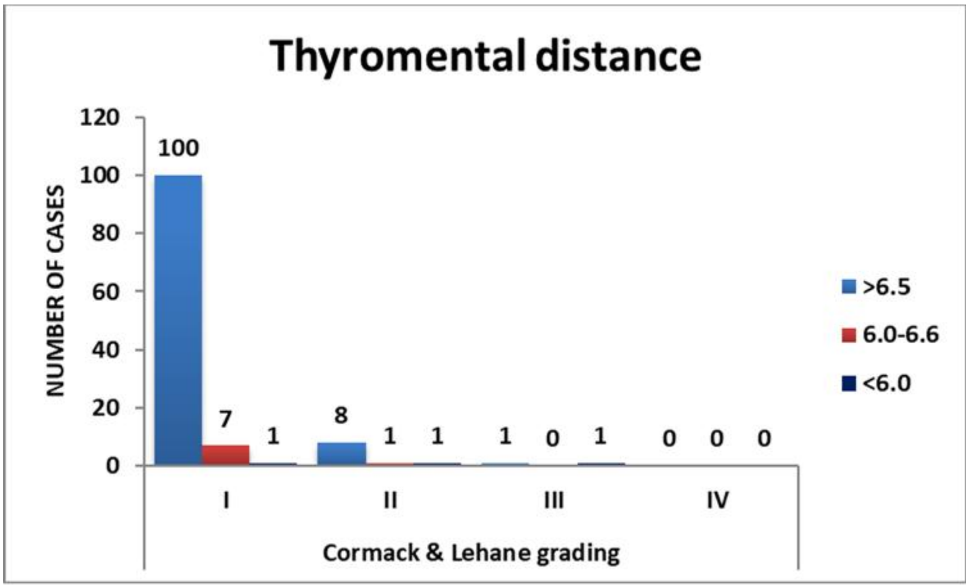

TABLE 16 : SENSTIVITY ANALYSIS OF THYROMENTAL DISTANCE TEST

TP (true positive)	1
FN (false negative)	1
FP (false positive)	2
TN (true negative)	116

	Thyromental distance (cm)
Sensitivity	50.00%
Specificity	98.31%
PPV	33.33%
NPV	99.15%
Accuracy	97.50%

Out of 120 cases, according to TMD, 116 cases were true negatives, 2 cases were false positive, 1 was false negative and only 1 case was true positive. TMD had sensitivity of 50%, specificity 98.31%, PPV 33.33%, NPV 99.15%.

TABLE 17 : DISTRIBUTION OF CASES ACCORDING TO PRE OPERATIVE PREDICTION

Pre op prediction	**N**	**%**
Easy	116	96.7
Difficult	4	3.3
Total	**120**	**100.0**

Out of 120 cases, 116 cases were predicted to have easy intubation preoperatively (96.7%) and remaining were predicted to have difficult intubation.

GRAPHS 13 : DISTRIBUTION OF CASES ACCORDING TO PRE OPERATIVE PREDICTION

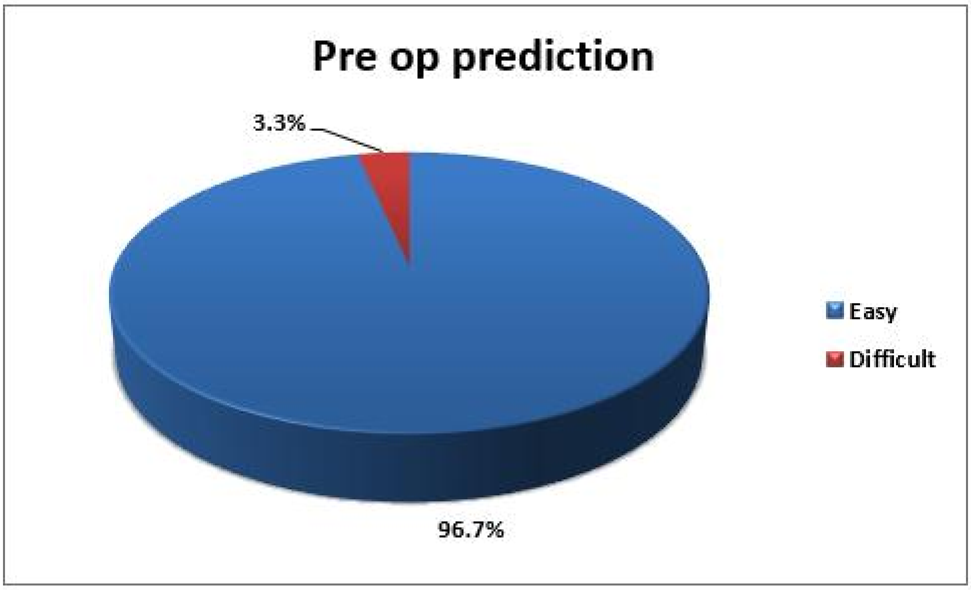

TABLE 18 : DISTRIBUTION OF CASES ACCORDING TO ASSESSMENT DURING INTUBATION

Assessment during intubation	**N**	**%**
Easy	117	97.5
Difficult	3	2.5
Total	**120**	**100**

Out of 120 cases, 117 cases had easy intubation (96.7%) and remaining had difficult intubation.

GRAPH 14 : DISTRIBUTION OF CASES ACCORDING TO ASSESSMENT DURING INTUBATION

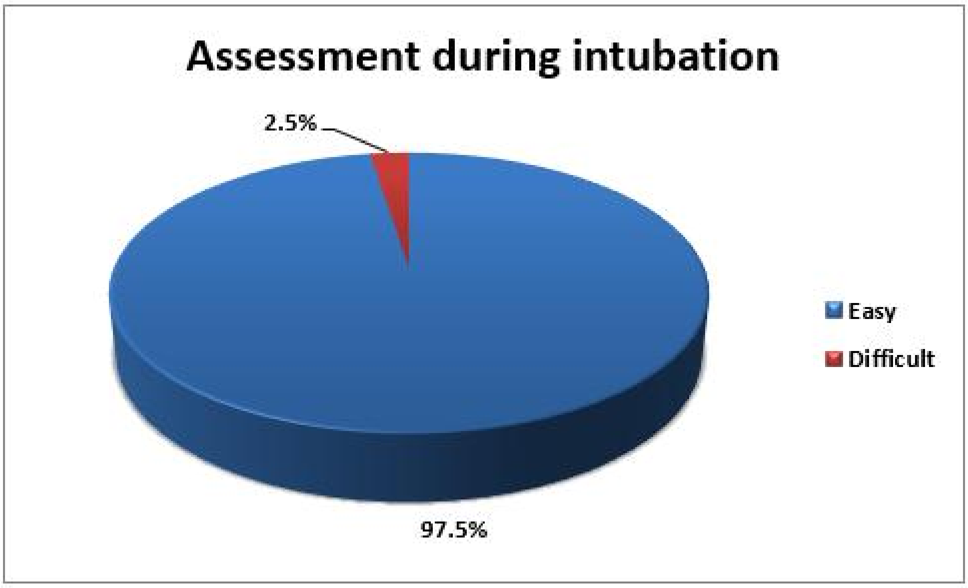

TABLE 19 : COMPARISON OF PRE OP PREDICTION WITH ASSESSMENT DURING INTUBATION

Pre operative prediction	Assessment during intubation		Total	p value
	Easy	Difficult		
Easy	115	1	116	<0.001*
Difficult	2	2	4	
Total	**117**	**3**	**120**	

Note: * significant at 5% level of significance (p<0.05)

When pre operative prediction was compared with assessment during intubation, it was found statistically significant (p value <0.001)

GRAPH 15 : PRE OPERATIVE PREDICTION ACCORDING TO ASSESSMENT DURING INTUBATION

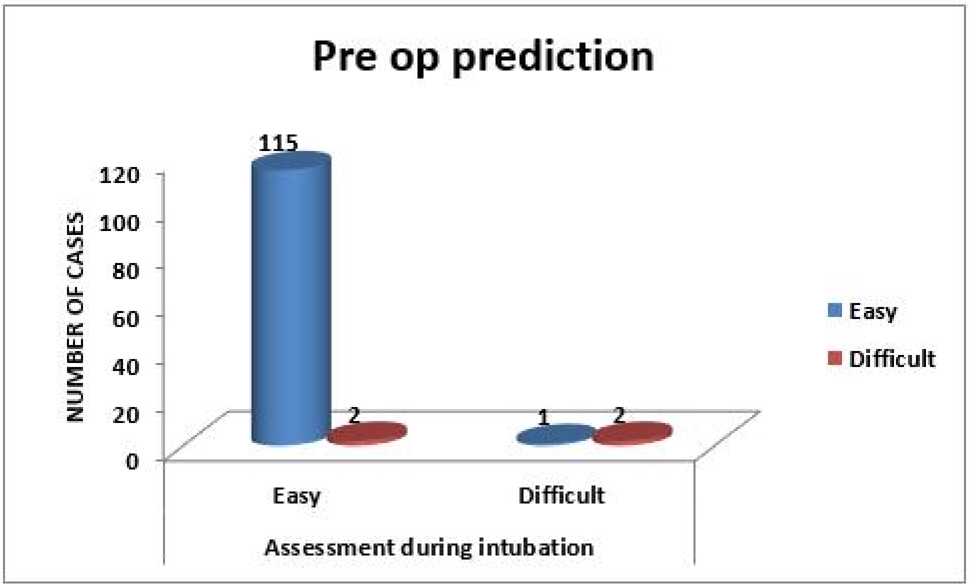

TABLE 20 : SENSTIVITY ANALYSIS OF MULTIPLE PREDICTORS

TP (true positive)	2
FN (false negative)	1
FP (false positive)	2
TN (true negative)	115

	Multiple predictor
Sensitivity	66.67%
Specificity	98.29%
PPV	50.00%
NPV	99.14%
Accuracy	97.50%

Out of 120 cases, according to multiple predictors, 115 cases were true negatives, 2 cases were false positives, 1 was false negatives and only 2 cases were true positives. Multiple predictors had sensitivity of 66.67%, specificity 98.29%, PPV 50%, NPV 99.14%.

TABLE 21 : SUMMARY TABLE

	Modified Mallampatti test	Head & Neck Movement	Inter incisor gap (cm)	Thyromental distance (cm)	Multiple predictor
Sensitivity	100.00%	50.00%	50.00%	50.00%	66.67%
Specificity	97.46%	100.00%	100.00%	98.31%	98.29%
PPV	40.00%	100.00%	100.00%	33.33%	50.00%
NPV	100.00%	99.16%	99.16%	99.15%	99.14%
Accuracy	97.50%	99.17%	99.17%	97.50%	97.50%

TEST	TP (true positive)		FN (false negative)		FP (false positive)		TN (true negative)	
	N	%	N	%	N	%	N	%
Modified Mallampatti test	1	0.83 %	1	0.83%	3	2.50%	115	95.83 %
Head & Neck Movement	1	0.83 %	1	0.83%	0	0.00%	118	98.33 %
Inter incisor gap (cm)	1	0.83 %	1	0.83%	0	0.00%	118	98.33 %
Thyromental distance (cm)	1	0.83 %	1	0.83%	2	1.67%	116	96.67 %
Multiple predictor	2	1.67 %	1	0.83%	2	1.67%	115	95.83 %

- A highly significant association was observed between all the individual tests of difficult intubation and Cormack & Lehane grading with p values <0.001.
- When individual factors were taken into consideration, false negative result was 0.83%.
- When individual factors were taken into consideration, false positive results ranged from 0-2.50%.
- The PPV of Head and Neck movement and IIG is 100% which is higher than other tests.
- When multiple predictors were taken into consideration the false negative result was 0.83%.
- The false positive result was 1.67% and positive predictive value was 50% with multiple predictors.
- There was a considerable reduction in the false positives with improvement in the positive predictive value with the use of multiple predictors

DISCUSSION

DISCUSSION

Successful and safe tracheal intubation with induction of anesthesia should prevent morbidity and avoid serious consequences of failure to establish the airway. Various clinical trials have outlined the preoperative airway assessment plans to aid the anesthesiologist. Several methods using both single and multiple tests have been employed to predict the difficult airway. A screening test employed for prediction of difficult intubation should have high specificity and sensitivity and resulting in minimal false positive and false negative values. The consequences of false negative results are deleterious and life threatening[9].

A test to predict difficult intubation should have high sensitivity so that it will identify most patients in whom intubation will be truly difficult. It should also have high positive predictive value so that only a few patients with airways actually easy to intubate are subjected to the protocol for management of difficult airway[7].

The frequency of difficult intubation varies according to the population studied and the definition of difficult intubation used. There is no universally acceptable definition of difficult intubation. Definitions vary widely and include grades 3 and 4 laryngoscopy, the need to use specialist equipment, more than one, two or three attempts at laryngoscopy, intubation time more than ten minutes and failure to intubate the trachea[24,25,26,32,39]

The incidence of difficult intubation in various studies range from 1-18% and that of failure to intubate is between 0.05%-0.35%[7]. In the present study, the rate of difficult intubation was 2.5%.

A screening test for prediction of difficult intubation should be rapidly performed and provide reliable results. Designing a good predictive test for difficult intubation is problematic because many factors may affect the visualization of larynx at intubation such as maximum mouth opening distance, circumference and length of the neck, compressibility of tongue and soft tissues of the floor of the mouth and the extent of movement of the temporomandibular joint during laryngoscopy. In addition the ability of the person performing the intubation cannot be incorporated into a standardized assessment[7].

These factors were taken into consideration in the present study where in preoperative airway assessment of 120 patients posted for elective surgery under general anesthesia was conducted incorporating multiple screening tests which include patient's weight, modified Mallampatti test, Thyromental distance, inter-incisor gap and maximum range of head and neck movement.

Taking patient's weight into consideration, all patients had weight of <90Kg. Based on our criteria for difficult intubation weight >110kg, none were predicted to have difficult intubation based on weight and hence it did not have any significant association with difficult intubation in present study.

Prediction using modified Mallampatti Test

In 1983, Mallampatti hypothesized that the size of the base of the tongue as assessed by oropharyngeal structures visualized could be used as a clinical test to predict subsequent difficult intubation[23]. A prospective study conducted by him to evaluate the test in a general surgical population showed that the degree of difficulty in visualizing the oropharyngeal structures was an accurate predictor of difficulty with direct laryngoscopy[2]. Samsoon and Young modified this in 1987 and added the fourth class that is an extreme form of class 3 in which only hard palate could be visualized but not the soft palate[3].

In the present study**, modified Mallampatti test of Samsoon and Young** was adapted**.** Out of 120 cases, 29 cases belonged to Grade I (24.2%), 86 cases belonged to Grade II (71.7%), 5 cases belonged to Grade III (4.2%).

Of the 86 cases of MMT Grade II, 1 case had difficult intubation (1.1%). Out of 5 cases of MMT Grade III 2 cases had difficult intubation (40%). The present study clearly shows that difficulty in intubation increases with MMT classification

Out of 120 cases, according to MMT 115 cases were true negatives, 3 were false positives , 1 was false negative and only 1 case was true positive. MMT had sensitivity of 100%, specificity 97.46%, PPV 40%, NPV 100%.

In a similar study conducted by **Frerk in 1991** on 244 patients, 2 of 192 cases with MMT Grade I and II had difficult intubation (0.01%) 9 of 52 cases with MMT Grade III and IV had difficult intubation (17.4%). MMT had a sensitivity of 81.2%, specificity of 81.5% and PPV of 17%[6].

In the study of **Savva in 1994**, MMT had a sensitivity of 64.7%, specificity of 66.1% and PPV of 89%[30].

In the present study, out of 115 cases of MMT Grade I and II predicted to be easy intubation. only 1 case had difficult intubation (0.8%) and 99.1% of cases had easy intubation. This means that MMT grade I and II assessments can reassure the anesthesiologist that serious difficulty in intubation will not be a problem, but cannot be ruled out totally, as the incidence of false negatives is 0.83% in present study.

On the contrary, out of 5 cases of MMT Grade III 2 cases had difficult intubation (40%) and the rest were easy to intubate (60%). This shows that predicting difficult intubation based solely on MMT grade III or IV is likely to be associated with high false positive results. Thus despite widespread general agreement with the usefulness of the original findings, the so called Mallampatti test has significant false positive and false negative rates and cannot be considered to be entirely predictive of severe intubation difficulty[6,25.]

Considering the individual factors, modified Mallampatti Test had greater sensitivity — 100% than other predictors. Its specificity of 99.46% is less than other predictors. Its positive predictive value of 40% lower than other predictors. The results are likely to improve if multiple screening tests like reduced TMD, reduced mouth opening, limitation of head and neck movement are also taken with MMT.

Prediction using head and neck movement

It has long been well appreciated that when the neck is moderately flexed on the chest and the atlanto-occipital joint is well extended, the oral, pharyngeal and laryngeal axes are brought more nearly into a straight line[16]. In this position, which is also known as Magill's position or sniffing position, less of the tongue obscures the view of the larynx and there will be much less need for strenuous effort to displace the tongue anteriorly. X-ray evidence has indicated that limitation of atlanto-occipital joint may be responsible for difficult intubation. Accurate measurement of this head and neck movement is difficult.

In the present study, the maximum range of head and neck movement is measured by a simple chart which has markings of the angles(Fig 11). Limitation of maximum range of head and neck movement $<80^{\circ}$ is taken as predictor of difficult intubation.

In 120 cases, 116 patients had head and neck movement $>100^{\circ}$ (96.7%), 3 patients had head and neck movement $80\text{-}100^{\circ}$ (2.5%) and only 1 patient with head and neck movement $<80^{\circ}$ (0.8%). Out of 116 patients with head and neck movement >100°, 1 case had difficult intubation (0.8%) and 115 cases had easy intubation (99.1%). Of the 3 cases with head and neck movement between $80\text{-}100^{\circ}$, 2 cases had easy intubation (66.6%) and 1 case had difficult intubation (33.3%) and 1 case with head and neck movement $<80^{\circ}$ had difficult intubation (100%).

Even though the percentage of cases with reduced head and neck movement $<80^{\circ}$ is very less (0.8%) in the present study, one can always predict difficult intubation in these cases as difficulty in intubation is 100% and these cases require special techniques like usage of bougie. Its specificity and PPV is 100% but its sensitivity is low.

Head and neck movement in the present study had a poor sensitivity of 50%, but a specificity and PPV of 100%. The results are highly significant when compared with Cormack and Lehane grading (p value <0.001).

The results of present study correlates with the results of **Tse, Rimm** and **Hussain(1995),** where in head and neck movement had a poor sensitivity of 10% and specificity of 93%[7]. The results also correlates with those of **Renju Kuriakose(2003)** and colleagues where in head and neck movement had a poor sensitivity of 2.5% with 100% specificity and positive predictive value as their cases also involved pathological conditions of airway[33].

Comparing the results of head and neck movement with other predictors, it is for behind the other predictors with MMT having sensitivity of 100%, but it has better specificity and PPV than other predictors.

Prediction using inter incisor gap

In 120 cases, 106 cases had IIG of >5 cms (88.3%), 13 cases had IIG of 3.5-5 cms (10.8%) and 1 case had IIG of <3.5 cms (0.8%).

Of 106 cases with IIG of >5cms, 104 cases had easy intubation (98.3%), and 2 cases had difficult intubation (1.8%). 1 case with IIG <3.5cms had difficult intubation (100%).

Of the 1 case with IIG <3.5cms associated with difficult intubation, direct laryngoscopy could be done but intubation was difficult and was done with the help of bougie

The present study clearly shows that decrease in inter-incisor gap is associated with difficult intubation. Inter-incisor gap had a sensitivity of 50%, specificity of 100%, very good positive predictive value of 100% and negative predictive value of 99.16%. The results are highly significant when compared with Cormack and Lehane Grading (p values <0.001).

When compared with other predictors, the sensitivity of IIG is less (50%), sensitivity of MMT is 100%.

Prediction using Thyromental distance

Thyromental distance expressed as the distance between the thyroid notch and symphysis menti when the neck is fully extended is indicative of the space anterior to the larynx. This space determines how easily the laryngeal axis will fall in line with the pharyngeal axis when the atlanto-occipital joint is extended. Furthermore, laryngoscopy pushes the tongue into this space and if reduced or narrowed, the laryngeal axis will make a more acute angle with the pharyngeal axis and it will be difficult for atlanto-occipital extension to bring these two axes into one line[25]. The same has been highlighted by **Patil, Stehling and Zander in 1983** suggesting that if during the initial clinical examination, the existing signs of a potentially difficult intubation supplement a thyromental distance of <6.0cms, then intubation is going to be difficult and alternative methods such as fiberoptic laryngoscopy may be indicated[4].

Benumof in 1991 stressed the importance of TMD and its combination with oropharyngeal examination of modified Mallampatti test in predicting difficult intubation. When there is a large mandibular space, the larynx is relatively posterior and the tongue is easily compressed into this compartment and need not be pulled maximally forward in order to reveal the larynx. However, when there is a small mandibular space, the larynx is relatively anterior and the tongue has to be compressed in a much smaller compartment and pulled forward maximally to reveal the larynx[25]

A Thyromental distance of >6cms correlates well with MMT Grade I and II and strongly suggest that direct laryngoscopy will be relatively easy. TMD of <6cms correlates well with MMT grade III and IV indicating that direct laryngoscopy will be difficult, however, TMD of >6cms may not rule out difficult laryngoscopy in MMT grade III or IV.

In the present study, out of 120 cases, 109 cases had TMD of >6.5cms (90.8%), 8 cases had TMD of 6.0-6.5cms (6.7%), 3 cases had TMD of <6.0cms (2.5%).

Out of 109 cases of TMD >6.5 ems., 107 cases had easy intubation (98.1%) and 2 cases had difficult intubation (1.8%). In 3 cases with TMD <6.0cms 2 cases had easy intubation (66.6%) and 1 case had difficult intubation (33.3%).

When TMD is <6.0cms, there is 33.33% chance of difficult intubation as shown in the present study. Thyromental distance had a sensitivity of 50%, specificity of 98.31%, PPV of 33.33% and NPV of 99.15%. The results are highly significant when compared with Cormack and Lehane grading(p value <0.001).

Considering the individual factors thyromental distance is far behind modified Mallampatti test with a sensitivity of 50% for TMD and 100% for MMT and TMD had less PPV than MMT. 33.33% against 40.00% of MMT. The values of specificity and NPV do not vary much for TMD and MMT.

Tse and Colleagues**(1995**) have reported TMD to have sensitivity of 32%, specificity of 80% and PPV of 20% in a study conducted on 471 patients[7].

Frerk(1991) in his study found TMD to have sensitivity of 90.9%, specificity of 81.5% and a poor PPV of 18.8%. High sensitivity and specificity of TMD in his study might have been due to the criteria for prediction of difficult intubation i.e. TMD of <7cms in contrast to the present study where is TMD of <6cms was predicted as difficult intubation[6].

Savva(1994) has reported sensitivity of 64.7%, specificity of 66.1% and PPV of 15.1% in his study conducted on 350 patients[30]**. Krishna, Agarwal, Rali (2005)***et al* have reported sensitivity of 76.47%, specificity of 56.64%, PPV of 13.54% in their study. They felt that TMD varies with patient size and a single cut of value may not be logical. This is taken care of by ratio of patient height to TMD (RHTMD) which accounts for patient size as well and is a better predictor of difficult laryngoscopy than TMD[37].

In the present study out of 3 cases which had difficult intubation, 2 cases had TMD of >6.5cms. Even though TMD has low sensitivity when compared to MMT, false positive predictions are lesser than MMT but that false positive of IIG is less than that of modified Mallampatti test.

Table 22 : Prediction and outcome of individual tests

	Modified Mallampatti test	**Head & Neck Movement**	**Inter incisor gap (cm)**	**Thyromental distance (cm)**
Sensitivity	100.00%	50.00%	50.00%	50.00%
Specificity	97.46%	100.00%	100.00%	98.31%
PPV	40.00%	100.00%	100.00%	33.33%
NPV	100.00%	99.16%	99.16%	99.15%
Accuracy	97.50%	99.17%	99.17%	97.50%

TEST	**TP (true positive)**		**FN (false negative)**		**FP (false positive)**		**TN (true negative)**	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Modified Mallampatti test	1	0.83%	1	0.83%	3	2.50%	115	95.83%
Head & Neck Movement	1	0.83%	1	0.83%	0	0.00%	118	98.33%
Inter incisor gap (cm)	1	0.83%	1	0.83%	0	0.00%	118	98.33%
Thyromental distance (cm)	1	0.83%	1	0.83%	2	1.67%	116	96.67%

1) A highly significant association was observed between all the individual tests of difficult intubation with Cormack and Lehane Grading.$p<0.001$ (HS)

2) When individual factors were taken into consideration, the false negative result was 0.83%.

3) When individual factors were taken into consideration, the false positive results ranged from 0-2.50%.

4) The PPV of Head and neck movement is and IIG is 100% that is higher than the other tests.

In the study of **Frerk(1991)**, two factors — MMT and TMD were evaluated for their usefulness in predicting difficult intubation separately. He found that both the tests had high false positive results and were not specific for routine use. But if both the tests are combined, the resultant sensitivity was same but there was a considerable improvement in specificity (97.8%) and positive predictive value (64.2%) with less false positive results[6].

In **1994 Rose and Cohen** used four factors — mouth opening, neck movement, TMD and visualization of hypopharynx. They found that mouth opening and TMD were best predictors. If multiple predicting factors are used preoperatively and are abnormal the likelihood of poor visualization of larynx at laryngoscopy increases. But they have not evaluated the sensitivity, specificity, positive and negative predictive values of these tests[32].

R. Kuriakose(2003) and colleagues have evaluated four factors — MMT, TMD, IG, AOJE for their ability to predict difficult intubation and found MMT to be more sensitive than other predictors. They also suggested that the combination of these 4 tests had better specificity (82.6%) and PPV (71.92%) than individual tests[33].

In the present study same method was adopted and all the four factors — MMT, TMD, Head and neck movement and IIG were evaluated individually and in combination for their ability to predict difficult intubation and their sensitivity, specificity, positive and negative predictive values were calculated.

Prediction using multiple predicting factors

Considering multiple predicting factors, out of 120 cases 3 cases had multiple predictors of difficult intubation. These 3 cases, required special techniques like usage of bougie

Of the remaining 117 cases, 115 cases had easy intubation (97.9%)- True negative and 1 case had unanticipated difficulty in intubation (0.83%)- False negative. This 1 case had normal preoperative airway assessment with no abnormality. This case did not have any predictor of difficult intubation and had normal preoperative airway assessment. In this case direct laryngoscopy revealed a view of grade III and intubation was difficult requiring three attempts and the use of bougie (115:TN + 1:FN + 2:TP + 2:FP = 120cases).

Multiple predicting factors had a sensitivity of 66.67%, specificity of 98.29%, PPV Of 50% and NPV of 99.14%.

Table 23 : Results of Multiple predictors of difficult intubation

TP (true positive)	2(1.67%)
FN (false negative)	1(0.83%)
FP (false positive)	2(1.67%)
TN (true negative)	115(95.83%)

	Multiple predictor
Sensitivity	66.67%
Specificity	98.29%
PPV	50.00%
NPV	99.14%
Accuracy	97.50%

1) When multiple predictors were taken into consideration the false negative result was 0.83%.
2) The false positive result was 1.67% and positive predictive value was 50% with multiple predictors.
3) There was a considerable reduction in the false positives with improvement in the positive predictive value with the use of multiple predictors.

When individual factors were considered, the incidence of false negatives (unanticipated difficult intubation) was 0.83%. When considering multiple predicting factors, the incidence of false negatives was also 0.83%. There is no significant decrease in the number of false negatives and the unanticipated difficult intubation. Moreover most of the cases predicted easy using multiple predicting factors result in easy intubation (True negatives).

Similarly when individual factors were considered, the incidence of false positives ranged from 0-2.50% . But when multiple predicting factors were considered, the incidence false positive was 1.67% There is significant decrease in the number of false positives with multiple predicting factors, thereby decrease in unnecessary interventions due to over prediction of difficult airway.

Application of multiple predictors of difficult intubation can reduce unnecessary interventions related to overprediction of airway difficulty (false positives). Assessment of the patient should be done in the preoperative evaluation of the patient either using the individual tests or multiple tests and should be graded for the ease or difficulty of intubation knowing the pitfalls of these tests. One should keep the difficult airway cart with necessary equipment ready and be prepared to follow one's own protocol to avoid serious complications.

Table 24 : False negative case.

Sno.	**Case No.**	**Airway Pathology**	**Modified Mallampatti test**	**Head & Neck Movement**	**Inter incisor gap (cm)**	**Thyromental distance (cm)**
1	44	Nil	II	80˚-100˚	>5	>6.5

CONCLUSION

CONCLUSION

In the present study, attempting to predict difficult intubation using individual factors resulted in large percentage of false negatives (0.83%) i.e., unanticipated difficul intubation and false positives (0-2.50%) i.e., over prediction of difficult intubation.

When multiple predictors were taken into consideration, there was considerable reduction in the false positives (1.67%) but no change in false negatives (0.83%). The sensitivity, specificity and positive predictive value were greater than the individual factors. Application of multiple predictors for prediction of difficult intubation can reduce the frequency of both unanticipated failures and unnecessary interventions related to over prediction of airway difficulty.

Even the multiple predictors had 0.83% false negatives and 1.67% false positives. These 0.83% cases had no predictors of difficult intubation and had normal preoperative airway assessment but had unanticipated difficulty in intubation. No screening test can be both 100% specific and 100% sensitive. Inevitably some difficult intubations are missed and some false positives do occur. Using either single or multiple predictors, the anesthesiologist should be aware of the inadequacy of the attempts to predict difficult intubation. Assessment of the airway should be done in the preoperative evaluation of the patient either using the individual tests or multiple tests and should be graded for the ease or difficulty of intubation knowing the pitfall's.

SUMMARY

SUMMARY

In the present study one twenty patients posted for elective surgery under general anesthesia in the age group of 18-50 years were preoperatively assessed for prediction of the ease or difficulty of tracheal intubation incorporating multiple screening tests which include patient's weight, height, modified Mallampatti test, thyromental distance, inter incisor gap, head and neck movement. These were evaluated for their usefulness when present alone (single factor) or in combination (multiple predicting factors).

SUMMARY TABLE

	Modified Mallampatti test	**Head & Neck Movement**	**Inter incisor gap (cm)**	**Thyromental distance (cm)**	**Multiple predictor**
Sensitivity	100.00%	50.00%	50.00%	50.00%	66.67%
Specificity	97.46%	100.00%	100.00%	98.31%	98.29%
PPV	40.00%	100.00%	100.00%	33.33%	50.00%
NPV	100.00%	99.16%	99.16%	99.15%	99.14%
Accuracy	97.50%	99.17%	99.17%	97.50%	97.50%

TEST	TP (true positive)		FN (false negative)		FP (false positive)		TN (true negative)	
	N	%	N	%	N	%	N	%
Modified Mallampatti test	1	0.83%	1	0.83%	3	2.50%	115	95.83%
Head & Neck Movement	1	0.83%	1	0.83%	0	0.00%	118	98.33%
Inter incisor gap (cm)	1	0.83%	1	0.83%	0	0.00%	118	98.33%
Thyromental distance (cm)	1	0.83%	1	0.83%	2	1.67%	116	96.67%
Multiple predictor	2	1.67%	1	0.83%	2	1.67%	115	95.83%

1)When individual factors were taken into consideration, the false negative result was 0.83%.

2)When individual factors were taken into consideration, the false positive results ranged from 0-2.50%.

3)The PPV of Head and neck movement and IIG is 100% that is higher than the other tests.

4) When multiple predictors were taken into consideration the false negative result was 0.83%.

5) The false positive result was 1.67% and positive predictive value was 50% with multiple predictors.

6) There was a considerable reduction in the false positives with improvement in the positive predictive value with the use of multiple predictors.

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ANNEXURES

ANNEXURES

INVESTIGATIONS / INTERVENTIONS:

Investigations or interventions required in this study were routine standardized procedures. There were no animal experiments involved in this study.

SAMPLE INFORMED CONSENT FORM:

B.L.D.E.(DEEMED TO BE UNIVERSITY) SHRI B.M. PATIL MEDICAL COLLEGE HOSPITAL AND RESEARCH CENTRE, VIJAYAPUR – 586103, KARNATAKA

TITLE OF THE PROJECT: "PREOPERATIVE ASSESSMENT TO PREDICT DIFFICULT AIRWAY USING MULTIPLE SCREENING TESTS**"**

PRINCIPAL INVESTIGATOR	**:**	Dr. RASHMI B PATIL Department of Anaesthesiology Email: b.rashmi26@gmail.com
PG GUIDE	**:**	Dr.R.R.KUSUGAL Associate Professor, Dept. of Anaesthesiology B.L.D.E.(DEEMED TO BE University)'s Shri B.M. Patil, Medical College Hospital & Research Centre, Vijayapur-586103

PURPOSE OF RESEARCH:

I have been informed that this study is: " A PREOPERATIVE ASSESSMENT TO PREDICT DIFFICULT AIRWAY USING MULTIPLE SCREENING TESTS"

.I have been explained about the reason for doing this study and selecting me/my ward as a subject for this study. I have also been given free choice for either being included or not in the study.

PROCEDURE:

I understand that I will be participating in the study**: "**A PREOPERATIVE ASSESSMENT TO PREDICT DIFFICULT AIRWAY USING MULTIPLE SCREENING TESTS**"**

RISKS AND DISCOMFORTS:

I understand that I/my ward may experience some pain while intubating and I understand that necessary measures will be taken to reduce these complications as and when they arise.

BENEFITS:

I understand that me/my wards participation in this study will help in: ""PREDICTING DIFFICULT AIRWAY USING MULTIPLE SCREENING TESTS"

CONFIDENTIALITY:

I understand that medical information produced by this study will become a part of this Hospital records and will be subjected to the confidentiality and privacy regulation of this hospital. If the data are used for publication in the medical literature or for teaching purpose, no names will be used and other identifiers such as photographs and audio or video tapes will be used only with my special written permission. I understand that I may see the photograph and videotapes and hear audiotapes before giving this permission.

REQUEST FOR MORE INFORMATION:

I understand that I may ask more questions about the study at any time. Dr. Rashmi B Patil is available to answer my questions or concerns. I understand that I will be informed of any significant new findings discovered during the course of this study, which might influence my continued participation.

If during this study, or later, I wish to discuss my participation in or concerns regarding this study with a person not directly involved, I am aware that the social worker of the hospital is available to talk with me.

And that a copy of this consent form will be given to me for keep for careful reading.

REFUSAL OR WITHDRAWL OF PARTICIPATION:

I understand that my participation is voluntary and I may refuse to participate or may withdraw consent and discontinue participation in the study at any time without prejudice to my present or future care at this hospital.

I also understand that Dr. Rashmi B Patil will terminate my participation in this study at any time after he has explained the reasons for doing so and has helped arrange for my continued care by my own physician or therapist, if this is appropriate

INJURY STATEMENT:

I understand that in the unlikely event of injury to me/my ward, resulting directly due to my participation in this study, such injury will be reported promptly, then medical treatment would be available to me, but no further compensation will be provided.

I understand that by my agreement to participate in this study, I am not waiving any of my legal rights.

I have explained to ____ the purpose of this research, the procedures required and the possible risks and benefits, to the best of my ability in patient's own language.

Date: Dr. Rashmi B Patil

(Investigator)

Patient's signature Witness signature

STUDY SUBJECT CONSENT STATEMENT:

I confirm that **Dr.Rashmi B Patil** has explained to me the purpose of this research, the study procedure that I will undergo and the possible discomforts and benefits that I may experience, in my own language.

I have been explained all the above in detail in my own language and I understand the same. Therefore I agree to give my consent to participate as a subject in this research project.

________________________________ __________________

(Participant) Date

________________________________ __________________

(Witness to above signature) Date

PROFORMA

PREOPEREATIVE ASSESSMENT TO PREDICT DIFFICULT AIRWAY USING MULTIPLE SCREENING TESTS

Date: Case no : IP .No.

1.Name of the patient-Mr/Mrs.

2.Age in Yrs

3.Sex-Male/Female

4.Height (cms)

5.Wt (kgs)

6.Preoperatve diagnosis

7.Proposed surgery

8.Airway assessement (tick which ever applicable)

BEFORE INDUCTION:

I. Modified Mallampatti's Test

Class I -Soft palate, fauces, uvula, pillars visible

Class II -Soft palate, fauces, uvula visible

Class III -Soft palate, base of uvula visible

Class IV -Soft palate not visible

II. Maximum range of Head and Neck movement

$>100^{0}$

$90+/-10^{0}$

$<80^{0}$

III. Inter-incisor gap

>5cms

3.5-5cms

<3.5cms

IV. Thyromental distance

>6.5cms

6-6.5cms

<6cms

9. Preoperative assessement of Intubation- Easy intubation

Difficult intubation

AFTER INDUCTION:

10. Cormack and Lehane's grading of laryngoscopic view

Grade I: Whole of vocal cords visible

Grade II: Only posterior commissure visible

Grade III: Only epiglottis visible

Grade IV: None of the visible

11. Assessement during intubation-

Easy intubation

Difficult intubation [three attempts / more than one intubator / usage of bougie or stylet/special techniques employed -specify

12. Outcome

I. Predicted difficult, turned out difficult intubation (True positive)
II. Predicted difficult, turned out easy intubation(False positive)
III. Predicted easy, turned out easy intubation (True negatives)
IV. Predicted easy, turned out difficult intubation (False negatives)

BIO-DATA

GUIDE NAME	:	DR. R.R.KUSUGAL
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EDUCATION	:	M.B.B.S. – 1977 GOVT. MEDICAL COLLEGE, BELLARY, KARNATAKA. M.D ANAESTHESIOLOGY-1985 AFMC PUNE MAHARASHTRA
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INVESTIGATOR

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MASTER CHART

MASTER CHART

Case No.	I.P. No.	Age	Sex	Height(cm)	Weight (Kg)			Airway Pathology	Modified Mallampatti test				Head & Neck Movement			Inter incisor gap (cm)			Thyromental distance (cm)			Pre op prediction		Cormack & Lahane grading				Assessment during intubation		Outcome			
					<90	90-110	>110		I	II	III	IV	>100°	80°-100°	<80°	>5	3.5-5	<3.5	>6.5	6.0-6.6	<6.0	Easy	Diff.	I	II	III	IV	Easy	Diff.	I	II	III	IV
1	3533	32	M	162	*			Nil		*			*				*		*			*		*				*				*	
2	3536	45	M	168	*			Nil		*			*			*			*			*		*				*				*	
3	3582	32	F	158	*			Nil		*				*			*		*			*		*				*				*	
4	4152	25	F	152	*			Nil		*			*				*		*			*		*				*				*	
5	4219	42	F	158	*			Nil		*			*			*			*			*		*				*				*	
6	4226	23	M	174	*			Nil		*			*			*			*			*		*				*				*	
7	4425	41	M	172	*			Nil			*				*			*			*		*			*			*				
8	4089	38	F	160	*			Nil		*			*			*			*			*		*				*				*	
9	5239	22	M	172	*			Nil		*			*			*			*			*		*				*				*	
10	4990	35	M	168	*			Nil		*			*			*			*			*		*				*				*	
11	5439	30	M	168	*			Nil	*				*			*			*			*		*				*				*	
12	6065	25	F	152	*			Nil		*			*			*			*			*		*				*				*	
13	6568	36	M	164	*			Nil		*			*			*			*			*		*				*				*	
14	6741	24	M	176	*			Nil	*				*			*			*			*		*				*				*	
15	4985	28	M	166	*			Nil		*			*			*			*			*		*				*				*	
16	7070	22	M	160	*			Nil		*			*			*			*			*		*				*				*	
17	7066	36	M	162	*			Nil		*			*			*			*			*		*				*				*	
18	7435	29	M	164	*			Nil		*			*			*			*			*		*				*				*	
19	7813	36	M	166	*			Nil			*		*			*			*			*				*			*				*
20	7793	36	F	156	*			Nil	*				*			*			*			*		*				*				*	
21	9083	42	M	170	*			Nil		*			*			*			*			*		*				*				*	
22	9088	27	F	154	*			Nil	*				*			*			*			*		*				*				*	
23	8972	22	M	148	*			Nil		*			*				*				*		*		*			*			*		
24	9442	41	M	174	*			Nil		*			*			*			*			*		*				*				*	
25	9453	36	F	160	*			Nil		*			*				*		*			*			*			*				*	
26	9424	33	M	168	*			Nil	*				*			*			*			*		*				*				*	
27	9554	41	F	154	*			Nil		*			*				*		*			*		*				*				*	
28	9441	31	M	168	*			Nil		*			*			*			*			*		*				*				*	
29	10159	22	F	162	*			Nil		*			*			*			*			*		*				*				*	
30	21650	41	M	174	*			Nil		*			*			*			*			*		*				*				*	
31	21678	21	F	154	*			Nil		*			*			*			*			*		*				*				*	
32	21780	30	F	160	*			Nil		*			*			*				*		*		*				*				*	
33	22182	42	M	158	*			Nil		*			*			*			*			*			*			*				*	
34	22178	36	M	170	*			Nil		*			*			*			*			*		*				*				*	
35	22682	19	M	168	*			Nil		*			*			*			*			*		*				*				*	
36	22640	27	F	158	*			Nil		*			*			*			*			*		*				*				*	
37	23208	35	M	174	*			Nil		*			*			*			*			*		*				*				*	
38	23511	21	F	160	*			Nil		*			*			*			*			*		*				*				*	
39	23510	45	F	154	*			Nil		*				*			*			*		*		*				*				*	
40	23187	26	F	160	*			Nil	*				*			*			*			*		*				*				*	
41	23441	30	F	162	*			Nil		*			*			*			*			*		*				*				*	
42	23541	19	M	160	*			Nil	*				*			*			*			*		*				*				*	
43	23770	18	F	154	*			Nil	*				*			*			*			*		*				*				*	
44	23185	28	M	164	*			Nil		*				*		*			*			*			*				*				*
45	23301	35	M	158	*			Nil	*				*			*			*			*		*				*				*	
46	24429	30	M	162		*		Nil	*				*			*			*			*		*				*				*	
47	24944	45	F	156	*			Nil	*				*			*			*			*			*			*				*	
48	26918	27	F	152	*			Nil	*				*			*			*			*		*				*				*	
49	28960	23	F	152	*			Nil		*			*			*			*			*		*				*				*	
50	28686	25	M	158	*			Nil	*				*			*			*			*			*			*				*	
51	28996	20	F	150	*			Nil	*				*			*			*			*		*				*				*	
52	29229	35	M	158		*		Nil	*				*			*				*		*		*				*				*	

53	29266	20	F	150	*			Nil	*				*			*			*			*		*				*				*	
54	468	25	M	156	*			Nil	*				*			*			*			*		*				*				*	
55	7049	21	F	152	*			Nil	*				*			*			*			*		*				*				*	
56	7455	20	F	158	*			Nil	*				*			*			*			*		*				*				*	
57	6863	20	F	158	*			Nil		*			*				*			*		*			*			*				*	
58	7262	28	F	154	*			Nil		*			*			*			*			*		*				*				*	
59	8180	33	F	160	*			Nil		*			*			*			*			*		*				*				*	
60	8528	30	F	162	*			Nil		*			*			*			*			*		*				*				*	
61	8780	33	F	158	*			Nil	*				*			*			*			*		*				*				*	
62	9057	22	F	158	*			Nil			*		*			*			*				*		*			*			*		
63	10754	47	F	160	*			Nil		*			*			*			*			*		*				*				*	
64	11071	28	F	162	*			Nil		*			*			*			*			*		*				*				*	
65	11076	25	M	170	*			Nil		*			*			*			*			*		*				*				*	
66	11415	25	F	160	*			Nil	*				*			*			*			*		*				*				*	
67	11411	35	F	152	*			Nil		*			*			*			*			*		*				*				*	
68	11817	44	F	162	*			Nil		*			*			*			*			*		*				*				*	
69	71821	19	M	160	*			Nil		*			*			*			*			*		*				*				*	
70	11846	37	M	172	*			Nil		*			*			*			*			*		*				*				*	
71	11750	20	M	166	*			Nil		*			*			*			*			*		*				*				*	
72	11948	36	F	164	*			Nil		*			*				*				*		*	*				*			*		
73	11949	35	M	170	*			Nil	*				*			*			*			*		*				*				*	
74	11955	44	M	168	*			Nil		*			*			*			*			*		*				*				*	
75	12185	27	F	158	*			Nil		*			*			*			*			*		*				*				*	
76	12272	40	F	162	*			Nil		*			*			*			*			*		*				*				*	
77	17261	32	F	158	*			Nil		*			*			*			*			*		*				*				*	
78	12252	30	M	166	*			Nil		*			*			*			*			*		*				*				*	
79	12243	45	F	160	*			Nil		*			*			*			*			*		*				*				*	
80	12638	42	F	158	*			Nil		*			*			*			*			*		*				*				*	
81	12778	48	F	162	*			Nil	*				*			*			*			*		*				*				*	
82	10094	27	M	174	*			Nil		*			*			*			*			*		*				*				*	
83	13469	50	M	170	*			Nil		*			*			*			*			*		*				*				*	
84	13550	22	M	168	*			Nil		*			*			*			*			*			*			*				*	
85	13871	29	F	160	*			Nil			*		*				*		*				*	*				*			*		
86	14120	23	F	154	*			Nil		*			*			*			*			*		*				*				*	
87	13854	25	F	166	*			Nil		*			*			*			*			*		*				*				*	
88	14233	38	F	156	*			Nil		*			*			*			*			*		*				*				*	
89	14231	48	M	168	*			Nil		*			*			*			*			*		*				*				*	
90	14005	25	M	172	*			Nil		*			*			*			*			*		*				*				*	
91	14782	23	M	168	*			Nil		*			*			*			*			*		*				*				*	
92	14830	27	M	170	*			Nil		*			*			*			*			*		*				*				*	
93	16308	48	F	158	*			Nil			*		*			*			*				*		*				*	*			
94	16307	19	M	168	*			Nil		*			*			*			*			*		*				*				*	
95	16406	32	F	160	*			Nil	*				*			*			*			*		*				*				*	
96	19033	33	M	170	*			Nil		*			*			*			*			*		*				*				*	
97	19485	28	F	164	*			Nil		*			*			*			*			*		*				*				*	
98	19602	34	M	168	*			Nil	*				*			*			*			*		*				*				*	
99	19520	40	F	154	*			Nil		*			*				*			*		*		*				*				*	
100	19888	21	F	156	*			Nil	*				*			*			*			*		*				*				*	
101	19911	42	F	158	*			Nil		*			*				*			*		*		*				*				*	
102	20471	38	M	170	*			Nil		*			*			*			*			*		*				*				*	
103	21068	50	M	162	*			Nil		*			*			*			*			*		*				*				*	
104	21692	25	F	158	*			Nil		*			*			*			*			*		*				*				*	
105	17428	22	F	158	*			Nil	*				*			*			*			*		*				*				*	
106	21897	25	F	160	*			Nil	*				*			*			*			*		*				*				*	
107	22238	22	F	160	*			Nil		*			*			*			*			*		*				*				*	
108	22323	40	F	158	*			Nil		*			*			*			*			*		*				*				*	
109	22457	44	F	156	*			Nil		*			*			*			*			*		*				*				*	
110	22757	22	F	162	*			Nil		*			*			*			*			*		*				*				*	
111	23210	19	M	172	*			Nil		*			*			*			*			*		*				*				*	

112	23511	30	F	158	*			Nil		*			*			*			*			*		*				*				*	
113	23577	19	M	160	*			Nil		*			*			*			*			*		*				*				*	
114	23631	37	M	168	*			Nil		*			*			*			*			*		*				*				*	
115	23799	27	M	170	*			Nil		*			*			*			*			*		*				*				*	
116	23794	19	M	164	*			Nil		*			*			*			*			*		*				*				*	
117	29092	42	F	156	*			Nil		*			*			*			*			*		*				*				*	
118	24080	19	M	164	*			Nil		*			*			*				*		*		*				*				*	
119	23874	48	F	154	*			Nil	*				*				*			*		*		*				*				*	
120	24352	26	F	158	*			Nil		*			*			*			*			*		*				*				*	