A STUDY OF CORRELATION OF PREOPERATIVE ULTRASONOGRAPHIC AIRWAY ASSESSMENT AND CLINICAL ASSESSMENT IN PREDICTION OF THE DIFFICULT AIRWAY

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TAMIL NADU

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DECLARATION

I, **Dr.V.NISHA** solemnly declare that, this dissertation titled "**A STUDY OF CORRELATION OF PREOPERATIVE ULTRASONOGRAPHIC AIRWAY ASSESSMENT AND CLINICAL ASSESSMENT IN PREDICTION OF THE DIFFICULT AIRWAY"** has been done by me. I also declare that this bonafide work or a part of this work was not submitted by me or any other for any award, degree or diploma to any other University or board either in India or abroad.

This is submitted to The Tamilnadu DR.M.G.R Medical University, Chennai in partial fulfillment of the rules and regulations for the award of Doctor of Medicine degree branch X (Anaesthesiology) to be held in APRIL 2019.

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ASSESSMENT OF AIRWAY

INTRODUCTION

The term “airway “refers to the upper airway that is defined as the extrapulmonary air passage consisting of nasal and oral cavities, the pharynx including nasopharynx, oropharynx and hypopharynx and the larynx, trachea and the large bronchi.

A “difficult airway” is a problem in establishing or maintaining gas exchange through a mask or through any artificial airway or can be both.

Routine preoperative airway examination usually includes an assessment of mouth opening and dentition, Mallampati classification, thyromental distance measurement, and evaluation of neck mobility.

These methods are quickly and easily performed at the bedside, but, unfortunately, their sensitivity and specificity for accurate prediction of difficulty with airway management is not the best. These bedside physical airway assessment tests have high inter-observer variability.

They may also be difficult to apply in emergency and critical care settings, where patients are frequently confused, uncooperative and unable to follow directions.

After direct laryngoscopic visualization by placing the intubating blade in the patient's airway, we can tell the Cormack-Lehane grading. If it becomes 3/4, this is a dreaded feature unless we are prepared for the difficult airway. Hence pre-operative prediction of these is a very useful tool for difficult airway assessment.

AIM OF THE STUDY

BACKGROUND

Difficult intubation is associated with serious morbidity and mortality and cannot be always predicted by conventional clinical predictors. Ultrasonographic airway assessment could be a useful predictor of difficult airway and thus correlating with various clinical and laryngoscopic view of the airway.

AIMS & OBJECTIVES

To find out the correlation between Ultrasonographic airway assessment and clinical and laryngoscopic airway assessment for difficult airway. Also, to find out the size of the appropriate endotracheal tube size and the post extubation complications. The aim of this study is to evaluate the sensitivity of individual parameters in predicting the difficult airway.

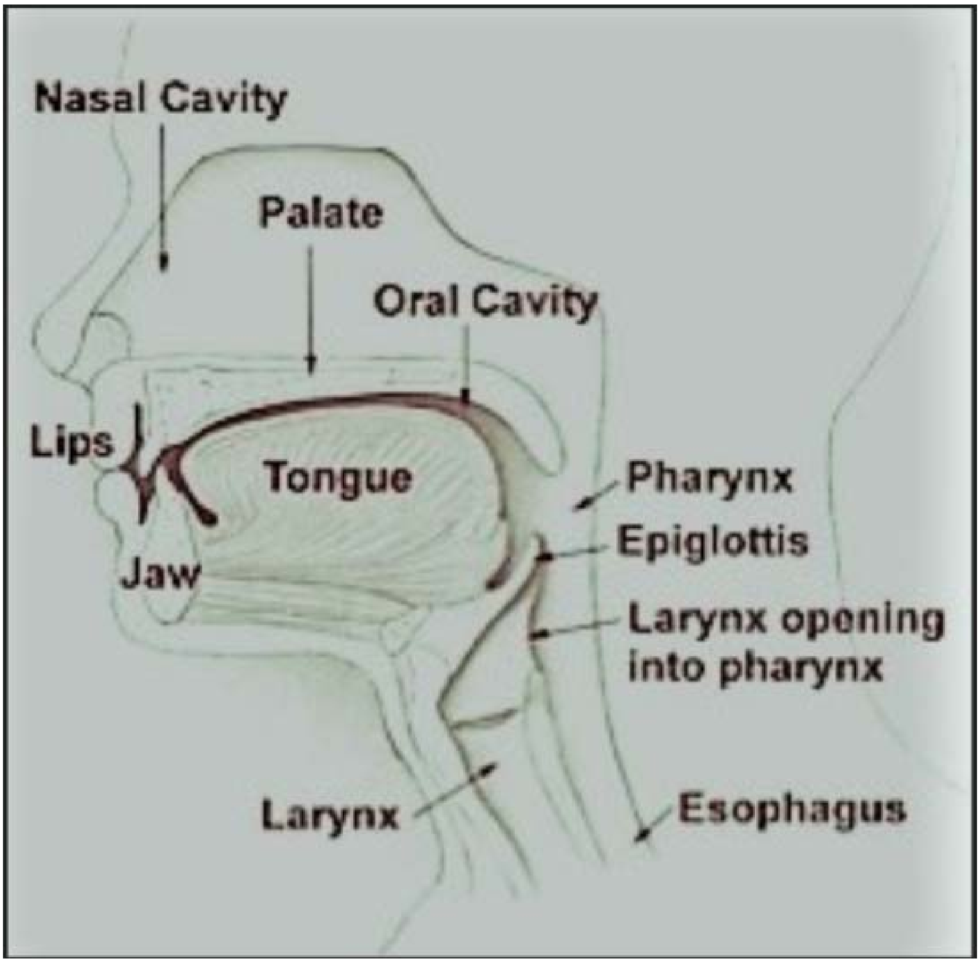
AIRWAY EXAMINATION

WHAT IS AN AIRWAY?

Anatomically, airway is a passage where air, gas passes during respiration. It is divided into an upper and a lower airway.

UPPER AIRWAY: Consists of mouth, nasopharynx, oropharynx, hypopharynx, and larynx. This is the most vulnerable area for obstruction.

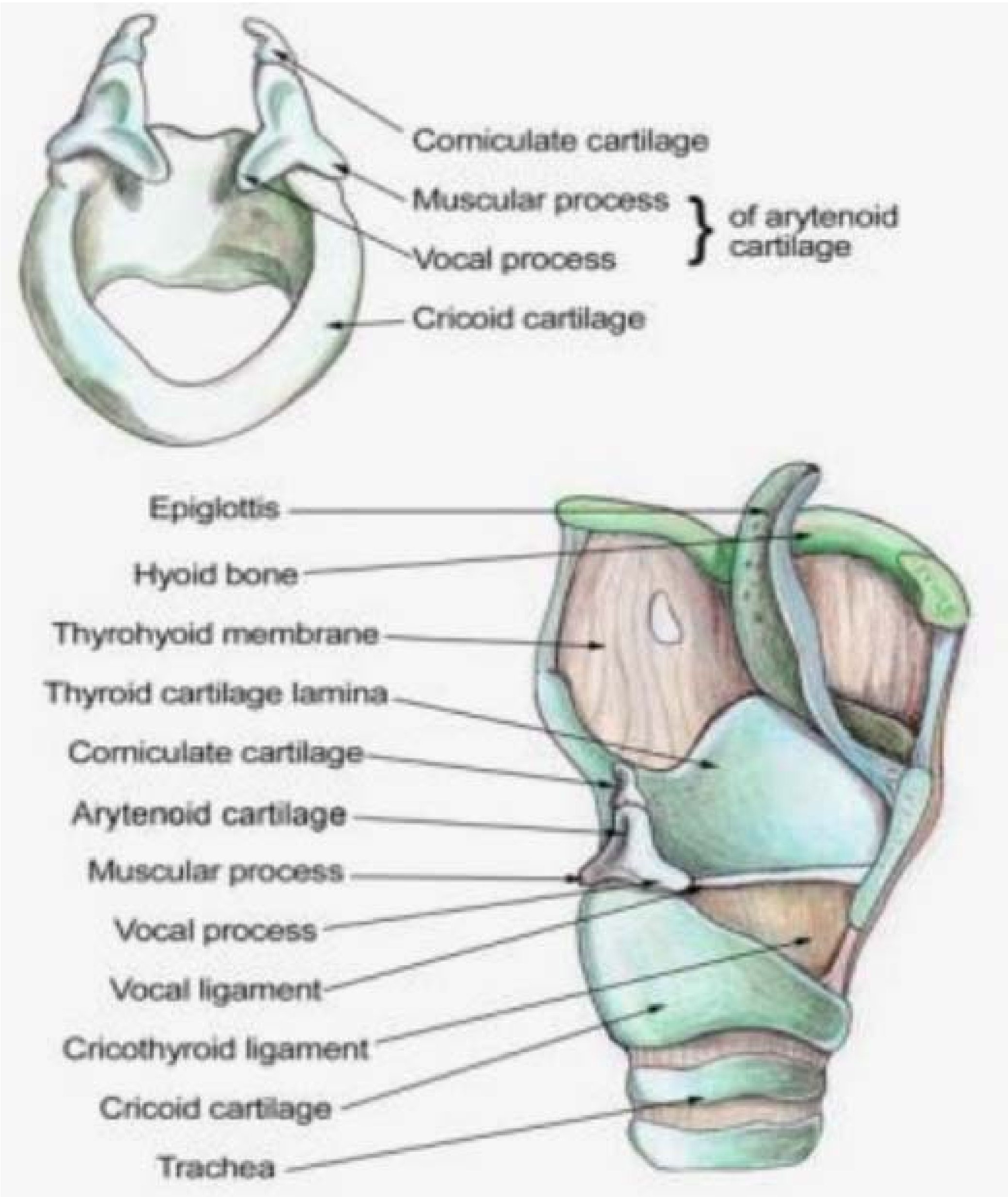
UPPER AIRWAY



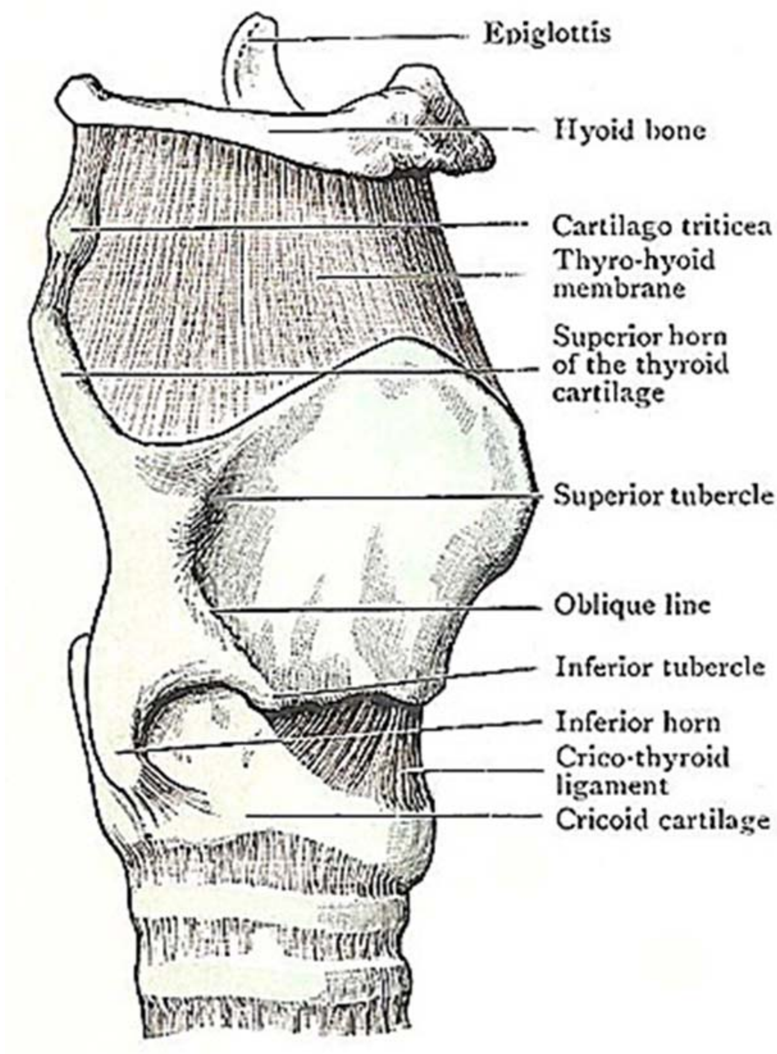
LARYNX: larynx has three paired and three unpaired cartilages.

Unpaired cartilages include the thyroid, cricoid and epiglottis.

Paired cartilages include the arytenoids, corniculates and the cuneiforms.

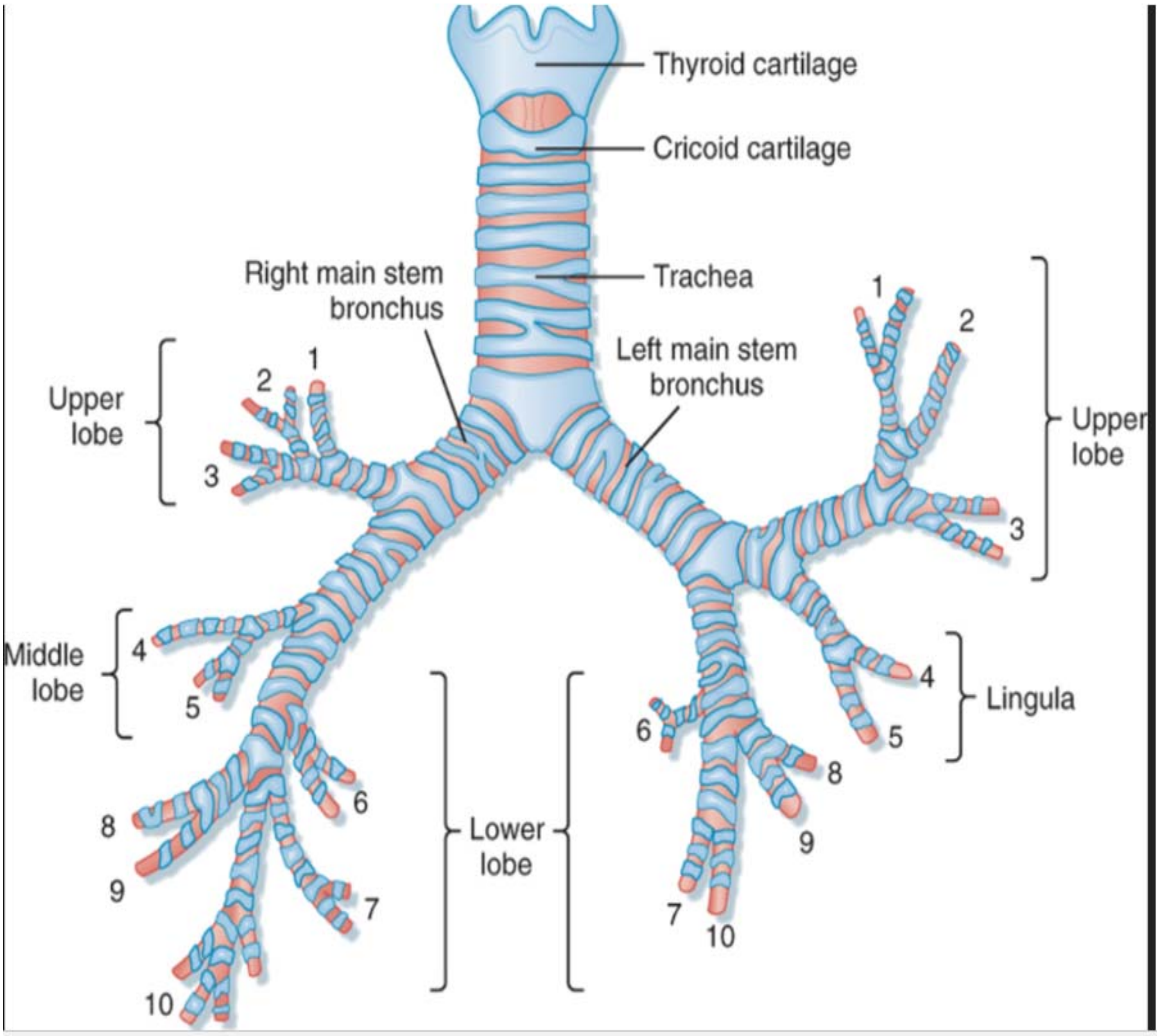


LARYNGEAL CARTILAGES



LOWER AIRWAY: It includes the trachea, bronchi and the bronchioles, which end in the alveoli. It is the epiglottis, which separates the larynx and the hypopharynx.

TRACHEO-BRONCHIAL TREE



DIFFICULT AIRWAY

The American Society of Anaesthesiologists (ASA) defines a difficult airway which is "The clinical situation where a conventionally trained anaesthesiologist has trouble in mask ventilation, difficulty in tracheal intubation or one of the above." This difficulty is due to complex interaction between patients, the clinical scenario and the skills and the preference of the practitioner.

DIFFICULT MASK VENTILATION

The ASA task force has defined difficult mask ventilation as occurring when "It is not possible for the unassisted anaesthesiologist to maintain oxygen saturation more than 90% using 100% oxygen and positive pressure mask ventilation in a patient whose oxygen saturation was more than 90% before anaesthetic intervention; and/or, it is not possible for the unassisted anaesthesiologist to prevent or reverse signs of inadequate ventilation during positive pressure mask ventilation."

DIFFICULT LARYNGOSCOPY

The ASA task force has defined difficult laryngoscopy as occurring when "it is not possible to visualize any portion of the vocal cords with conventional laryngoscope".

DIFFICULT ENDOTRACHEAL INTUBATION

The ASA task force defined difficult endotracheal intubation as occurring when "proper insertion of the tracheal tube with conventional laryngoscopy requires more than three attempts or more than ten minutes". An optimal or best attempt at laryngoscopy is 30 seconds.

ANOMALIES OF UPPER AIRWAY

1) FACIAL ANOMALIES

- Maxillary hypoplasia- Apert syndrome, Crouzon disease.
- Mandibular hypoplasia-Gierre Robin syndrome, Treacher Collins syndrome, Goldenhar syndrome.
- Mandibular hyperplasia (acromegaly, cherubism).

2) TEMPOROMANDIBULAR JOINT PATHOLOGY

Ankylosis or reduced movement (congenital, traumatic, infective).

3) ANOMALIES OF THE MOUTH AND TONGUE

- Microstomia (burns, trauma scarring).
- Diseases of the tongue (burns, trauma, Ludwig's angina-all lead to tongue swelling).
- Tumours of the mouth and tongue (hemangioma , lymphangioma).
- Macroglossia (Down's syndrome, hypothyroidism).

3) PROBLEM WITH TEETH: Missing left upper incisors, protruding upper incisors.

4) ANAMOLY OF THE NOSE

- Choanal atresia
- Hypertrophic PHIC turbinate and deviated nasal septum
- Tumours (Polyps, Gliomas)
- Foreign body

5) PATHOLOGY OF THE PALATE:

- Narrow arched palate.
- Large cleft defect
- Soft palatal swelling and haematomas

6) PATHOLOGY OF PHARYNX:

- Hypertrophic tonsils and adenoids
- Tumours and abscesses
- Retropharyngeal and/or Para pharyngeal abscess.

7) PATHOLOGY OF THE LARYNX:

- Supraglottic Epiglottitis
- Glottic: Laryngomalacia, granuloma, foreign body, papilloma

- Infraglottic: Congenital stenosis, traumatic stenosis, inflammatory oedema.

PATHOLOGY OF LOWER AIRWAY

1) Tracheal Pathology
    - Tracheitis
    - Tracheo-oesophageal fistula
    - Tracheal stenosis
    - Tracheal webbing
    - Foreign bodies
    - Tracheomalacia
    - Mass lesion of the neck or mediastinal mass deviating trachea.

2) **BRONCHIAL TREE PATHOLOGY**
    - Mediastinal masses distorting bronchi
    - Foreign body aspiration
    - Bronchial tumours

HEAD AND NECK MOVEMENTS DURING LARYNSGOSCOPY

Head extension, neck flexion and/or head and neck rotation are needed to successfully carry out endotracheal intubation with or without laryngoscope. The degree of head and neck movements, which are associated with easy intubation includes:

- Head extension:>80-85º
- Neck flexion:>25-30º
- Head/neck rotation:>70-75º

Normal lateral bending movements at cervical spines include 5-10º at each cervical spine below C2.

DISEASE STATES OF THE NECK AND CERVICAL SPINE

Disease states of the neck and cervical spine often constitute easily identifiable factors responsible for difficult airway.

1)Neck: Large goitres, abscesses, skin contractures

2)Spine: a) Limitation of movement (congenital-Klippel-Feil syndrome: acquired-surgical fusion, fracture of cervical vertebrae).

b) Cervical spine instability: Down syndrome, traumatic subluxation.

PATHOLOGIC STATES AFFECTING HEAD EXTENSION

- Ankylosing spondylitis
- Rheumatoid arthritis
- Cervical spondylitis
- Cervical fusion
- Fibrosis secondary to burns and irradiation
- Scleroderma
- Tube pedicle grafts
- Cystic hygroma
- Difficulty may be encountered in patients with large hydrocephalus and encephalocele

PATHOLOGIC STATES RESPONSIBLE FOR MOUTH OPENING

- Ankylosing spondylitis
- Rheumatoid arthritis
- Temporo-mandibular joint fixity (e.g. Post trauma)
- Scleroderma
- Local acute infection
- Localized tumours
- Tongue flaps
- Circumoral burns with scarring

AIRWAY ASSESSMENT

The purpose of undertaking airway assessment is to diagnose the potential for difficult airway for:

- Optimal patient preparation
- Proper selection of equipment and technique
- Participation of personnel experienced in the difficult airway management.

A multitude of indices have been used to predict a difficult airway. However, it should be noted that although each of these indices may be useful for the patients, and for the clinician who employs them, none have the prediction capability reaching close to 100% sensitivity or specificity. Thus the "cannot intubate" or the "cannot ventilate-cannot intubate" conditions may still arise, and hence it is vital that all managers of airway should be prepared for managing the difficult airway despite the absence of all difficult airway predictors. In contrast, sometimes the airway is falsely predicted to be difficult when intubation proves quite easy. This does not negate the usefulness of airway assessment as it has been verified by previous study that it helps in identifying more than 98% of difficult airways.

ESSENTIAL COMPONENTS OF AIRWAY ASSESSMENT

The four pillars of Airway management are:

- Mask ventilation
- Laryngoscopy and tracheal intubation
- Placement of supraglottic device
- Performing surgical access to the airway

Previous anaesthesia records may reveal a documented history of difficult airway. History of previous surgery, burns, trauma or tumour in and around the oral cavity, neck or cervical spine should be asked.

CLINICAL AIRWAY ASSESSMENT

The airway assessment for difficult airway may be divided into

1) Individual Predictors
2) Group Indices

EVALUATION OF DIFFICULT MASK VENTILATION

INDIVIDUAL PREDICTORS

- Presence of beard: There is difficulty in creating an effective seal by mask leading to loss of ventilated volume. Some recommend shaving the beard but sometimes it is a religious symbol of Muslims and Sikhs. Spreading an opsite film over the beard or applying Vaseline is recommended.
- OBESITY: Patients with BMI more than 26kg/m^2 require much large force during ventilation and have decreased functional residual capacity making them more prone to quick desaturation. Two person mask ventilation, using an appropriate size oral or nasal airway, appropriate mask can aid mask ventilation in these patients.
- TEETH: Patients with irregular teeth/artificial dentures or those who are edentulous offer poor fit for the conventional mask ventilation. It is recommended that the artificial dentures be left in place if they are well attached. They should be removed after the patient has been well oxygenated and immediately prior to laryngoscopy and intubation. Placing

an unfolded gauze (4 x 4 inch) fluffed and compressed inside the mouth along the buccal pouches restores the cheek fullness and helps to create an optional mask seal in these patients. In edentulous patients, using a large mask and a centrally placed large oral airway may be helpful.

- Elderly patient: Patients over the age of 55 years may be difficult to mask ventilate.
- Snorers: Patients with a history of snoring may pose problems during mask ventilation. Application of gentle, but continuous positive airway pressure (5-10 cm H_2O) while ventilating may help in keeping the airway patent by expanding the hypopharyngeal structures leading to easier ventilation.
- Hair bun: Tying of hair in a bun over the occiput is often practiced in India. Placing such patient in the sniffing position is difficult as the bun prevents extension of the atlanto-occipital joint. It is advisable to undo the bun prior to positioning the head and neck.
- Jewellery and facial piercing: These may not be a common sight in India but is occasionally encountered in individuals trying to establish a separate identity. Thus, lip, tongue and check piercings may come in the way of mass ventilation. It is recommended to get them removed before the procedure and restore them at the end.

GROUP INDICES

- BONES: **B**earded individual

  Obesity (BMI>26kg/m^2)

  No teeth

  Elderly (age>55 years)

  Snorer

Having two or more of these predictors are likely to have difficult mask ventilation

- MOANS: **M**ask seal may be difficult or impossible in patients with receding mandible, syndromes with facial abnormalities, burn contractures etc.

  Obesity (BMI>26) or **O**bstruction

  Advanced age

  No teeth

  Snorer

Having two or more of MOANS are likely to have difficult mask ventilation.

OBESE: **O**bese

Bearded

Elderly(age>55 years)

Snorer

Edentulous

Having 2 or more of OBESE are likely to have difficult mask ventilation.

MIMS: **M**ale sex

Increasing age

Mallampatti class 4

Snorer

EVALUATION FOR DIFFICULT LARYNGOSCOPY AND TRACHEAL INTUBATION

The predictor of difficult laryngoscopy and tracheal intubation have been grouped as:

1. INDIVIDUAL PREDICTORS

2. GROUP INDICES

INDIVIDUAL PREDICTORS

1. PHYSICAL EXAMINATION INDICES: Assessment of cervical and atlanto -occipital (a-o) joint function. This is done in patients with stiff joint syndrome.

1. DIRECT ASSESSMENT: Laryngoscopic view becomes easier when the neck is flexed on the chest by 25-35 º and the a-o joint is well extended to 85 º. This is called "sniffing the morning air "position or "Magill's position". Assess the first movement by asking the patient to touch his manubrium sternii with his chin. If done, this assures neck flexion of 25-35 º. Following this ask the patient to look at the ceiling without raising the eyebrows to test the a-o joint function. Reduction in a-o joint extension can be graded as -

    1. No reduction
    2. One third reduction
    3. Two third reduction
    4. Complete reduction

2/3rd or complete reduction implies a clear pointer towards difficult laryngoscopy.

DELILKAN'S TEST: This test assesses the movement of the occiput on the atlas during extension. A normal range of head or neck flexion and extension is necessary for an easy laryngoscopy or intubation. The ability to fully extend the head on the neck is basically the movement of the occiput on the atlas. This is usually assessed by asking the patient to look at the ceiling without raising the eyebrows. In this test, the patient is asked to look straight ahead. The head is held in a neutral position. The index finger of the left hand of the clinician is placed under the tip of the jaw while the index finger of the right hand is placed under the occipital tuberosity. The patient is now asked to look at the ceiling. The left index finger becomes higher than the right ,then the extension is considered normal. If it is in the same level or lower level, extension is abnormal. Suddenly a clunk is felt as the head starts to extend, and the movement stops. These are the warning signs for difficult laryngoscopy and intubation.

2.INDIRECT ASSESSMENT: Nearly one third of long term juvenile diabetic patient present with laryngoscopic difficulty due to stiff joint syndrome. These patients have difficulty in approximating their palms (PRAYER SIGN) at the interphalangeal joints especially and cannot bend their fingers backward. If present we should be cautious of the possibility of cervical spine involvement with limited a-o joint movement.

PALM PRINT TEST – Joint rigidity seen in diabetic patients due to glycosylation can also involve the cervical joints and lead to difficult laryngoscopy. The patients are asked to keep their palm prints on a white paper and this is scored as

a) Phalangeal areas completely visible
b) Interphalangeal areas 4^{th}-5^{th}digits are partly visible
c) Interphalangeal areas 2^{nd} and 5^{th} hardly visible
d) Only finger tips visible

B) ASSESSMENT OF TEMPORO MANDIBULAR JOINT (TMJ) FUNCTION:

The functions of TMJ are rotation of condyle in synovial cavity and forward displacement of condyle. Rotation is responsible for initial 2-3 cm of mouth opening. Forward displacement is needed for later 2-3 cm mouth opening.

- Ask the patient to open his mouth wide and place his three fingers in the opening. This is >5cm, hence adequate for direct laryngoscopy.
- Place Index finger in front of the tragus and the thumb in front of the lower part of the mastoid process behind the ear. When the patient opens his mouth the condyle of the mandible slides forward, the index finger in front of the tragus can be indented in its space and the thumb can feel the sliding of the condyle. This suggests a normal functioning TMJ.
- CALDER TEST: The patient is asked to protrude the mandible as far as possible. The lower incisors will lie anterior to or aligned with or posterior to the upper incisors. The later two suggest reduced view at laryngoscopy.

C) ASSESSMENT OF THE MANDIBULAR SPACE:

The space superior to the larynx is expressed as thyromental or hyomental distance. This space tells us how easily the laryngeal and pharyngeal axis will fall in line when the a-o joint is extended. Laryngoscopy pushes the tongue into the space, hence if this is reduced exposure of the glottis is inadequate.

- THYROMENTAL DISTANCE: This is the distance between the thyroid notch and symphysis menti when the neck is fully extended.

  >6.5cm: easy laryngoscopy and intubation

  6 – 6.5 cm: without other concomitant anatomical problems laryngoscopy and intubation are difficult, but possible.

  <6.0 cm: laryngoscopy may be impossible

- HYOMENTAL DISTANCE: This is the distance between the hyoid bone and the mentum. It is graded as:

  GRADE I: >6.0 cm

  GRADE II: 4.0 – 6.0 cm

  GRADE III:<4.0 cm

  Grade III hyomental distance is associated with impossible laryngoscopy and intubation.

- LENGTH OF THE MANDIBLE: This is not used as an individual predictor of difficult intubation. A horizontal length of mandible of at least 9 cm guarantees easy intubation.

D) ASSESSMENT THE ADEQUACY OF OROPHARYNX FOR LARYNGOSCOPY AND INTUBATION:

There are two tests for this assessment. They are:

1. MALLAMPATI GRADING: This is the most commonly used test for predicting the airway management difficulty. This indicates the amount of space within the oral cavity to accommodate the Laryngoscope and the

ETT. This is performed by asking the patient to open the mouth as wide as possible and stick out the tongue without phonation such as saying "ah" which lowers the grade by one step i.e. grade 2 becomes grade 1. One should also ensure that the patient is in sitting position with head protruding the head forward mimicking the sniffing position of laryngoscopy. The observer's eye should be at the level of patient's open mouth. Observe the degree to which faucial pillars, uvula, soft palate and hard palate are visible. As per SAMSOON and YOUNG modification of MPG, the following are the four grades:

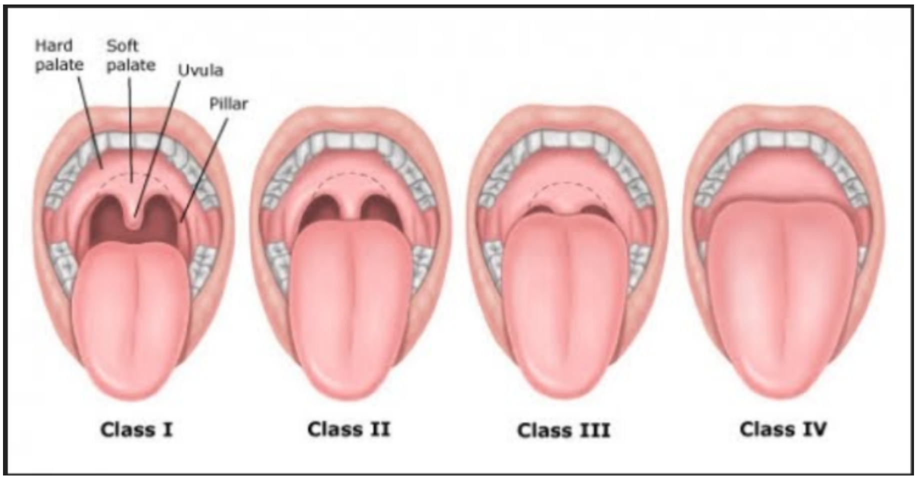
Grade 1: faucial pillars, uvula, soft and hard palate visible.

Grade 2: Uvula, soft and hard palate visible.

Grade 3: Base of uvula or none, soft and hard palate visible.

Grade 4: Only hard palate visible.

Grades 1 and 2 are associated with easy laryngoscopic view of glottis. Grades 3 and 4 are associated with difficult laryngoscopy and intubation.



MALLAMPATI GRADING

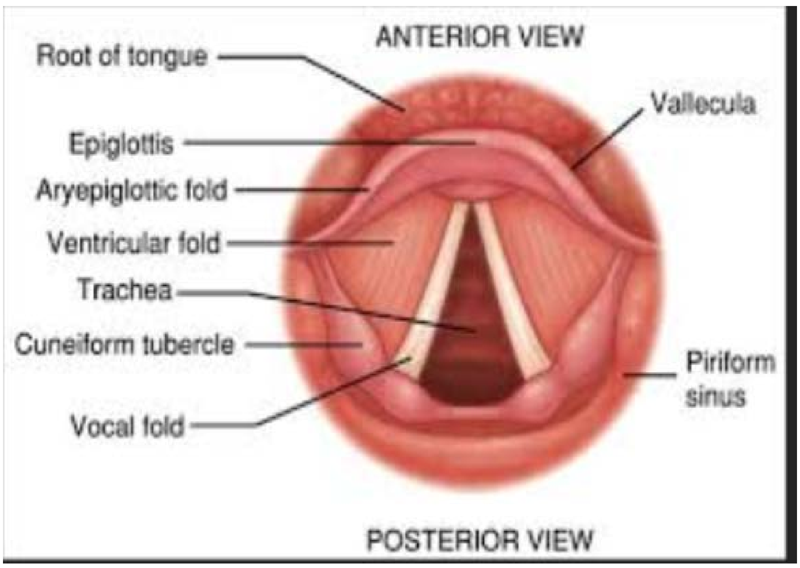
EXTENDED MALLAMPATI SCORING: In this test patient is asked to sit in full extension of neck and same test done. This was claimed to have better predictive value of difficult airway.

2. NARROWNESS OF THE PALATE: A narrow high arched palate offers very little space for laryngoscopy and endotracheal intubation.

3. The anterior tilt of the thyroid cartilage relative to the horizontal plane also predicts difficulty in glottic exposure with rigid conventional laryngoscopy.

E) ASSESSMENT OF QUALITY OF GLOTTIC VIEW DURING LARYNGOSCOPY: There are two tests which assess the quality of glottic opening visualization. They are Indirect mirror laryngoscopic view and "awake look" Direct laryngoscopic view.

- Indirect mirror laryngoscopic view: This also correlates with Cormack – Lehane grading



INDIRECT LARYNGOSCOPIC VIEW

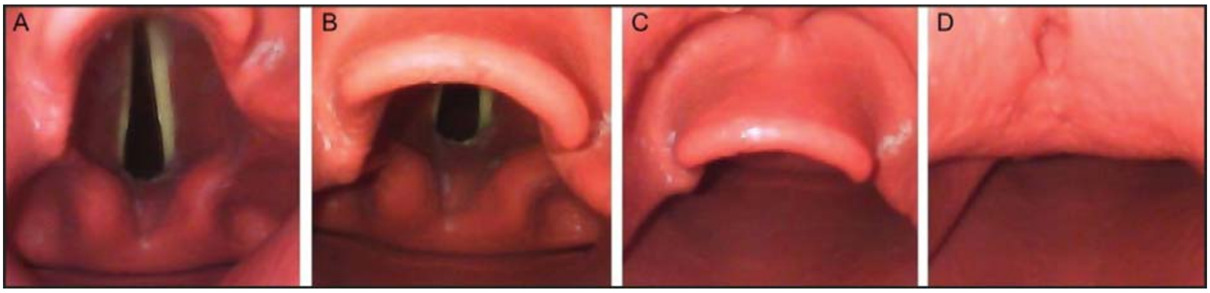
- Direct Laryngoscopy: This gives the best estimate of laryngoscopy and intubation. There are four grades explained by Cormack and Lehane. They are

  Grade I: Visualization of entire vocal cards

  Grade II: Visualization of posterior part of Laryngeal Aperture

  GradeIII: Visualization of epiglottis

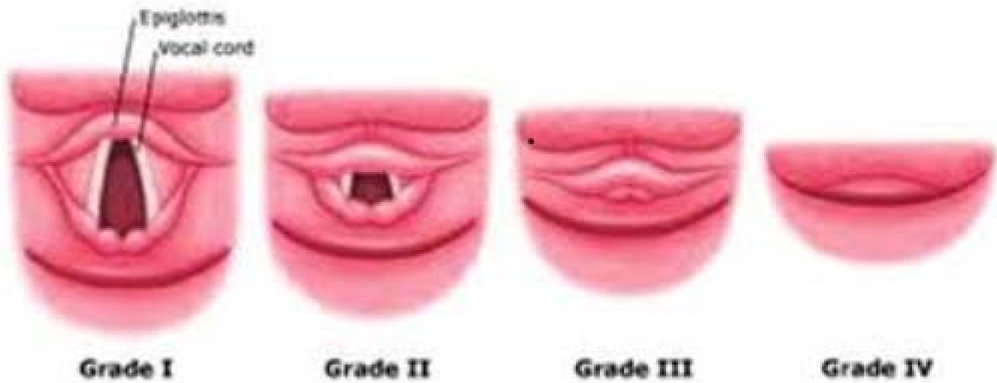
  Grade IV: No glottic structure seen



CORMACK – LEHANE GRADING

Grade I and II are considered as easy intubation.

Grade III and IV are considered as difficult intubation



CORMACK-LEHANE GRADING

POGO SCORING: Percentage of glottic opening. If the entire glottis is visible a score of 100% is given. When no glottic structure are seen a score of 0% is given. If only the lower third of the cords and the arytenoids are seen 33% is given.

- STERNOMENTAL DISTANCE: This is measured with head in full extension and mouth closed.

  <12.5cm predicts difficult laryngoscopic intubation. This is regarded as the best predictor of intubation.

- UPPER LIP BITE TEST: This test is used to assess the range and freedom of mandibular movement and architecture of the teeth.

  CLASS I: Lower incisors can bite the upper lip above the vermilion line.

  CLASS II: Lower incisors can bite the upper lip below the vermilion line

  CLASS III: Lower incisors cannot bite the upper lip.

  Patients with CLASS III of ULBT are expected to have Cormack and Lehane's grade III and IV.

GROUP INDICES

WILSON'S SCORING SYSTEM:

Parameter	0	1	2
Weight(kg)	<90	90-110	>110
Head and neck movement	>90º	=90º	<90º
Jaw movement (inter-incisor gap)	>5 cm	=5cm	<5 cm
Sliding mandibular beyond maxillary incisors	>0	=0	<0
Receding mandible	None	Moderate	Severe
Buck teeth	None	Moderate	Severe

Score: $\leq$ 5 indicates easy laryngoscopy

8-10 indicates difficult laryngoscopy

BENUMOF'S 11 PARAMETER ANALYSIS

Parameter evaluated	Minimal acceptable value	Significance
Inter-incisor gap in cm	>3 cm	Gap>3 cm permits easy insertion of laryngoscope blade
Look for buckteeth i.e. Involuntary anterior overriding of maxillary teeth on the mandibular teeth	No overriding	Buckteeth if present causes the laryngoscope blade to enter in cephalad direction
Length of upper incisors	Short incisors(<1.5cm)	Long incisors prevent easy aligning of oropharyngeal-laryngeal axes during laryngoscopy
Voluntary protrusion of the mandibular teeth anterior to maxillary teeth	Mandibular teeth can be protruded beyond the maxillary teeth	Suggests optimal TMJ function, both rotatory and sliding, thereby permitting easy laryngoscopy
Mallampatti class	Class II or less	Suggests optimal tongue size in relation to oropharyngeal cavity permitting easy laryngoscopy

Palate configuration	No arching or narrowness of the palate	A narrow, arched palate reduces room for laryngoscope blade and ETT
Length of the mandibular space (thyromental distance)	>5cm or >3 ordinary sized finger breadth	Suggests optimally placed larynx, permitting easy aligning of axes
Compliance of mandibular space	Mandibular space is soft to palpation	A compliant mandibular space allows easy tongue compressibility during laryngoscopy
Neck length	Qualitative, exact values need determination	A thick, short neck decreases the ability to align the upper airway axes
Neck thickness	Qualitative , exact values need determination	A thick , short neck decreases the ability to align the upper airway axes
Head and neck movement	Sniffing position= Neck flexion 35° & head extension 80°	The 3 axes of the upper airway (oral - pharyngeal-laryngeal) are best aligned in sniffing position

LEMON LAW:

1) **L**ook for anatomic features of difficulties like short neck, facial hair, edentulous patient, obesity, high larynx, small chin, buck teeth, big tongue, facial trauma, swelling, tumour.
2) **E**xamine airway anatomy: - 1. Assess oral opening-able to admit three fingers.

   2. Measure the ability of the mandible to accommodate the tongue – should fit 3 fingers between the mentum and the hyoid bone.

   3. Externally assess for a high larynx – should be able to get 2 fingers between the top of the thyroid cartilage and the mandible.
3) **M**allampati grading
4) **O**bstruction of the airway
5) **N**eck mobility

RADIOLOGICAL INDICES OF PREDICTION OF DIFFICULT LARYNGOSCOPY

Lateral X-RAY of head and neck has been used to predict difficult laryngoscopy. The three measurements used are

a. Ratio of effective mandibular length to its posterior depth i.e. < 3.6 – predicts difficulty
b. Reduced distance between occiput and spinous process of C1 < 5mm

c. An increase in the posterior depth of mandible of more than 2.5cm poses problems during laryngoscopy / intubation.

ADVANCED INDICES INCLUDING RADIOLOGICAL ONES FOR AIRWAY ASSESSMENT:

1. FLOW VOLUME LOOPS
2. ULTRSONOGRAPHY
3. MRI
4. ESOPHAGOGRAM
5. FLUOROSCOPY

ULTRASOUND

INTRODUCTION

BASICS OF ULTRASOUND

Ultrasound application allows for non-invasive visualization of tissue structures.

HISTORY OF ULTRASOUND

1880: Pierre and Jacques Curie discovered about the piezoelectric effect in crystals.

1942: Karl and Dussik described ultrasound used as diagnostic tool.

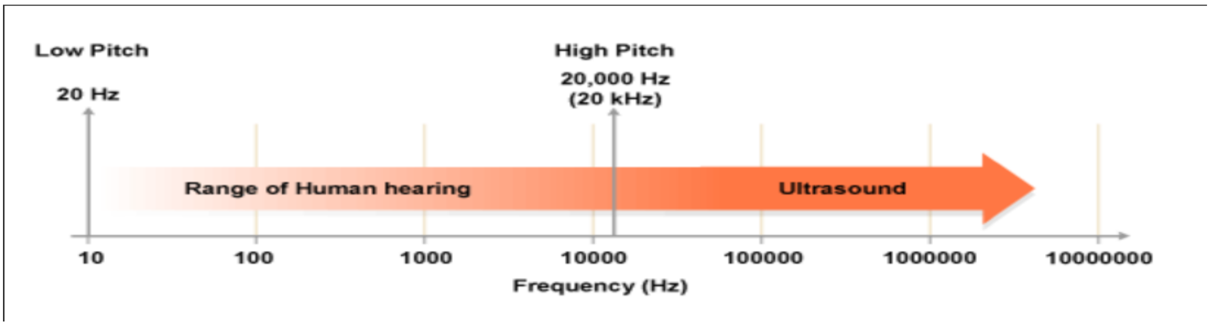
1978: P. La Grange published ultrasound application for placement of needles for nerve blocks.

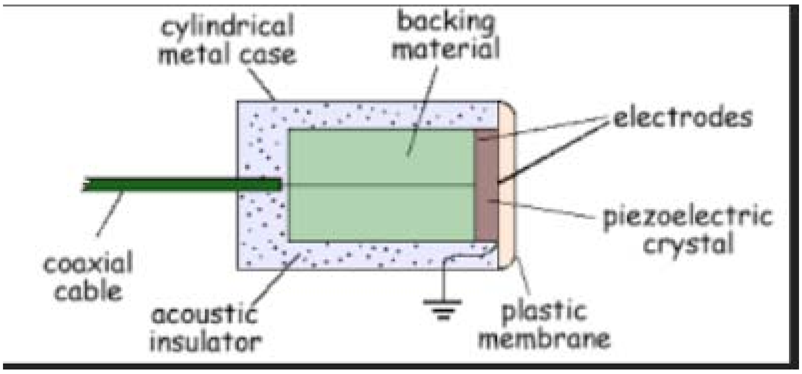
1989: P. Ting and V. Sivagnanaratnam used USG to demonstrate the anatomy of the axilla and observe the spread of local anaesthetics during axillary block.

1994: Steven Kapral and colleagues explored brachial plexus blockade using B-mode ultrasound.

Audible frequency of sound is in the range of 20 – 20000Hz (or) cycles per second. Ultrasound refers to the frequency range above 20000 Hz. In medical imaging frequencies used is from 1-20 M Hz. Ultrasound transducers act as both transmitters and receivers of reflected sound waves from various tissue interfaces. The transducers consist of quartz crystals i.e. piezo electric crystals sandwiched between electrodes. The piezo electric element converts electrical elements into mechanical vibrations (transmit mode) and mechanical vibrations into electrical signals (receiver mode).

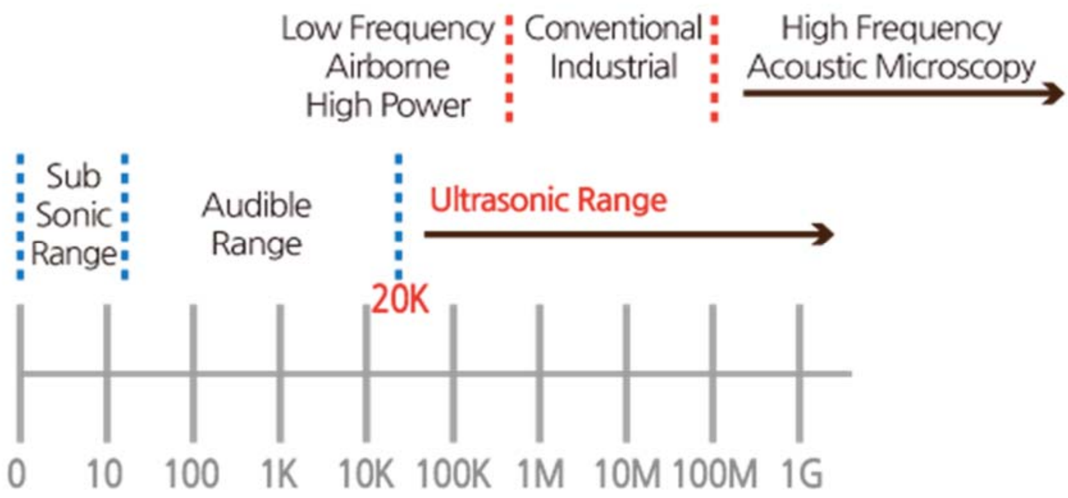
FREQUENCY RANGE





COMPONENTS OF A TRANSDUCER

Tissues exhibit different acoustic Impedance values due to reflection occurring in the various types of tissues. Impedance difference is greatest between soft tissue and bone/air.



FREQUENCY RANGE

ECHOGENICITY - Sound waves reflected at the interface of two tissues with different acoustic Impedance generates an echogenicity. Hyperechoic structures give a strong echo i.e. appear white e.g. fat/bone. Here the ultrasound beam does not pass easily through the structure. Whereas in certain tissues the beam passes easily like fluid collection or blood in vessels which exhibit weak echogenicity called as Hypoechoic which appears black on screen.

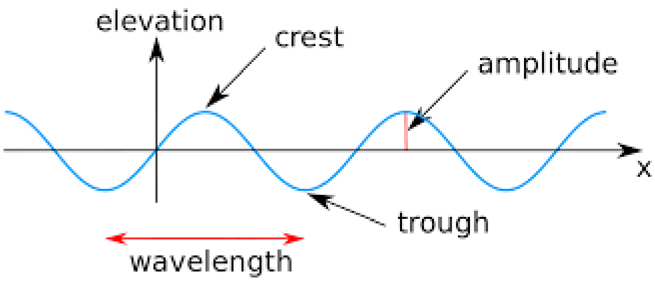
When the beam reaches the surface of a bone all waves get absorbed- which shows only a small depth of bony tissue. No tissue is seen beyond the bone. It appears dark and called as acoustic shadowing.Bone appears as a hyperechoic white line.

Cartilaginous structures will be homogeneous i.e. uniformly hypoechoic i.e. black since the beam passes through the cartilage. With age as it calcifies Echogenicity may increase.

Muscles and connective tissue membranes are hypoechoic(dark) but have a more heterogenous, striated or irregular appearance.

Glandular structures like the Submandibular and thyroid glands are homogenous and hyperechoic when compared to the surrounding soft tissue structures.

Air is a very bad conductor of Ultrasound, so when beam reaches the interface between air and tissue, there is a strong reflection and hence hyperechoic white line appears. Beyond this only artefact will be seen. Most common artefact is reverberation artefacts with multiple parallel lines beyond this line.



The higher the frequency of ultrasound wave the better the image resolution and lower the penetration in depth. The terminologies are explained below.

ULTRASOUND TERMINOLOGIES

1) Wavelength: It is the travel distance from beginning to the end of the cycle.
2) Acoustic Velocity: It is the speed at which sound wave travels through a medium. Its determinants are stiffness and density of the medium. It is directly proportional to stiffness and inversely proportional to density.
3) Acoustic Impedance:It is degree of difficulty by which a sound wave can be transmitted through a medium. It is a multiplication of density and acoustic velocity.
4) Attenuation Coefficient: It increases with increasing frequency of the ultrasound.

Self-focusing effect of Ultrasound: Natural narrowing of the ultrasound beam at a certain travel distance in the ultrasonic field. This effect amplifies ultrasound signals by increasing acoustic pressure.

RESOLUTIONS

AXIAL: Minimum separation of above-below planes along the beam axis.

LATERAL: Side by side distance between the two objects is seen.

TEMPORAL: To observe the moving objects mainly.

The available ultrasound transducer probes are:

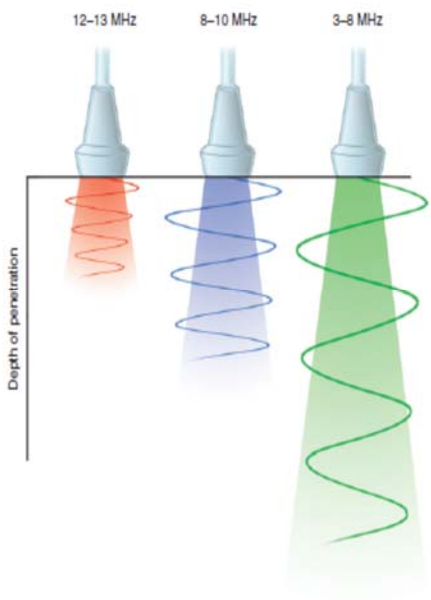
1) High frequency (7 to 12 MHz), linear

2) Low frequency (2 to 6 MHz), curvilinear

3) Micro convex (4 to 10 MHz)

4) Hockey stick (6 to 10 MHz)

DIFFERENT TYPES OF PROBES

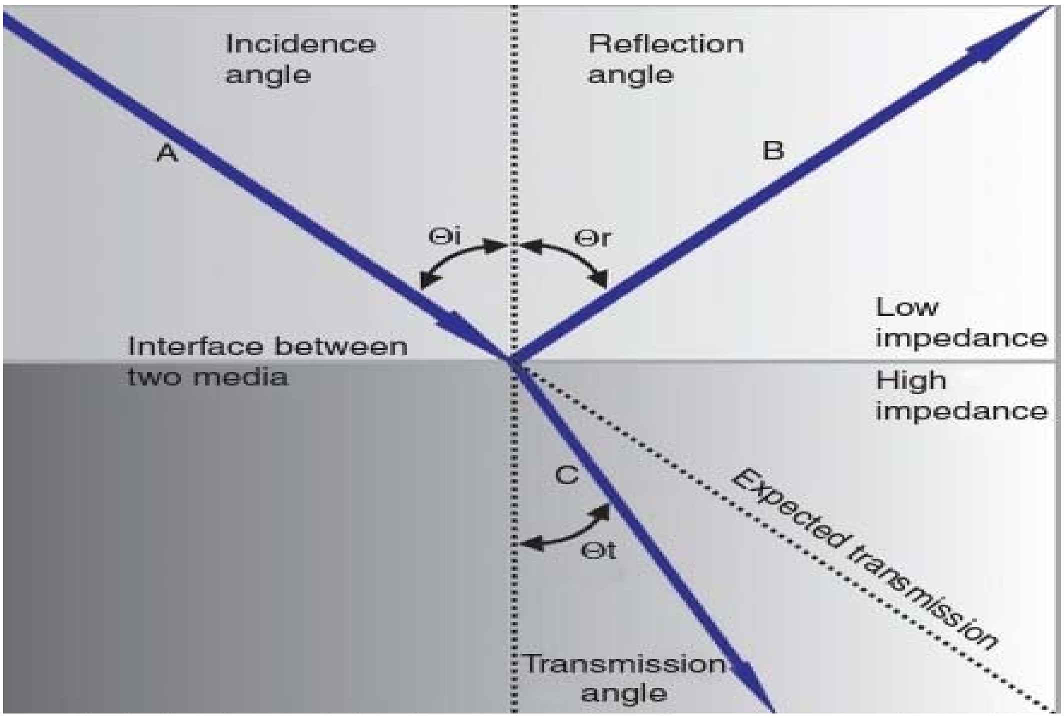


PROBE FREQUENCIES AND DEPTH

INTERACTION OF ULTRASOUND WAVES WITH TISSUES

REFLECTION: Reflection of a sound wave is similar to an optical reflection. Here energy is sent back into the starting or the originating medium. True reflection means, reflection angle must be equal to the incidence angle. The strength of the reflection depends on the difference of impedance between the two media and the incident angle.

If the impedances is equal, there is no reflection. If there is a significant difference between the media impedances, there will be far greater or complete reflection. This reflection intensity is highly angle dependent, which means that the ultrasound transducer must be placed perpendicularly to the target to be visualized.

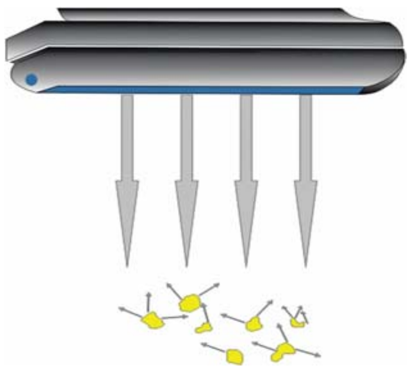


PHYSICS OF ULTRASOUND

SCATTERING: It is the redirection of sound in different directions through rough surfaces or heterogeneous media . Reflection intensities are relatively independent of the direction of the incident sound wave.

Therefore, the visualization of the target nerve is not significantly influenced by scattering.

This image describes scattering.



ABSORPTION: Absorption is defined as the direct conversion of sound energy into heat energy and thus the ultrasound scanning generates heat in the tissue. Higher scanning frequency gives better axial resolution and visualization of superficial structures. Lower frequency is selected to increase the penetration for visualization of deeper structures. Use of longer wavelengths produce lower resolution hence the resolution of ultrasound imaging is proportional to wavelength of the imaging wave. The frequencies between 6 and 12 MHz used for imaging of the peripheral nerves. Lower frequencies between 2 and 5 MHz, are used for imaging of neuraxial structures.

ULTRASOUND MODES:

B MODE - In this an array of transducers simultaneously scan a plane through the body which is seen as 2-Dimensional Image i.e., a slice of tissue will be seen on the screen.

M MODE - M represents motion. Rapid sequence of the B Mode image leads to a single line through the tissue slice. The image follows in sequence on the screen enabling us to see and measure the range of motion as the organ boundaries produce reflections which move relative to the probe.

COLOUR DOPPLER: Velocity Information is presented as a colour coded overlay on top of B mode image.

RULES TO DO DURING USG IMAGING:

The frequency range is chosen to be the highest frequency which allows adequate insonation of the full depth of the field. The footprint size which is the length of the active face of transducer that contacts the skin is chosen to provide a broad enough view of the structures to be seen. This size should be as large as the expected depth of the field. A square or landscape view is better than a keyhole view for visualization.

Universal precautions should be used while handling the equipment. The external surface of the probe requires disinfection between every use and prolonged periods of non-use as per the instruction of the manufacturer. Do not drop any ultrasound transducer because active face of the transducer is sensitive to contact with hard surface.

The manoeuvres to be done while visualising the structures include sliding, tilting, compression, rocking and rotation of the probe. Anisotropy - On inclination of the transducer, change in echogenicity is present. Because air does not conduct ultrasound waves, the probe must be in full contact with skin/mucosa without interfering air. Conduction gel provides contact between the probe and the skin.

Structures that can be seen while visualizing the airway using ultrasound

A) Mouth and Tongue

B) Oropharynx

C) Hypopharynx

D) Hyoid Bone

E) Larynx

F) Vocal Card

G) Cricothyroid Membrane

H) Trachea

I) Oesophagus

J) Lower Tongue and Bronchi

K) Lung and Pleura

L) Diaphragm

VISUALIZATION OF THE AIRWAY

In conventional transcutaneous ultrasound, using various types of probes airway can be seen sequentially from the tip of the chin to the mid-trachea along with the pleural aspect of the most peripheral alveoli and the diaphragm.

Transoesophageal Ultrasound helps to visualize the trachea from oesophagus. The tissue surrounding the more distal airway, from the mid-trachea to the bronchi can be visualized with endoscopic USG via bronchoscope.

A) MOUTH AND TONGUE: Tongue has 2 parts-

1) Mobile anterior part situated within the oral cavity.
2) Fixed posterior - pharyngeal portion.

Muscles of the tongue can be divided into two groups:

1) Extrinsic muscles – are those which have a bony insertion and alter the position of the tongue.

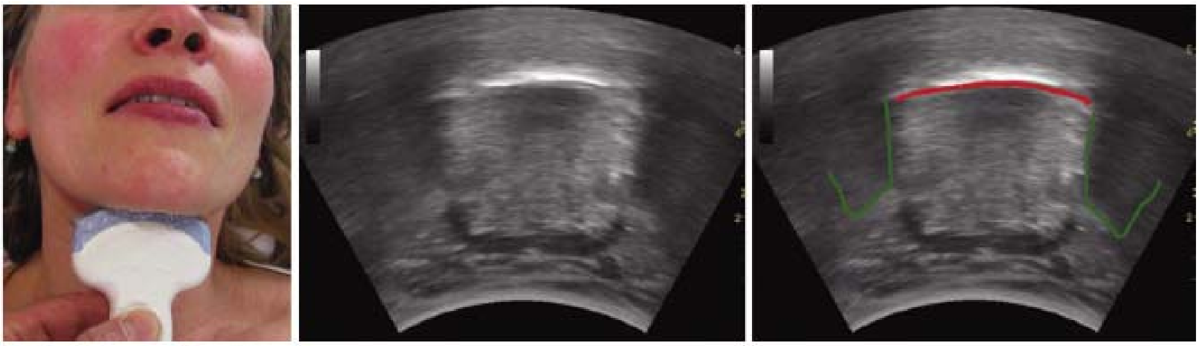
2) Intrinsic Muscles - are those, whose fibres decide the shape of the tongue.

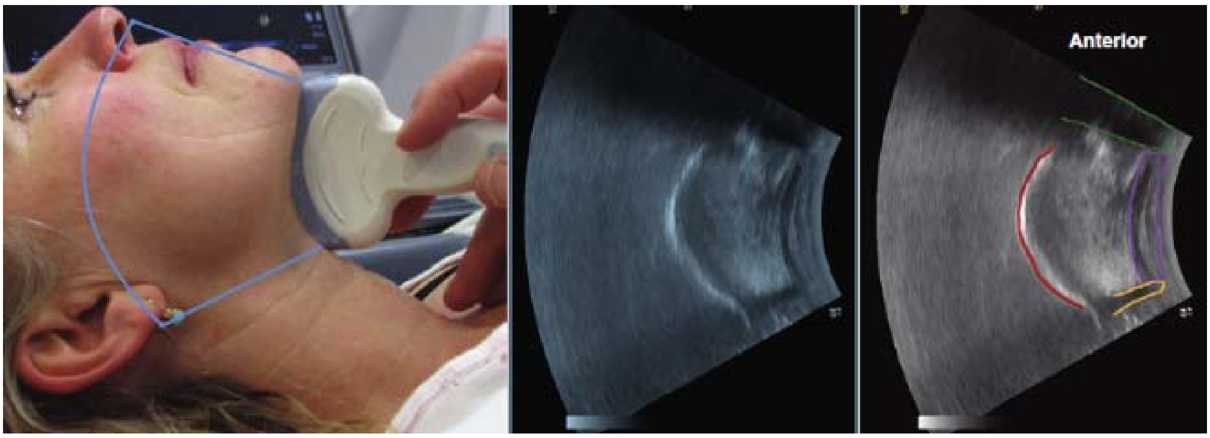
Tongue can be visualized from within the mouth and transcutaneously. But the image from within the mouth is difficult to interpret. The ultrasound probe transducer is kept sub-mentally posterior to the mentum and the tongue is visualised. The transducer probe is scanned in the coronal plane from the anterior end to the hyoid bone. Here all the layers of the floor of the mouth are scanned. The muscles of the tongue and other pathological growth can also be identified. The side of the scanned image will be flanked by the acoustic shadow of the mandible on both the sides. The dorsal or the lingual surface is clearly identified. The width of the tongue base can be measured by locating the 2 lingual arteries with Doppler ultrasound and then identifying the distance between two arteries as they enter the base of the tongue at the lateral and lower border. If the transducer is placed sub mentally in sagittal plane, then the longitudinal scan of the floor of the mouth is obtained. If the convex probe transducer is placed, within one image itself whole length of the floor of the mouth and majority of tongue can be seen.

The anterior and posterior limits are formed by the symphysis of the mandible and hyoid bone. In the longitudinal plane the functions of the tongue can be mainly seen which include bolus holding, lingual propulsion, lingual - palatal contact, tongue tip and dorsum motion or protrusion, clearance of the bolus and excursion of the hyoid bone.

For visualisation of the palate, the tongue must be in contact with the palate. If there is no contact, then air in between i.e. at the dorsum of the tongue will make visualization impossible. To improve the image water can be ingested and retained in the oral cavity. The water eliminates air-tissue border and allows visualizing of most of the oral cavity including the palate as well as better differentiation of the hard palate from the soft palate.

Vallecula is seen just below the hyoid bone. When the probe is angled caudally, the pre – epiglottic, para glottic space, infra hyoid space is seen.





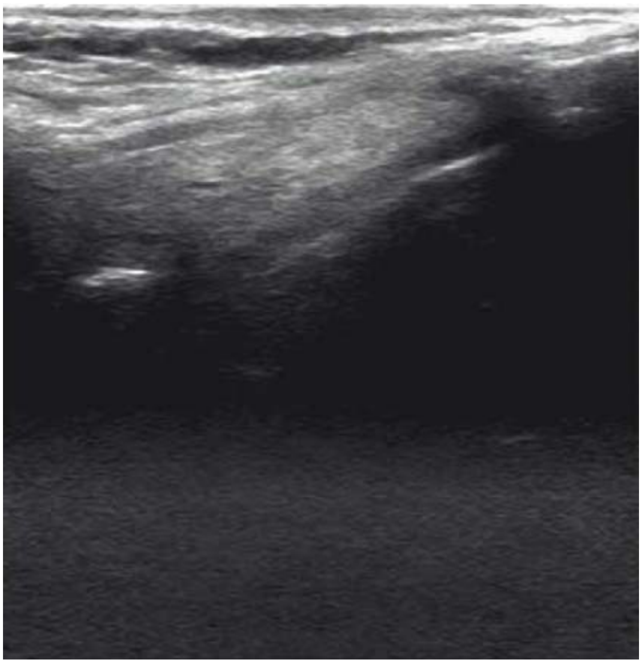
B) OROPHARYNX: The transducer is placed vertically with the upper edge approximately 1cm below the external auditory canal. Lateral pharyngeal border and the thickness of the lateral pharyngeal wall can be determined. Other uses include visualizing the para pharyngeal space by directly placing the probe in the mouth on the lateral pharyngeal wall which is very much difficult for the patient to tolerate.

C) HYPOPHARYNX: Ultrasound equates with CT scan for imaging any tumour located in the hypopharynx. The ultrasound is performed through the thyrohyoid membrane, cricothyroid space, cricothyroid membrane and thyroid cartilage lamina along its posterior edge.

D) HYOID BONE: The upper airway is divided at the level of the hyoid bone. The hyoid bone is visible in both transverse and sagittal views. In transverse view, hyoid is visible as a superficial, hyperechoic and inverted U shaped linear structure with posterior acoustic shadowing. On the sagittal and parasagittal views, the hyoid bone is visible in cross section like a narrow hyperechoic, curved structure that casts an acoustic shadow.

E) LARYNX: A linear high frequency transducer where resolution is greatest and superficial structures are seen best is used. Hyoid bone calcifies early in age and hence shows a post acoustic shadowing.

The cricoid cartilage is ring like and shows variable calcification throughout life. The thyroid cartilage is also like cricoid. Whereas epiglottis remains hypoechoic throughout the life. The vocal cords are seen. Both false and true vocal cords show calcification and is seen as strong echo with post acoustic shadowing. These calcifications do not hinder the visualization of the laryngeal structures.



F) VOCAL CORDS: Both the true and false vocal cords can be visualized. The true vocal cords appear like two triangular, hypoechoic structures due to vocalis muscles and they are outlined medially by the vocal ligaments which are hyper echoic. During phonation the vocal cords move medially and oscillate to and fro from its position. The false vocal cords lie in a parallel direction and anterior to true vocal cord and they appear hyper echoic comparatively and are immobile during phonation.They are visualized at the level of thyroid cartilage if these are non-calcified. If calcified vocal cords and arytenoids can be seen by keeping the transducer just cranial to the superior thyroid notch and angled caudally with orientation from the cricothyroid membrane in the midline and parasagittal with the transducer angled 30º cranially.

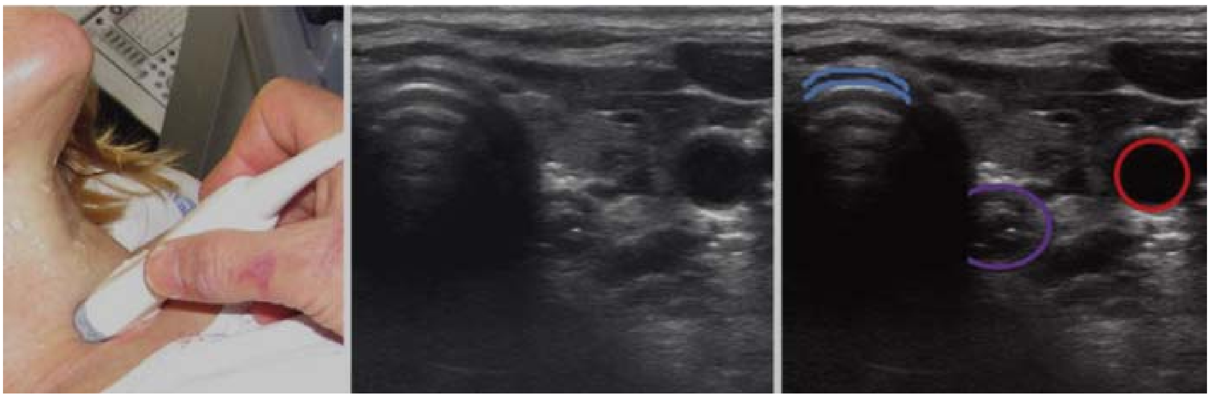
G) CRICOTHYROID MEMBRANE AND CRICOID CARTILAGE:

The cricothyroid membrane runs between thyroid cartilage posterior boundary and anterior border of the cricoid cartilage. This is visualized as a hyper echoic band connecting two hypo echoic structures and is seen in sagittal and parasagittal views.

The cricoid cartilage is seen in both views. In transverse view its like and arch and in sagittal view it is round and gives hypoechoic pattern.

H) TRACHEA: For transverse imaging of the anterior neck structures, in the midline the trachea is taken as reference point. The uppermost limit of the trachea is the cricoid cartilage. It appears thicker than the below tracheal rings. For sagittal neck imaging cricoid cartilage is the reference point. In the neck with mild extension six tracheal rings can be seen. The second and third tracheal rings are covered by the strap muscles and the isthmus of thyroid in sagittal view. The muscles are hypo echoic encased by hyper echoic cervical fascia. The appearance of the tracheal rings is called as “string of beads” in sagittal and para sagittal views. In transverse view the trachea appears as an inverted U-shaped structure.

Air – mucosal interface which thus appears hyper echoic and is lined posteriorly by a series of reverberation artefacts.



I) ESOPHAGUS: At the cervical level, oesophagus can be seen at the level of suprasternal notch posterolateral to trachea. The appearance is termed as “bull’s eye appearance”. This can be differentiated by compression movements on swallowing. The optimal position for visualization is minimal flexion of the head with pillow under it and head turned towards opposite side by 45º.

J) LOWER TRACHEA AND BRONCHI: Transoesophageal ultrasound shows a part of lower trachea. When a saline filled balloon is introduced in the trachea during cardio pulmonary bypass we can do an ultrasound through the trachea. End bronchial ultrasound differentiates between airway infiltration and compression by tumours.

K) PERIPHERAL LUNG AND PLEURA: The ribs are identified by the hyper echoic line with characteristic post acoustic shadowing. The pleural line is seen between two ribs when the probe is oriented perpendicular to them. This hyper echogenicity is due to the interface between the soft tissue of the chest wall and air.

PLEURAL SLIDING: To and fro movement synchronous with ventilation and spontaneous breathing. This movement is seen prominently because the surrounding tissue is motionless.

BAT SIGN: The probe is kept perpendicular to the ribs such that the two rib shadows are identified. The succession of the upper rib forms a characteristic pattern called so.

LUNG PULSE: Breath holding, or apnoea will have no sliding movement. Hence it is called so. But small pulsatile movements are present because of the movement with heart beat. This is due to vibrations of the heart transmitted to the lung.

CLINICAL APPLICATIONS OF AIRWAY ULTRASOUND

A) PREDICTION OF DIFFICULT LARYNGOSCOPY: The difficulty in visualizing the epiglottis and trachea with sub lingual ultrasound is a predictor of Cormack Lehane grading. The anterior neck soft tissue measured at the level of vocal cords was greater in patients with difficult laryngoscopy even after external laryngeal manoeuvres.

B) EVALUATING THE PATHOLOGY: Subglottic hemangiomas, laryngeal stenosis, laryngeal cysts, respiratory papillomatosis can be visualized with ultrasound. Zenker's diverticulum which is a pharyngeal pouch where regurgitation chance is very high can be visualized. High frequency linear probe is helpful in visualizing this on the postero lateral aspect of the left thyroid lobe. Airway malignancies and their position can be scanned.

Through prenatal ultrasound fetal airway abnormalities such as extrinsic obstruction can be caused by adjacent tumour like cervical teratoma and lymphatic malformation. Airway management can be planned with the above information either at birth or as ex utero intrapartum treatment (EXIT) procedure. The above EXIT procedure can be performed as a caesarean section and endotracheal intubation or tracheostomy, while the new born is still attached to the umbilical cord there by maintaining fetal circulation.

C) DIAGNOSIS OF OSA: The width of the tongue base, measured by ultrasound correlated with the severity of the sleep related breathing disorder. This can be asked by the patient's sensation of choking during the night. The width of the tongue can be measured by the distance between the two lingual arteries when they enter the tongue base at its lower lateral borders. The lateral pharyngeal wall thickness is increased in patients with OSA.

D) EVALUATION OF PRANDIAL STATUS: This is now useful in identifying full stomach. The accuracy was more than empty stomach.

E) PREDICTION OF THE APPROPRIATE DIAMETER OF ENDOTRACHEAL/ENDOBRONCHIAL /TRACHEOSTOMY TUBE:

Diameter of left main stem bronchus tells the diameter of the left DLT to be placed.The outer diameter of the trachea just above the sterno-clavicular joint predicts the size of the tube in children.

F) LOCALIZATION OF THE TRACHEA: When anticipated difficulty in mask ventilation or intubation is present such as obesity, short neck, neck mass, history of previous surgery, radiotherapy to neck etc., location of trachea is itself a challenge if especially seeking a surgical airway becomes necessary.

Hence in this emergency visualization of trachea using ultrasound is very useful.

G) LOCALIZATION OF THE CTM: The success rate in identification of the cricothyroid membrane based on landmark is 30%. Ultrasound identification is easier. In awake patients it is easier to localise the trachea before intubation. Hence it helps in emergency trans-cricoid axis if necessary. In obese patients or in patients with Ludwig's angina etc., the tracheal identification becomes easier with ultrasonography. The cricothyroid membrane is identified like an echogenic artefact with cricothyroid muscle laterally and thyroid cartilage cephalad.

H) AIRWAY RELATED NERVE BLOCKS: Ultrasound is used to block superior laryngeal nerve as a part of preparation for fibre optic intubation. Greater horn of hyoid bone and superior laryngeal artery are identified, and the local anaesthetic is injected in between.

I) CONFIRMATION OF ET TUBE PLACEMENT: The position of the ET tube can be identified in real time by screening the anterior neck during intubation. Indirect confirmation of the endotracheal intubation is by looking at the pleura or diaphragm or both. Hence oesophageal intubation is identified immediately before initiating ventilation. The advantage over capnography is that they are applied in very low cardiac output states.

J) TRACHEOSTOMY: Localisation of the trachea in the absence of surface landmarks is difficult. Preoperative ultrasonography for locating the trachea is suitable both for surgical and percutaneous dilatational tracheostomy. In children this is useful in locating the precise tracheostomy position thus avoiding sub glottic damage.

K) PERCUTANEOUS DILATATIONAL TRACHEOSTOMY

L) CONFIRMATION OF GASTRIC TUBE PLACEMENT

M) DIAGNOSIS OF PNEUMOTHORAX

N) DIFFERNETIATING LUNG AND PLEURAL PATHOLOGY

O) PREDICTING OF SUCCESSFUL EXTUBATION: The width of the air column when the transducer is placed on the cricothyroid membrane predicted the post extubation stridor. The functions of the respiratory muscles were predicted.

Thus, the ultrasonography is developing with its own merits and demerits in the airway management.

REVIEW OF LITERATURE

1. The study titled **Ultrasound of the airway** from Indian Journal of Anaesthesia conducted by Pankaj Kundra, Sandeep Kumar Mishra, Anathakrishnan Ramesh1, currently explains the role of ultrasound (US) in anaesthesia-related airway assessment and procedural interventions is encouraging, though it is still ill defined. Ultrasound can visualise anatomical structures in the supraglottic, glottic and subglottic regions. The floor of the mouth can be visualised by both transcutaneous view of the neck and by transoral or sublingual views. However, imaging the epiglottis can be challenging as it is suspended in air. Ultrasound may detect signs suggestive of difficult intubation, but the data are limited. Other possible applications in airway management include confirmation of correct endotracheal tube placement, prediction of post-extubation stridor, evaluation of soft tissue masses in the neck prior to intubation, assessment of subglottic diameter for determination of paediatric endotracheal tube size and percutaneous dilatational tracheostomy. With development of better probes, high-resolution imaging, real-time picture and clinical experience, Ultrasound has become the potential first-line non-invasive airway assessment tool in anaesthesia and critical care.

2. The study titled "**Upper airway imaging and its role in preoperative airway evaluation"** conducted by Jagadish G. Sutagatti, Madhuri S. Kurdi from Medical Journal of Dr.D.Y.Patil University reviews the various approaches to upper airway ultrasound imaging, interpretation of the images, limitations and disadvantages of the technique and its varied clinical applications in the preoperative period.

3. The study titled **Ultrasonography - A viable tool for airway assessment** conducted by Preethi B Reddy, Pankaj Punetha , Kolli S Chalam from Indian Journal of Anaesthesia reinforced that accurate prediction of the Cormack-Lehane (CL) grade preoperatively can help in better airway management of the patient during induction of anaesthesia. Our aim was to determine the utility of ultrasonography in predicting CL grade.

4. The study titled "**Use of Sonography for Airway Assessment**" conducted by Mandeep Singh, MBBS, MD, Ki Jinn Chin, MBBS, FANZCA, MMed, FRCPC,Vincent W. S. Chan, MD, FRCPC, David T. Wong, MD, Govindarajulu A. Prasad, MBBS, DA, FRCA, Eugene Yu, MD, FRCPC from American Institute of Ultrasound in Medicine analysed that they were able to visualize all relevant anatomic structures in all of the participants using either a linear or curved transducer oriented in 1 of 3 planes: sagittal, parasagittal, and transverse. Bony

structures (eg, the mandible and hyoid) were brightly hyperechoic with an underlying hypoechoic acoustic shadow. Cartilaginous structures (eg, the epiglottis, thyroid cartilage, cricoid cartilage, and tracheal rings) were hypoechoic, and their intraluminal surface was outlined by a bright air-mucosa interface. The vocal cords were readily visualized through the thyroid cartilage. However, the posterior pharynx, posterior commissure, and posterior wall of the trachea could not be visualized because of artefacts created by an intraluminal air column and thus concluded that Sonography of the upper airway is capable of providing detailed anatomic information and has numerous potential clinical applications.

5. The study titled "**Airway assessment: predictors of difficult airway**" conducted by Dr. Sunanda Gupta, Dr. Rajesh Sharma KR , Dr.Dimpel Jain from Indian Journal of Anaesthesia studied the various clinical parameters for prediction of difficult airway and concluded that no single airway test can provide a high index of sensitivity and specificity for prediction of difficult airway.Therefore it has to be a combination of multiple tests. It must be recognized, however, that some patients with a difficult airway will remain undetected despite the most careful preoperative airway evaluation. Thus, anaesthesiologists must always

be prepared with a variety of preformulated and practiced plans for airway management in the event of an unanticipated difficult airway.

6. The study titled "**A feasibility study on bedside upper airway ultrasonography compared to waveform capnography for verifying endotracheal tube location after intubation**" conducted by Osman Adi, Tan Wan Chuan and Manikam Rishya from Critical ultrasound Journal studied about in emergency settings, verification of endotracheal tube (ETT) location is important for critically ill patients. Ignorance of oesophageal intubation can be disastrous. Many methods are used for verification of the endotracheal tube location but none are ideal. Quantitative waveform capnography is considered the standard of care for this purpose but is not always available and is expensive. Therefore, this feasibility study is conducted to compare a cheaper alternative, bedside upper airway ultrasonography to waveform capnography, for verification of endotracheal tube location after intubation. This study concluded that ultrasonography can replace waveform capnography in confirming ETT placement in centres without capnography. This can reduce incidence of unrecognised oesophageal intubation and prevent morbidity and mortality.

MATERIALS AND METHODS

METHODOLOGY

After obtaining approval from Institute ethical committee and getting written informed consent, **150** adult patients undergoing elective surgery requiring general Anaesthesia were chosen. The study is a prospective randomized study where both the clinical airway assessment parameters and ultrasonographic parameters were noted and they were compared. Additional airway related parameters were also observed.

1. **Inclusion criteria:** Adult patients 18- 60yrs, undergoing elective surgeries, requiring general anaesthesia, both sexes were included.
2. **Exclusion criteria:** Patients with facio maxillary trauma, fractures in bones of the face, BMI >= 40 kg/m2, patients with restricted neck movements.

Preoperative evaluation of the patient was done prior to surgery. The airway assessment was done in two stages. The modified mallampatti class was noted by asking the patient to protrude the tongue and not to phonate.

Thyromental distance was noted from mentum to the thyroid notch with full neck extension.

Sternomental distance was noted from suprasternal notch to the mentum with neck fully extended.

Hyomental distance was noted from the hyoid bone to the mentum.

Neck circumference was measured using an inch tape at the level of midpoint between the angle of mandible and the shoulder with head in neutral position.

The ultrasonographic measurements were done using sonosite turbo ultrasound system with high frequency linear probe (6 to 15 MHz), low frequency curvilinear probe (2 -6 MHz).

In the transverse view, the width of the tongue, cross sectional area of floor of mouth, the anterior neck soft tissue and the skin to epiglottis distance and the related parameter were noted.

In the sagittal view mentohyoid distance, the strap muscle, the thyrohyoid membrane, cricothyroid membrane, thyroid cartilage and surrounding structures are visualized.

PARAMETERS TO BE MONITORED:

CLINICAL PARAMETERS:

1. Modified mallampati grading
2. Mouth opening
3. Hyomental distance
4. Thyromental distance
5. Neck circumference

ULTRASONOGRAPHIC PARAMETERS:

TRANSVERSE VIEW:

1. Width of the tongue
2. Cross sectional area of the floor of the mouth
3. Anteroposterior thickness of the geniohyoid muscle
4. Skin to hyoid distance
5. Skin to epiglottis distance

MID – SAGITTAL VIEW

1. Cross sectional area of the tongue
2. Mento hyoid distance

CORMACK – LEHANE GRADING – I, II, III, IV

All the patients were induced and intubated by an anaesthesiologist. Direct laryngoscopy was performed using a Macintosh blade size 3 or size 4 or Mccoy blade according to the patient and Cormack Lehane grade was noted. Appropriate sized endotracheal tube was used and anaesthesia maintained.

STATISTICAL ANALYSIS

Total sample size was arrived to be 150 for a power of 80%.
The target significance was .05.

- The distribution of Cormack Lehane grade is compared with US parameters, Mallampati class, TMD – thyromental distance and sterno mental distance.

- The chi-square test used to determine the significance in categorical data comparing 4 CL grades with the clinical parameters and ultrasonographic parameter.

- The one-way ANOVA was used to compare the continuous data for the four groups.

- The students unpaired t test used for continuous data.

- The sensitivity, specificity, positive predictive value and negative predictive value is to be calculated for all parameters in prediction of difficult intubation.

- The Receiver operator characteristics curve (ROC) is to be plotted at the end of the study and the area under the curve is used to assess the prognostic accuracy.

The MS Excel and SPSS software packages were used for data entry and analysis.The results were averaged (mean ± standard deviation [SD]) for each parameter for continuous data .The Chi-square test was used to determine whether there was a statistical difference between the patients with easy and difficult intubations. The predictive value of the tests was assessed by calculating the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV). To assess the optimal cut-off scores, a Reciever operator characteristics (ROC) curve was plotted and the area under the curve was calculated to assess the prognostic accuracy.

TABLE 1 : Comparison of ultrasound parameters and Cormack – lehane CL grade

PARAMETER	CL GRADE	N	MEAN	SD	P value
ANS- HYOID	1	61	0.36	0.07	P=0.46 Not significant
	2	62	0.36	0.07	
	3	24	0.39	0.07	
	4	3	0.38	0.07	
ANS-VC	1	61	0.26	0.08	P=0.000 Highly significant
	2	62	0.25	0.08	
	3	24	0.41	0.08	
	4	3	0.39	0.08	
PRE-E	1	61	0.95	0.11	P=0.000 Highly significant
	2	62	1.11	0.11	
	3	24	1.03	0.11	
	4	3	1.04	0.12	
E-VC	1	61	0.94	0.08	P=0.000 Highly significant
	2	62	0.87	0.08	
	3	24	0.86	0.08	
	4	3	0.86	0.08	
PRE-E/E-VC	1	61	1.02	0.17	P=0.0001 Highly significant
	2	62	1.27	0.17	
	3	24	1.21	0.17	
	4	3	1.21	0.18	

TABLE 2 : Distribution of Cormack- Lehane according to Mallampatti grading

MP CLASS	CL GRADE,NUMBER (%)				TOTAL	X^2	P value
	1	2	3	4			
Class 1	15(10)	19(12.7)	2(1.3)	0	36(24.1)	X^2 =95.198 P=0.0001 Highly significant	
Class 2	35(23.3)	35(23.3)	6(4)	0	76(50.6)		
Class 3	11(7.3)	8(5.33)	15(10)	1(0.66)	35(23.3)		
Class 4	0	0	1(0.66)	2(1.3)	3(2)		
total	61(40.6)	62(41.4)	24(16)	3(2)	150(100)		

TABLE 3 : DISTRIBUTION OF CORMACK- LEHANE ACCORDING TO THYROMENTAL DISTANCE

TMD in cm	Cl grade – number (percentage)				Total	X^2	P value
	1	2	3	4			
<6cm	1(0.7)	0	0	1(0.7)	2(1.4)	X^2 =33.345 P=0.0001 Highly significant	
6.0-6.5	4(2.6)	5(3.3)	6(4.0)	1(0.7)	16(10.6)		
>6.5	56(37.3)	57(38.0)	18(12.0)	1(0.7)	132(88.0)		
Total	61(40.6)	62(41.3)	24(16.0)	3(2.1)	150(100)		

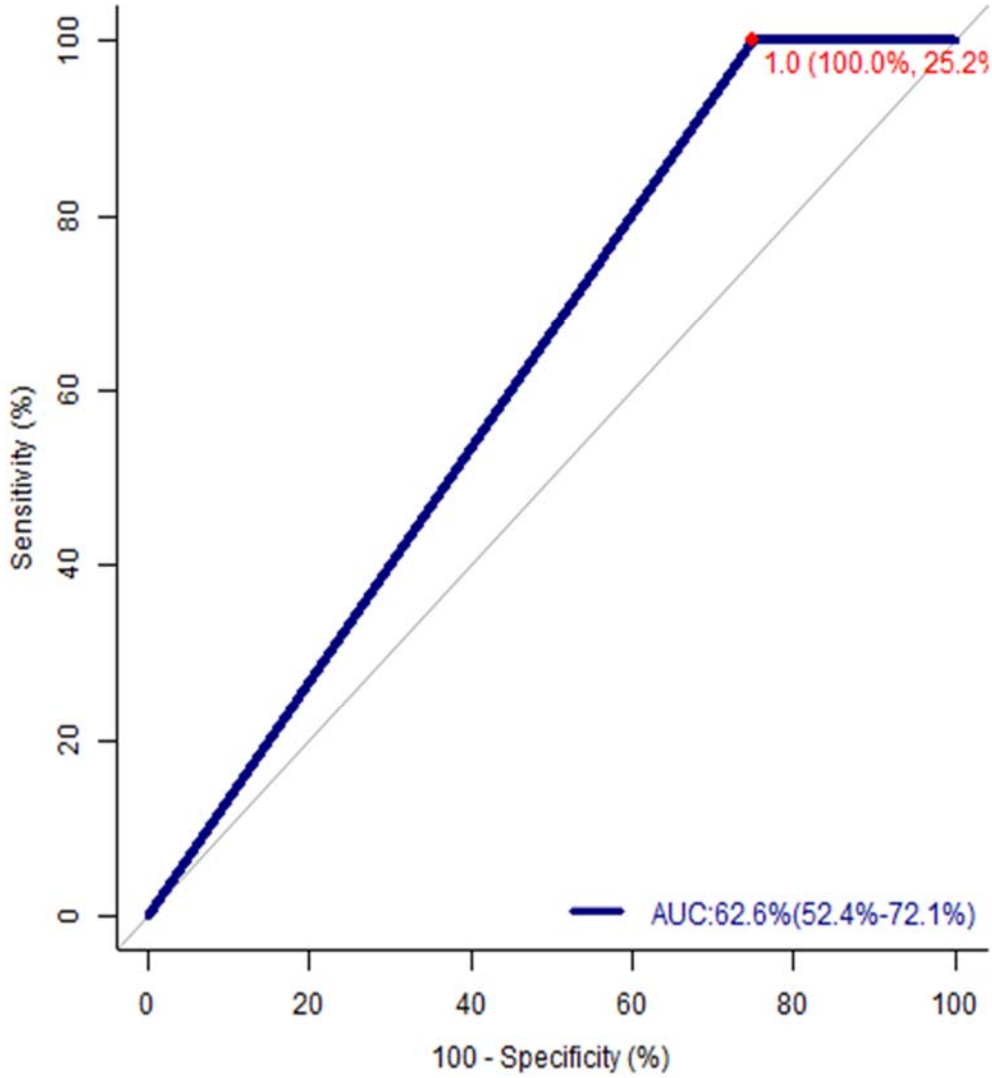
Table 4 Distribution of Cormack-Lehane (CL) grade according to sternomental distance (SMD)

PSMD	CLASS GRADE NUMBER %				TOTAL	X^2	PVALUE
	1	2	3	4			
<12.5	**0**	**0**	**4(2.6)**	**2(1.4)**	**6(4.0)**	X^2 =20.219 P=0.0001 Highly significant	
>12.5	**59(39.4)**	**69(46)**	**15(10)**	**1(0.6)**	**144(96)**		
TOTAL	**59(39.4)**	**69(46)**	**19(12.6)**	**3(2.0)**	**150(100)**		

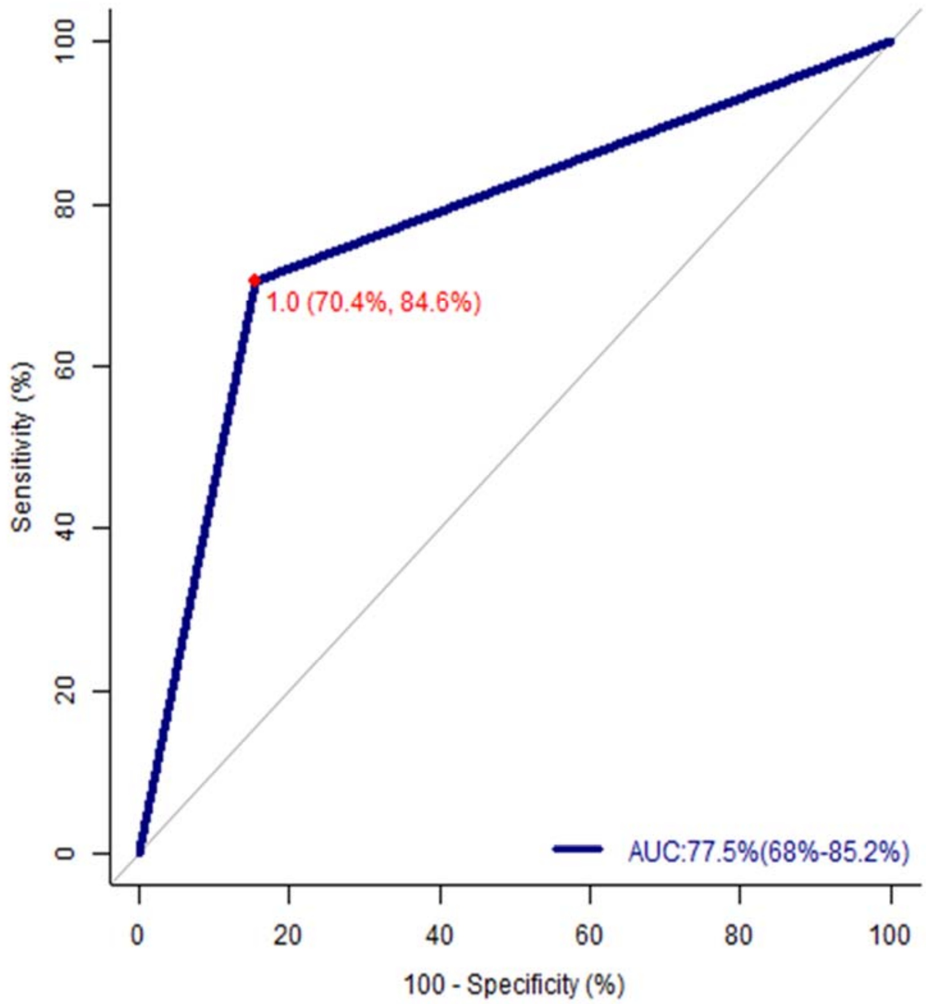
Table 6 : Comparison of ultrasonographic measurements in predicting the Cormack – Lehane (CL) grade

PARAMETER	SENSITIVITY (%)	SPECIFICITY (%)	PPV (%)	NPV (%)
ANS VC > 0.23CM	100	25.2	22.7	100
PRE-E/E-VC 2-3	0	100	-	82.0
MP CLASSS >3	70.3	84.5	50.0	92.8
TMD <6.5 CM	29.6	91.8	44.4	85.6
SMD ≤12.5CM	18.5	99.1	83.3	84.7

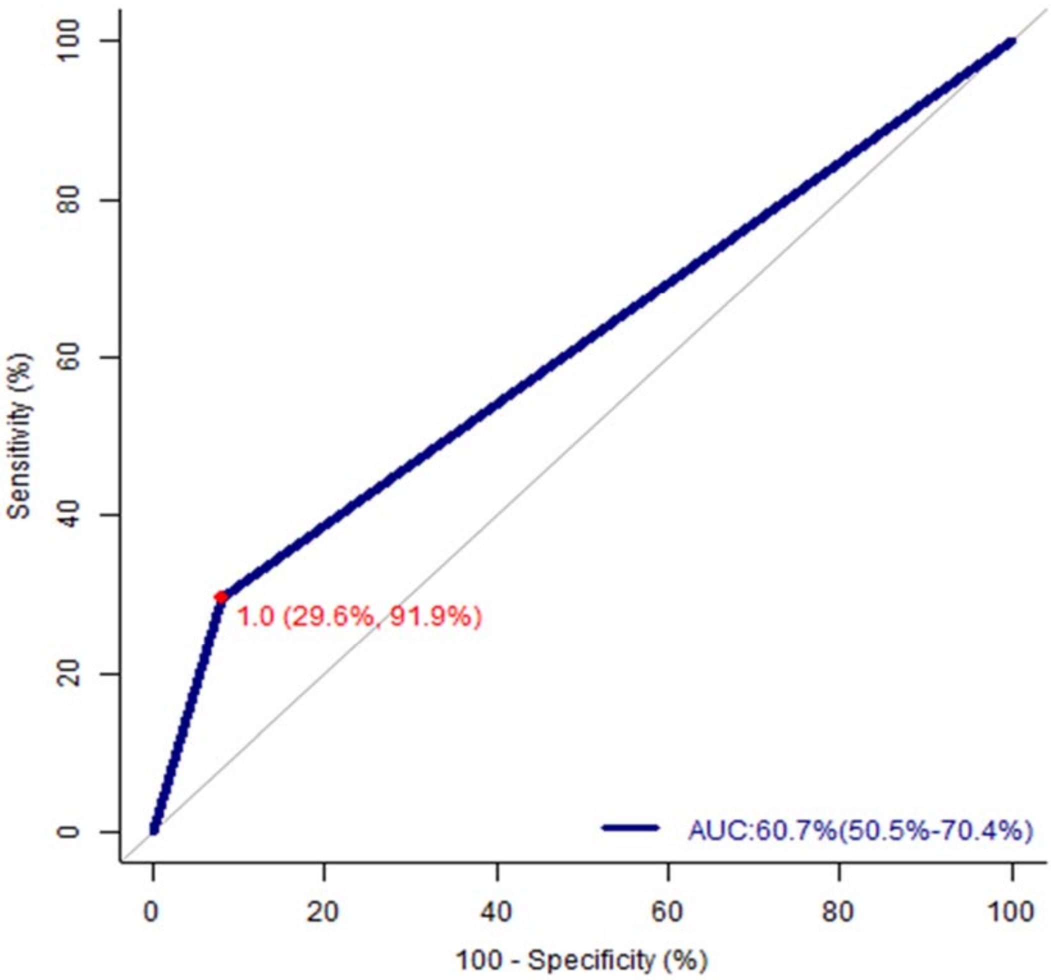
RECIEVER OPERATOR CHARACTERISTIC CURVE – FOR ANTERIOR NECK SOFT TISUUE AT THE LEVEL OF VOCAL CORD



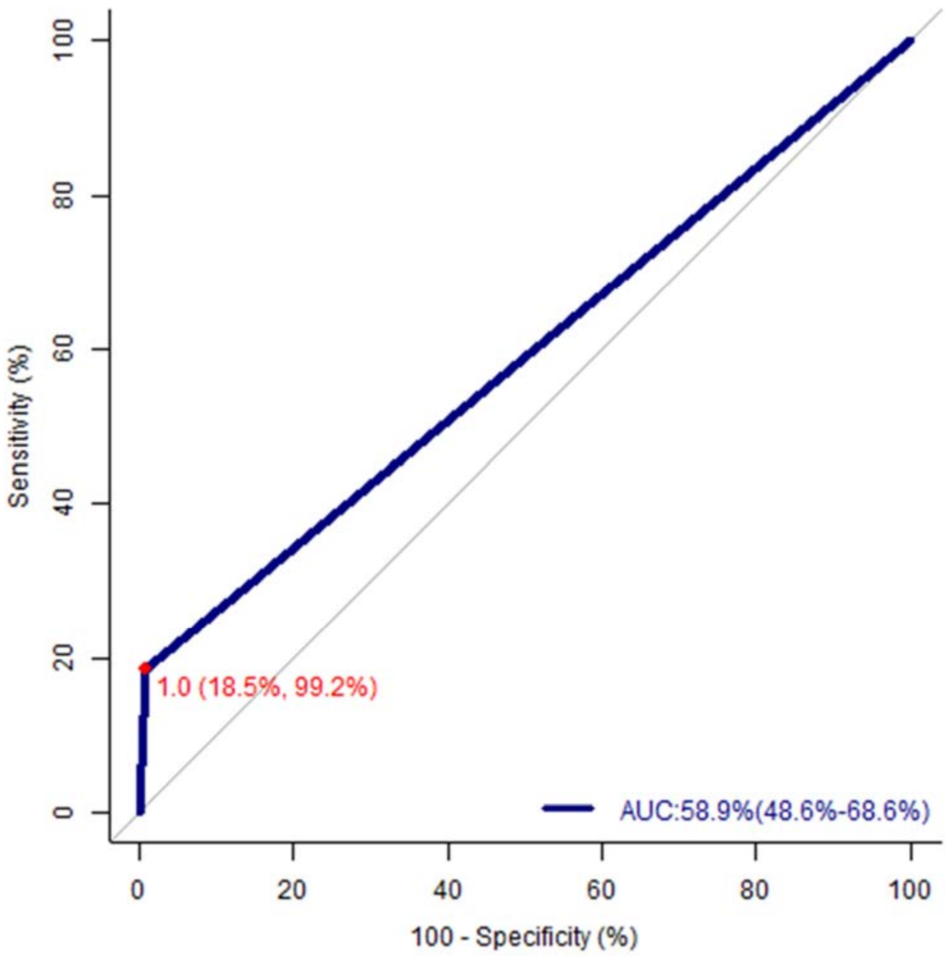
RECIEVER OPERATOR CHARACTERISTIC CURVE FOR MAMALLAMPATTI CLASS



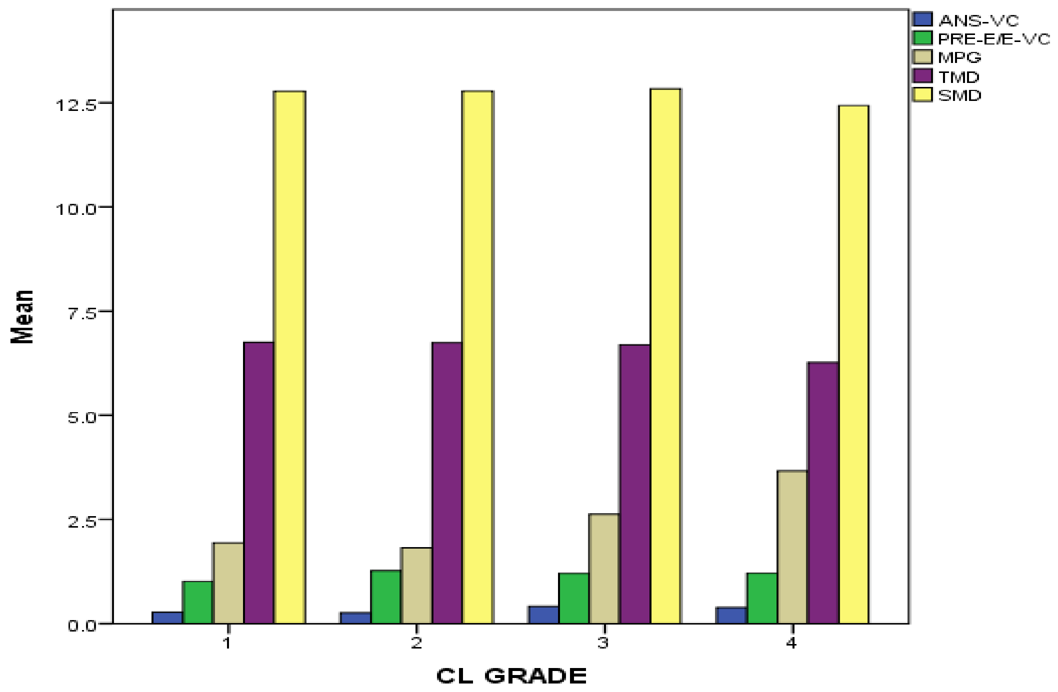
RECIEVER OPERATOR CHARACTERISTIC CURVE FOR THYRO MENTAL DISTANCE

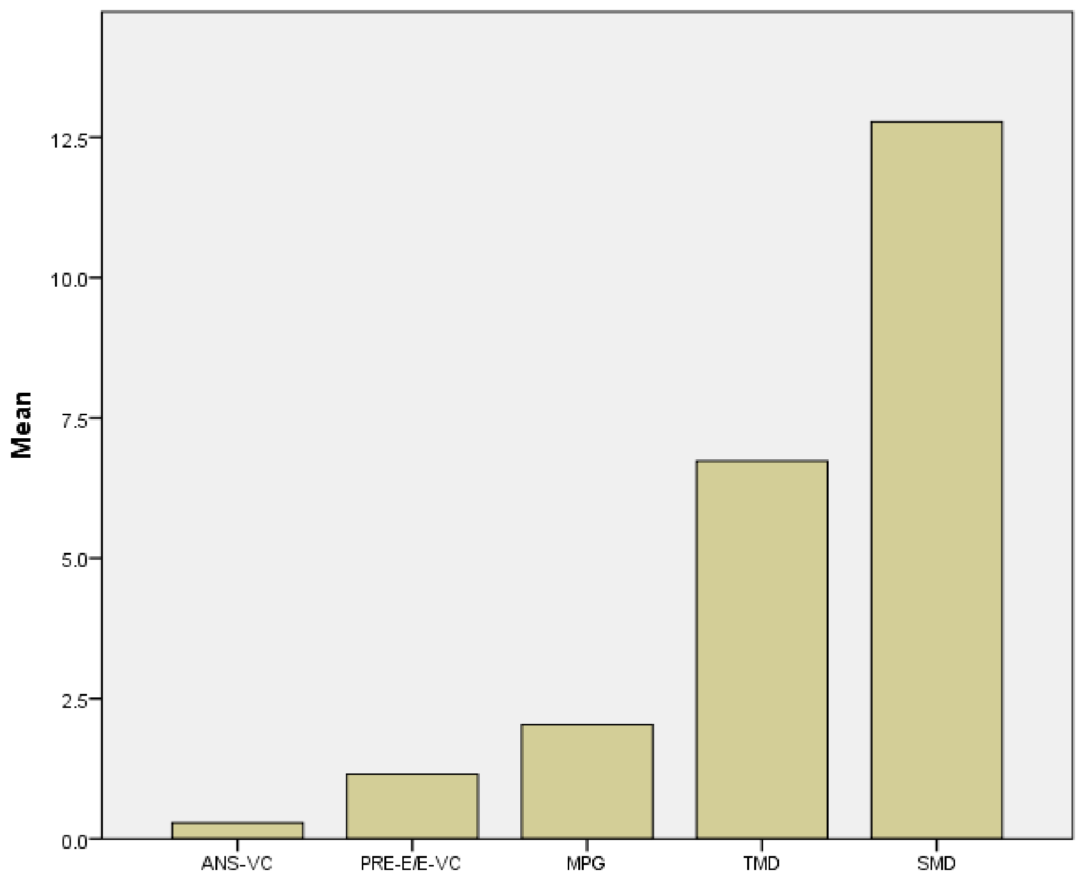


RECIEVER OPERATOR CHARACTERISTIC CURVE FOR STERNOMENTAL DISTANCE



BAR DIAGRAMS FOR ULTRASONOGRAPHIC PARAMETERS





RESULTS

One hundred and fifty adult patients undergoing elective surgery under general anaesthesia by endotracheal intubation are included in the study. The study included population aged between 18 to 60 years with 74% male patients and 35.5% female patients. The BMI- Body mass index of the study population ranged from 21.63 to 34.89 kg/m^2. 40% of patients belonged to Cormack Lehane grade I. 41.3% of patients belonged to Cormack Lehane grade II. 16% of the patients belonged to Cormack Lehane grade III and the remaining 2% of the population belonged to grade IV.

The distribution of Cormack Lehane grade was compared with the ultrasound parameters i.e., ANS-HYOID (Anterior neck soft tissue – at the level of hyoid), ANS –VC (Anterior neck soft tissue – vocal cord) , PRE-E (Pre-epiglottic space), E-VC (Epiglottis to vocal cord distance) ,PRE-E/E-VC. The four groups in Cormack Lehane grade was analysed comparing with each of the parameters. The Anterior neck soft tissue at the hyoid level was not significant with p value 0.46 and hence it suggests that it does not correlate with Cormack Lehane grading. The anterior neck soft tissue at the vocal cord level was calculated and the analysis with Cormack Lehane grading suggests that it is statistically significant with p value less than 0.001. Hence it correlates with Cormack Lehane grade. The distance from skin to epiglottis which is Pre epiglottic space distance (p value < 0.001), epiglottis to vocal cord distance (E-VC - p value <0.001) and the ratio of Pre-Epiglottis space and epiglottis to Vocal cord distance is also statistically significant.Their ratio is also statistically significant.Hence these values are found to predict difficult intubation.

The distribution of Cormack Lehane grading was compared to Mallampatti grading, thyromental distance and sternomental distance. The analysis was statistically significant and thus it indicates that there is correlation between these parameters and CL grading.

The sensitivity was defined here as true positivity that is it indicates that the parameter indicates difficult intubation and the CL grade also indicates difficult intubation (CL 2/3). The specificity – true negative is that the parameter indicates easy intubation and the CL grade is also suggestive of easy intubation (CL 1/2) .Using this positive and negative predictive value was calculated. Using the sensitivity and specificity Receiver operator characteristic curve was drawn for ANS VC, Thyromental distance, sternomental distance and for Mallampatti grading.

The hyomental distance was calculated for all patients. It was found that out of 123 patients who had CL grade 1/2, 110 had HMD > 5.5 cm (89.4%) . The patients with CL grade 3/4, HMD was less than 5.5cm for 23 population (85.2%)

The neck circumference was measured. Out of the population with difficult intubation, 20(74%) had neck circumference more than 40cm.

Using ultrasound the width of the tongue was measured. The history of choking during sleeping was elicited. 15 patients gave history of OSA in them, 10 people had width more than 6.0 cm.

Thus the statistical analysis showed that all the ultrasonography parameters ANS-VC, PRE-E, E-VC and PRE-E / E-VC were found to be significantly in correlating with the Cormack Lehane grading.

DISCUSSION

Ultrasound has now become the part of the anaesthesiologists work to facilitate the various procedures. Imaging the airway has now become the new application after regional nerve blocks.

Other applications include the predicting the size of the endotracheal tube in paediatric age group, predicting the size of the double lumen tube, confirming the position of the endotracheal tube, diagnosing other upper airway tumours and growth, any suggestion of obstruction, locating the cricothyroid membrane and thus acting as guidance for percutaneous dilatational tracheostomy and cricothyroidotomy for performing the nerve blocks for preparation for awake intubation. In paediatric age groups it helps in the identification of sub-glottic stenosis and also for predicting the post extubation stridor. The position of the laryngeal mask airway can also be confirmed by ultrasound.

The other uses include assessing the size of the tongue, floor of the mouth muscles, Pre-epiglottis, Epiglottis-Vocal Cord and anterior neck soft tissue thickness and their clinical correlation. Inability to see the hyoid bone while screening indicates difficult intubation in the subject.

In my study, the Anterior Neck Soft tissue – Vocal Cord is a potential guide for assessing the airway and increased thickness had 100% sensitivity in predicting the difficult intubation. The pre epiglottic soft tissue thickness was also found to be statistically significant. Hence this also predicted difficult intubation. The epiglottis to vocal cord distance was also significant. The ratio of the distances was found to be statistically significant.

In my study the Anterior Neck Soft tissue – HYOID distance was not statistically significant (p value – 0.46). Previous studies had showed conflicting results in this as well as pre epiglottic distance parameter. This was probably due to difference in the population group.

Among clinical parameters in my study, the Mallampatti class, Thyromental distance and Sternomental distance had a significant value (p value < 0.0001) for predicting the difficult intubation (CL grade 3 / 4).

In my study amongst all parameters, Anterior Neck Soft tissue- Vocal cord distance had the highest sensitivity more than the clinical parameters. But its specificity was lower than the clinical parameters. Out of the clinical parameters, Sternomental distance had the highest specificity. Negative predictive value was highest for Anterior neck soft tissue – Vocal cord followed by Mallampatti class. Pre – Epiglottis / Epiglottis- Vocal Cord was useful in predicting difficult intubation. But it had very low sensitivity. Specificity was high. The clinical parameter Mallampatti class had high specificity and negative predictive value. The ultrasound parameter Anterior Neck Soft tissue – Hyoid distance was not a useful indicator.

LIMITATIONS

a. Only very few population had a BMI of more than 30kg/m^2. Hence if I had included a larger population with obese individuals my parameters may have been different and difficult to elicit.

b. I did not include paediatric age group.

Patients with dentition problems, facial abnormalities, trauma were not included in my study. The age, increased BMI, the dentition problems do not correlate with the Cormack Lehane grading.

Thus ultrasound is emerging as a tool for airway assessment both in pre operative patients and also in critical care.

CONCLUSION

Ultrasonographic measurement of the Anterior neck soft tissue -Vocal Cord is thus an excellent predictor of difficult intubation. The higher the value is the most sensitive physical parameter compared to other clinical parameters such as Mallampatti class, Thyromental distance and Sternomental distance in predicting difficult intubation. Measurement of Anterior neck soft tissue -Hyoid is not a useful indicator in predicting difficult intubation. Thus the parameters can be used to predict the difficulty which was until now quantified by the traditional Cormack- Lehane grading.

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PROFORMA

NAME: **I.P.NO:** **ASA:**

AGE & SEX:

WEIGHT:

DATE & TIME OF ADMISSION: **DATE&**

TIME OF

DISCHARGE:

DIAGNOSIS:

PROCEDURE:

HISTORY:

CLINICAL EXAMINATION: PR, BP, SPO2, RS, CVS, P/A, CNS

AIRWAY ASSESSMENT:

CLINICAL ASSESSMENT:

1.Modified mallampati grading

2.Mouth opening

3.Hyomental distance

4.Thyromental distance

5.Neck circumference

ULTRASONOGRAPHIC ASSESSMENT:

TRANSVERSE VIEW:

1. Width of the tongue
2. Cross sectional area of the floor of the mouth
3. Anteroposterior thickness of the geniohyoid muscle
4. Anterior neck soft tissue -

   At hyoid level

   At vocal cord level
5. Skin to epiglottis distance – Pre epiglottic space
6. Vocal cord to epiglottis distance

MID – SAGITTAL VIEW

7. Cross sectional area of the tongue
8. Mento hyoid distance

- TONGUE VOLUME – (PRODUCT OF MID SAGITTAL CS OF THE TONGUE AND THE WIDTH OF THE TONGUE)
- MUSCLE VOLUME OF THE FLOOR OF THE MOUTH – (PRODUCT OF THE CS OF THE MUSCLES OF THE FLOOR OF THE MOUTH AND THE HYOMENTAL DISTANCE)

PREDICTION OF EASE OF AIRWAY –

- DURING INTUBATION THE CORMACK LEHANE SCORING – 1/2/3/4

QUESTIONAIRRES USED IN THE STUDY

1) H/O facial trauma or fracture of facial bones

2) Patient details

3) Surgery details.

MASTER CHART

SL NO	NAME	AGE	SEX	I P NO	ASA	WEIGHT(kgs)	HEIGHT(in cms)	BMI	CL GRADE	MPG	HMD(in cms)	SMD(in cms)	TMD
1	MUNUSAMY	34	M	7634	I	67	163	25.22	1	1	5.6	12.6	6.7
2	KANDASAMY	42	M	4321	II	70	155	29.14	2	1	6.3	12.8	6.6
3	SELVAM	37	F	2431	II	63	159	24.92	3	3	5.6	13.3	6.7
4	MARUTHU	38	M	12300	I	55	149	24.77	1	1	5.8	12.9	6.9
5	SELVI	28	F	4537	II	69	144	33.28	2	2	5.9	12.7	6.7
6	KANNAN	43	M	2367	I	60	155	24.97	1	2	6.1	12.8	6.8
7	THIRUMURGAN	39	M	3467	II	65	157	26.37	3	3	4.9	13.1	6.8
8	MAYILU	40	F	9856	II	55	149	24.77	1	2	6.0	12.7	6.6
9	KANDAN	42	M	23190	III	64	157	25.96	2	1	5.7	12.9	6.8
10	ARUNA	30	F	3457	I	70	149	31.53	1	1	5.8	12.8	6.7
11	KUPPAN	42	M	5671	I	57	149	25.67	2	2	6.3	13.0	6.4
12	AERUMUGAM	47	M	2814	II	60	154	25.30	1	1	6.2	12.8	6.2
13	TAMILARASI	42	F	3498	II	63	159	24.92	3	2	5.3	13.2	6.9
14	MARUTHU	37	M	6789	I	59	148	26.94	1	3	5.3	12.6	6.8
15	RAVIKUMAR	43	M	4561	II	58	154	24.46	2	1	5.4	12.9	6.9
16	SIVA	33	M	9823	I	66	160	25.78	1	2	5.7	12.7	6.9
17	SEKAR	42	M	12067	II	64	161	24.69	2	2	5.4	12.9	6.8
18	SELVAMANI	25	M	4209	I	70	149	31.53	1	2	5.9	12.6	6.8
19	GANESHAN	39	M	21067	II	61	155	25.39	2	2	6.1	12.8	6.7
20	KRISHNAN	27	M	4097	I	48	144	23.15	2	2	5.9	12.7	6.5
21	RAJEN	39	M	2315	II	51	144	24.59	1	3	5.7	13.0	6.4

22	KUMAR	29	M	1230	II	75	154	31.62	2	1	5.8	12.7	6.6
23	PONDITHURAI	33	M	2390	II	68	148	31.04	4	3	5.4	12.0	5.8
24	PONDIAMMAL	42	F	3489	III	55	150	24.44	1	1	6.0	12.9	6.7
25	MANGAIAMMAL	38	F	4587	I	44	140	22.45	2	2	6.2	12.8	6.7
26	DURAIPONDI	41	M	9871	II	56	152	24.24	1	3	5.8	12.7	7.0
27	MANNAGATTI	49	M	8723	II	59	153	25.20	2	3	5.9	12.9	6.3
28	VELLATHAYE	43	M	7645	I	63	161	24.30	1	2	6.0	13.0	6.8
29	KARUPPAYE	47	F	1298	II	61	155	25.39	2	1	5.6	12.8	6.8
30	KARUPPANAN	39	M	3409	II	76	150	33.78	3	3	4.8	13.0	6.7
31	MUTHUPONDY	44	M	6709	I	58	149	26.12	1	2	6.1	12.7	6.9
32	THANGAMANI	42	F	3412	I	86	157	34.89	2	2	5.9	12.8	6.9
33	BALAMURUGAN	37	M	2341	II	44	139	22.77	1	1	6.4	12.6	5.8
34	MUTHUKUMARASAMY	44	M	8745	I	71	168	25.16	2	3	5.7	12.9	6.7
35	MUTHU	33	M	5490	II	64	159	25.32	2	2	6.0	12.7	6.8
36	RANI	47	F	5478	II	65	149	29.28	1	2	5.9	12.8	6.7
37	MANGAMMAL	48	F	12987	I	63	158	25.24	2	2	5.6	12.7	6.2
38	BRINDHA	37	F	2309	I	50	149	22.52	3	2	5.2	12.9	6.3
39	MUTHUPACHI	50	F	21876	II	67	164	24.91	1	2	5.8	12.6	6.8
40	BAVATHARANI	38	F	3487	II	87	184	25.70	2	2	6.3	12.9	6.8
41	SOORPANAGAI	47	F	11987	I	52	149	23.42	2	2	6.2	12.8	6.9
42	SANKAR PONDY	38	M	7654	II	51	148	23.28	1	1	5.9	12.6	6.9
43	KUTTAPPAN	49	M	13789	II	63	157	25.56	2	1	5.8	12.7	6.8
44	SUNDARARAJAN	47	M	14876	I	70	163	26.35	2	2	5.4	12.7	6.6
45	SUNDARAPONDY	46	M	3456	II	83	159	32.83	3	3	5.0	11.8	7.0
46	MAGHIZHAVANI	39	F	2109	III	62	158	24.84	1	3	5.9	12.8	6.7
47	THAMIZHARASI	45	F	3487	I	57	150	25.33	2	3	6.4	12.9	6.7
48	SURIYA	39	M	7654	II	75	147	34.71	2	2	5.3	13.0	6.8

49	RAVICHANDRAN	36	M	5698	II	59	158	23.63	1	2	5.9	12.5	6.6
50	ASOKAN	48	M	1237	I	64	163	24.09	2	1	5.7	12.8	6.1
51	ANANDHAN	45	M	9876	II	68	167	24.38	2	2	5.6	12.9	6.7
52	TAMIL	44	M	3409	II	59	158	23.63	1	2	5.9	12.7	6.4
53	TAMILARASAN	39	M	5678	I	70	165	25.71	3	3	4.8	12.8	6.1
54	PRIYA	49	F	1234	II	55	149	24.77	2	2	5.8	12.6	6.9
55	VADIVU	48	F	7654	II	63	161	24.30	1	2	6.4	12.8	6.9
56	BHAVANI	37	F	3421	I	54	153	23.07	1	2	6.0	12.7	7.0
57	MAGA	39	F	9067	I	58	154	24.46	2	2	5.8	12.6	6.8
58	SEETHA	49	F	8945	II	71	168	25.16	1	2	5.5	12.8	6.9
59	DEVI	38	F	7834	I	55	154	23.19	2	2	5.6	12.9	6.7
60	RANI	46	F	6712	II	59	158	23.63	1	3	5.9	12.7	6.8
61	RAJA	39	M	4509	I	54	153	23.07	3	1	5.3	13.0	6.8
62	RAMU	29	M	3421	I	48	147	22.21	1	2	6.1	12.8	6.9
63	VARADHAN	33	M	6734	II	54	153	23.07	2	1	5.4	12.6	6.9
64	DURAI	49	M	2345	II	63	160	24.61	2	2	6.0	12.9	6.8
65	PANDI	44	M	3456	III	58	155	24.14	1	2	6.4	12.8	6.7
66	MARI	29	M	9874	II	50	149	22.52	2	3	5.9	12.7	6.9
67	MUTHUMARI	27	M	2345	II	54	153	23.07	2	2	6.0	12.8	6.8
68	SARASWATHY	36	F	9067	I	62	159	24.52	1	2	5.8	12.6	6.8
69	SARASU	25	F	1239	I	45	143	22.01	2	2	6.1	12.7	6.7
70	VIKRAM	29	M	6723	II	66	164	24.54	3	3	5.4	13.3	6.9
71	PRAVEEN	24	M	5421	I	59	158	23.63	1	1	5.7	12.9	6.9
72	RAGHUL	37	M	9823	I	66	165	24.24	2	2	5.9	12.6	6.8
73	ARUN	44	M	9834	II	70	169	24.51	2	1	5.5	12.7	6.9
74	GOWTHAM	33	M	5612	II	53	150	23.56	1	2	5.7	12.8	6.7
75	VASU	41	M	3206	I	54	150	24.00	2	2	5.8	12.9	6.8

76	DEVAN	25	M	7692	III	49	144	23.63	2	1	5.4	12.7	6.7
77	RAMAKRISHANAN	44	M	4501	I	64	163	24.09	1	2	5.9	12.9	6.4
78	VENU	37	M	3231	II	63	160	24.61	2	2	6.0	12.7	6.8
79	GOPU	50	M	9823	II	71	165	26.08	1	2	6.1	12.6	6.8
80	SUNDAR	46	M	5671	I	73	170	25.26	2	1	5.8	12.9	6.7
81	SRIDHAR	39	M	9834	II	69	165	25.34	1	2	6.4	12.6	6.7
82	PAVITHRA	29	F	1205	II	59	154	24.88	3	4	5.1	13.1	6.8
83	ANITHA	28	F	8833	I	62	159	24.52	2	2	5.9	12.8	6.8
84	NISHANTHI	25	F	7722	I	58	153	24.78	2	3	5.6	12.9	6.9
85	DEELAPAN	30	M	6600	II	66	164	24.54	1	3	5.9	12.7	6.9
86	KALA	41	F	5599	II	69	165	25.34	3	3	4.9	12.0	6.7
87	PRABHU	39	M	4477	II	61	159	24.13	2	2	5.8	12.6	6.8
88	PRABHAKARAN	33	M	2298	III	62	158	24.84	1	1	6.1	12.9	6.8
89	RAJENDRAN	30	M	3098	I	64	162	24.39	3	1	5.6	12.9	6.2
90	LAKSHMI	47	F	2109	I	73	169	25.56	2	1	6.0	12.6	6.7
91	SANGAMITHIRAI	37	F	2387	I	61	159	24.13	1	2	5.5	12.8	6.7
92	SEETHALAKSHMI	44	F	6781	II	76	164	28.26	3	2	5.5	12.6	6.8
93	LAKSHMIKANTHAN	29	M	3421	II	60	159	23.73	3	3	4.9	12.2	6.9
94	KANTHI	39	M	9034	III	62	158	24.84	1	2	6.1	12.7	6.9
95	MAGESHWARI	33	F	2341	I	59	155	24.56	2	2	5.5	12.6	6.8
96	MAGESH	42	M	9824	I	58	150	25.78	2	2	5.8	12.8	6.8
97	GOKUL	45	M	8061	II	73	169	25.56	1	2	6.2	12.7	6.8
98	SANDHYA	33	M	5423	I	54	149	24.32	2	1	5.9	12.6	6.9
99	KUMARI	39	F	1243	II	57	155	23.73	4	4	5.3	12.5	6.2
100	RAMESH	44	M	7056	II	70	169	24.51	1	2	6.4	12.9	6.8
101	KANDHAN	31	M	2340	I	63	160	24.61	2	1	5.5	13.0	6.7
102	VIJAYA	44	F	9867	II	68	164	25.28	3	3	4.9	12.7	6.8

103	SINDHU	32	F	6432	III	67	166	24.31	1	1	5.7	12.6	6.9
104	KEETRTHANA	44	F	1234	I	71	169	24.86	2	3	5.3	12.7	6.8
105	GULASEKARAN	33	M	5678	II	65	164	24.17	3	3	5.4	13.3	6.4
106	MANIKANDAN	29	M	3476	II	59	154	24.88	1	3	5.9	12.9	6.8
107	MANI	27	M	1279	I	54	150	24.00	2	2	6.0	12.7	6.9
108	MAHESH	28	M	2453	I	50	149	22.52	1	2	6.1	13.0	6.8
109	SELVAN	36	M	1209	II	71	168	25.16	2	1	6.2	12.7	6.7
110	SUMATHI	31	F	2378	I	64	160	25.00	2	2	5.8	12.9	6.7
111	NIRMAL	44	M	8734	II	73	169	25.56	1	2	5.7	12.8	6.9
112	KUMARESH	38	M	9043	I	68	167	24.38	2	2	5.6	12.7	6.8
113	LOGESH	43	M	4567	I	72	169	25.21	1	2	5.6	12.8	6.7
114	NITHIN	33	M	2398	II	90	165	33.06	3	3	5.3	13.1	7.0
115	KOPIKA	29	F	6708	II	59	157	23.94	1	2	5.9	12.9	6.9
116	MATHU	28	F	7548	I	61	159	24.13	2	1	6.0	12.7	6.6
117	KAYALVIZHI	27	F	5632	I	63	160	24.61	1	2	5.4	12.8	6.8
118	DIVYA	33	F	9870	II	65	164	24.17	2	3	5.7	12.9	6.9
119	HEMA	44	F	2170	III	72	171	24.62	3	3	5.7	13.0	6.8
120	MANICKAM	39	M	7767	I	69	167	24.74	1	1	6.1	12.9	6.7
121	ACHI	47	F	4309	II	70	168	24.80	2	1	6.2	12.8	6.8
122	THIAGARAJAN	44	M	45671	II	71	167	25.46	1	2	5.9	12.6	6.9
123	KALAIMANI	39	F	1235	I	63	162	24.01	2	2	5.7	12.7	6.9
124	MANIPAYAL	38	M	7647	I	60	159	23.73	3	2	5.0	12.7	6.9
125	KARMEGAM	42	M	8023	II	64	160	25.00	1	3	5.6	12.8	6.6
126	RAMANI	49	M	7190	II	69	165	25.34	2	2	5.3	12.9	6.8
127	MAHADEVAN	48	M	5409	II	73	172	24.68	1	2	6.2	12.7	6.8
128	RAVI	39	M	3298	II	68	167	24.38	3	3	5.5	12.8	6.5
129	LALITHA	36	F	2176	I	63	161	24.30	1	1	6.3	13.0	6.7

130	BALAMURUGAN	43	M	9856	I	69	165	25.34	1	2	5.6	12.6	6.9
131	BANU	36	F	8723	II	54	153	23.07	2	1	6.5	12.9	6.7
132	ABINAYA	29	F	7612	III	53	150	23.56	1	3	5.8	12.8	6.8
133	UMA	34	F	1234	I	57	155	23.73	2	2	5.7	12.7	6.8
134	VIGNESH	22	M	9876	I	70	167	25.10	1	1	6.4	13.0	6.9
135	PRASANTH	27	M	3456	II	74	171	25.31	3	3	5.3	13.2	6.8
136	PRAKASH	31	M	8765	II	69	167	24.74	1	1	6.5	12.9	6.8
137	NIKIKLA	30	F	1254	II	60	159	23.73	2	2	5.4	12.6	6.9
138	ANANTHAN	29	M	9834	I	63	160	24.61	1	2	5.7	12.8	6.7
139	SATHYA	37	M	12043	I	70	169	24.51	2	2	6.3	12.9	6.8
140	NIRUPAMA	29	F	10943	I	63	162	24.01	1	3	5.8	12.7	6.8
141	NAYRAYANAN	22	M	2045	III	59	158	23.63	1	1	6.4	13.0	6.9
142	KASI	31	M	1209	I	71	170	24.57	3	2	5.1	12.4	6.7
143	KUPPAIAH	20	M	3076	I	43	141	21.63	1	2	5.9	12.7	6.8
144	THULUKANATHAM	27	M	6723	II	54	153	23.07	2	1	6.2	12.6	6.7
145	JOHN	22	M	7823	II	49	148	22.37	3	3	5.7	13.0	6.6
146	AHMED	33	M	6723	I	60	157	24.34	4	4	5.2	12.8	6.8
147	SURESH	29	M	4508	II	55	154	23.19	1	2	5.3	12.8	6.9
148	MOHAMED	21	M	2310	I	45	144	21.70	2	3	5.8	13.0	6.8
149	BALAGURU	20	M	8765	II	47	146	22.05	1	3	5.9	12.9	6.7
150	SAVITHIRI	33	F	2301	I	64	163	24.09	3	2	4.8	12.7	6.4

N.C(in cms)	WIDTH OF TONGUE(in cms)	CROSS SECTION OF TONGUE	C.S.FLOOR OF MOUTH	MENTOHYOID DISTANCE RATIO	TONGUE VOLUME	MUSCLE VOLUME	ANS-HYOID	ANS-VC	PRE-E	E-VC	PRE-E/E-VC
36.00	5.3	20.04	4.06	1.12	106.21	22.74	0.36	0.26	0.87	0.80	1.09
38.00	5.6	24.48	4.24	1.14	137.09	26.71	0.24	0.15	1.10	0.78	1.41
51.50	7.5	25.04	4.04	1.03	187.80	22.62	0.30	0.39	0.90	0.75	1.20
40.00	5.5	22.64	4.64	1.15	124.52	26.91	0.38	0.30	0.97	0.95	1.02
39.00	5.8	24.08	5.25	1.16	139.66	30.98	0.35	0.30	1.18	0.89	1.33
37.00	5.7	22.16	6.00	1.14	126.31	36.60	0.39	0.32	1.05	1.05	1.00
42.50	5.5	25.00	4.08	1.02	137.50	19.99	0.35	0.48	1.10	0.85	1.29
38.00	5.6	25.25	4.81	1.13	141.40	28.86	0.33	0.27	0.89	0.88	1.01
36.00	5.1	25.84	5.25	1.12	131.78	29.93	0.46	0.21	0.99	0.99	1.00
39.00	5.2	24.81	5.64	1.15	129.01	32.71	0.41	0.28	0.93	0.96	0.97
40.00	5.8	25.81	5.81	1.16	149.70	36.60	0.27	0.29	1.07	0.81	1.32
37.50	5.6	24.49	6.00	1.13	137.14	37.20	0.37	0.24	0.97	1.04	0.93
53.00	7.4	24.04	5.25	1.04	177.90	27.83	0.44	0.35	0.96	0.90	1.07
38.00	6.0	23.36	4.64	1.12	140.16	24.59	0.42	0.27	1.05	1.09	0.96
36.00	5.7	24.49	4.16	1.00	139.59	22.46	0.33	0.19	1.03	0.97	1.06
39.50	5.9	24.36	4.08	1.14	143.72	23.26	0.34	0.30	0.88	0.87	1.01
40.00	5.8	23.81	5.08	1.16	138.10	27.43	0.42	0.27	1.08	0.82	1.32
40.00	5.3	22.04	6.00	1.15	116.81	35.40	0.33	0.26	0.86	0.93	0.92
36.50	5.4	22.81	4.04	1.14	123.17	24.64	0.48	0.33	1.07	0.88	1.22
39.00	5.7	26.64	5.64	1.14	151.85	33.28	0.29	0.29	1.23	0.98	1.26
38.00	5.8	25.25	4.04	1.13	146.45	23.03	0.44	0.32	0.87	0.94	0.93
39.00	5.7	25.08	4.81	1.13	142.96	27.90	0.33	0.17	0.93	0.87	1.07
38.50	5.7	25.00	4.00	1.04	142.50	21.60	0.36	0.28	0.95	0.76	1.25
36.00	5.8	24.08	4.25	1.14	139.66	25.50	0.33	0.28	0.93	0.88	1.06

38.50	5.9	24.36	4.08	1.13	143.72	25.30	0.44	0.16	0.96	0.98	0.98
37.00	5.4	23.81	5.64	1.12	128.57	32.71	0.30	0.26	0.99	0.81	1.22
36.00	5.1	24.64	5.49	1.14	125.66	32.39	0.38	0.33	1.09	0.79	1.38
40.50	5.3	25.25	6.00	1.16	133.83	36.00	0.40	0.30	0.91	1.02	0.89
39.00	5.4	24.49	4.81	1.14	132.25	26.94	0.37	0.27	1.14	0.79	1.44
36.00	5.9	24.08	4.16	1.05	142.07	19.97	0.43	0.46	1.03	0.94	1.10
38.00	5.9	23.08	4.16	1.13	136.17	25.38	0.32	0.28	1.02	1.04	0.98
36.50	6.0	23.16	5.64	1.14	138.96	33.28	0.48	0.29	0.94	0.80	1.18
36.00	5.8	22.64	4.04	1.15	131.31	25.86	0.44	0.27	0.88	0.84	1.05
38.00	5.4	22.81	4.08	1.16	123.17	23.26	0.37	0.36	1.08	0.99	1.09
39.00	5.9	24.64	5.64	1.14	145.38	33.84	0.46	0.14	1.18	0.79	1.49
38.50	6.0	25.25	5.25	1.13	151.50	30.98	0.28	0.33	0.94	1.05	0.90
37.00	5.5	24.08	5.81	1.12	132.44	32.54	0.37	0.27	1.20	0.86	1.40
48.50	6.9	25.08	4.25	1.05	173.05	22.10	0.38	0.33	1.12	0.85	1.32
36.00	5.8	24.04	6.00	1.15	139.43	34.80	0.41	0.29	1.05	1.06	0.99
38.00	5.7	22.08	5.64	1.16	125.86	35.53	0.29	0.17	1.18	0.88	1.34
39.00	5.8	26.00	4.04	1.14	150.80	25.05	0.27	0.27	0.93	0.96	0.97
40.50	6.0	24.08	4.36	1.13	144.48	25.72	0.28	0.35	0.96	0.88	1.09
37.00	5.3	25.25	4.49	1.12	133.83	26.04	0.36	0.25	1.04	0.85	1.22
38.00	5.4	24.16	4.64	1.14	130.46	25.06	0.44	0.36	1.18	0.94	1.26
44.50	5.7	25.25	4.36	1.04	143.93	21.80	0.33	0.43	1.05	0.79	1.33
39.00	5.5	24.64	4.81	1.16	135.52	28.38	0.24	0.28	0.99	0.94	1.05
40.00	5.6	23.81	5.64	1.14	133.34	36.10	0.60	0.33	1.24	0.86	1.44
37.50	5.9	24.64	5.49	1.15	145.38	29.10	0.38	0.18	0.99	0.79	1.25
38.00	5.8	24.72	4.08	1.14	143.38	24.07	0.44	0.26	1.06	0.93	1.14
39.00	5.7	24.81	6.00	1.12	141.42	34.20	0.29	0.16	0.94	0.83	1.13
40.00	5.4	20.64	4.64	1.14	111.46	25.98	0.37	0.25	1.05	0.98	1.07

37.50	5.1	20.49	4.49	1.16	104.50	26.49	0.48	0.27	1.04	0.87	1.20
49.00	6.5	24.08	5.49	1.03	156.52	26.35	0.34	0.39	0.99	0.89	1.11
36.00	5.3	21.64	4.80	1.14	114.69	27.84	0.29	0.27	1.08	0.78	1.38
39.50	5.2	22.84	5.80	1.16	118.77	37.12	0.36	0.28	0.83	0.94	0.88
37.00	5.1	24.64	5.81	1.14	125.66	34.86	0.40	0.29	0.98	1.03	0.95
38.00	5.7	23.64	6.00	1.12	134.75	34.80	0.44	0.23	1.13	0.84	1.35
40.50	5.9	24.64	4.08	1.13	145.38	22.44	0.44	0.27	0.88	0.85	1.04
37.00	5.6	21.81	4.04	1.14	122.14	22.62	0.36	0.22	1.24	0.85	1.46
36.00	5.8	22.64	4.16	1.15	131.31	24.54	0.32	0.30	0.95	0.82	1.16
48.00	5.6	25.16	6.49	1.02	140.90	34.40	0.45	0.37	1.03	0.93	1.11
39.00	5.9	23.49	4.64	1.16	138.59	28.30	0.28	0.23	1.03	0.91	1.13
38.00	5.4	24.36	5.25	1.12	131.54	28.35	0.38	0.17	0.93	0.82	1.13
40.00	5.8	25.16	6.00	1.16	145.93	36.00	0.29	0.16	1.08	0.80	1.35
37.50	5.2	25.08	4.64	1.14	130.42	29.70	0.22	0.33	1.02	0.95	1.07
39.00	5.1	24.49	4.04	1.16	124.90	23.84	0.36	0.24	1.14	0.88	1.30
38.00	5.3	23.81	4.08	1.14	126.19	24.48	0.25	0.33	1.07	0.78	1.37
36.50	5.4	20.08	4.16	1.14	108.43	24.13	0.47	0.34	0.99	1.07	0.93
40.00	5.8	21.16	4.24	1.13	122.73	25.86	0.43	0.21	1.03	0.80	1.29
47.50	6.8	25.04	4.64	1.01	170.27	25.06	0.31	0.43	1.13	0.76	1.49
37.50	5.7	22.08	4.34	1.12	125.86	24.74	0.36	0.35	0.87	0.83	1.05
37.00	5.3	23.04	5.24	1.13	122.11	30.92	0.44	0.24	1.25	0.78	1.60
38.50	5.2	24.25	5.49	1.12	126.10	30.20	0.33	0.20	0.88	0.90	0.98
40.00	5.1	25.09	6.00	1.14	127.96	34.20	0.35	0.28	0.86	0.87	0.99
39.00	5.0	24.16	4.42	1.15	120.80	25.64	0.45	0.26	1.25	0.88	1.42
36.50	5.9	24.24	4.04	1.16	143.02	21.82	0.26	0.34	0.95	0.87	1.09
39.00	5.8	25.36	4.81	1.15	147.09	28.38	0.38	0.28	0.84	0.96	0.88
39.00	5.7	26.00	4.08	1.16	148.20	24.48	0.28	0.27	1.02	0.84	1.21

38.00	5.7	24.04	5.81	1.14	137.03	35.44	0.40	0.26	0.86	0.89	0.97
37.50	5.8	24.09	5.64	1.13	139.72	32.71	0.44	0.33	0.94	0.86	1.09
36.00	5.4	23.09	5.49	1.12	124.69	35.14	0.39	0.23	0.95	1.09	0.87
37.00	5.8	26.00	5.81	1.04	150.80	29.63	0.33	0.37	0.98	0.97	1.01
40.00	5.3	25.16	5.04	1.14	133.35	29.74	0.39	0.19	1.00	0.78	1.28
39.00	5.2	24.04	5.08	1.16	125.01	28.45	0.47	0.20	1.17	0.79	1.48
38.00	5.1	24.49	4.64	1.15	124.90	27.38	0.36	0.28	0.94	0.90	1.04
47.00	5.7	25.25	4.04	1.05	143.93	19.80	0.45	0.44	1.02	0.72	1.42
36.80	5.8	23.08	4.08	1.14	133.86	23.66	0.36	0.26	1.19	0.98	1.21
37.00	5.7	23.16	5.08	1.16	132.01	30.99	0.30	0.26	0.93	0.80	1.16
36.50	5.6	26.00	4.81	1.03	145.60	26.94	0.44	0.46	0.97	0.86	1.13
38.00	5.6	24.64	5.16	1.13	137.98	30.96	0.38	0.28	1.12	0.80	1.40
37.00	5.9	25.22	5.24	1.12	148.80	28.82	0.40	0.26	0.91	0.87	1.05
49.00	7.4	25.00	4.25	1.04	185.00	23.38	0.41	0.35	1.00	0.83	1.20
48.00	5.9	25.05	5.09	1.03	147.80	24.94	0.39	0.46	0.97	0.90	1.08
38.00	5.7	25.08	6.00	1.14	142.96	36.60	0.50	0.28	0.83	0.97	0.86
40.00	5.6	24.09	4.84	1.16	134.90	26.62	0.28	0.31	1.28	0.97	1.32
38.00	5.3	22.81	4.48	1.16	120.89	25.98	0.24	0.32	1.06	0.81	1.31
36.00	5.1	21.64	5.56	1.14	110.36	34.47	0.25	0.27	0.97	1.06	0.92
37.50	5.4	22.08	6.00	1.16	119.23	35.40	0.37	0.27	1.07	0.93	1.15
38.00	5.8	24.64	5.16	1.03	142.91	27.35	0.42	0.48	1.10	0.84	1.31
36.50	5.3	24.18	4.76	1.12	128.15	30.46	0.31	0.29	1.07	1.02	1.05
36.00	5.8	24.28	4.64	1.13	140.82	25.52	0.36	0.26	1.24	0.94	1.32
48.50	6.6	25.25	4.64	1.04	166.65	22.74	0.42	0.35	0.96	0.80	1.20
37.50	5.7	24.38	4.84	1.14	138.97	27.59	0.32	0.28	0.87	0.84	1.04
38.00	5.2	25.48	4.64	1.15	132.50	24.59	0.46	0.24	1.20	0.87	1.38
53.00	5.4	26.04	5.36	1.03	140.62	28.94	0.37	0.46	1.12	0.79	1.42

37.00	5.9	23.36	4.49	1.16	137.82	26.49	0.30	0.22	1.06	0.85	1.25
39.00	5.7	24.48	5.54	1.15	139.54	33.24	0.38	0.36	1.08	0.83	1.30
36.00	5.6	20.22	5.64	1.14	113.23	34.40	0.28	0.32	0.92	0.86	1.07
36.00	5.8	21.44	4.64	1.13	124.35	28.77	0.29	0.19	1.24	0.96	1.29
37.00	5.7	22.36	4.86	1.12	127.45	28.19	0.38	0.20	1.09	0.79	1.38
37.00	5.6	23.64	5.86	1.13	132.38	33.40	0.45	0.21	0.86	0.98	0.88
36.00	5.8	24.48	5.76	1.14	141.98	32.26	0.36	0.33	0.97	0.85	1.14
40.00	5.9	25.25	4.66	1.16	148.98	26.10	0.47	0.18	0.84	0.93	0.90
48.50	5.6	25.49	5.49	1.02	142.74	29.10	0.36	0.36	1.11	0.93	1.19
38.00	5.2	26.81	5.56	1.14	139.41	32.80	0.40	0.27	0.86	0.85	1.01
37.00	5.1	25.64	5.60	1.14	130.76	33.60	0.37	0.36	1.25	0.97	1.29
39.50	5.3	24.08	4.60	1.13	127.62	24.84	0.32	0.28	1.08	0.94	1.15
36.00	5.4	24.16	4.48	1.12	130.46	25.54	0.46	0.32	1.20	0.98	1.22
52.00	6.9	25.25	5.25	1.01	174.23	29.93	0.45	0.35	1.04	0.85	1.22
37.50	5.8	25.25	5.64	1.14	146.45	34.40	0.36	0.20	1.06	0.87	1.22
40.00	5.9	24.06	6.00	1.15	141.95	37.20	0.30	0.29	1.09	0.89	1.22
36.00	5.8	22.64	5.56	1.16	131.31	32.80	0.38	0.26	0.86	1.00	0.86
37.00	5.3	21.81	4.80	1.14	115.59	27.36	0.40	0.15	1.22	0.90	1.36
40.50	5.9	25.00	4.16	1.05	147.50	20.80	0.44	0.44	0.90	0.94	0.96
38.00	5.2	22.08	4.92	1.13	114.82	27.55	0.28	0.27	0.87	0.99	0.88
37.00	5.1	23.16	4.72	1.12	118.12	25.02	0.29	0.14	1.24	0.95	1.31
35.00	5.8	24.16	4.64	1.14	140.13	28.77	0.48	0.28	0.95	0.88	1.08
47.00	6.5	24.49	4.81	1.04	159.19	26.46	0.38	0.47	0.99	0.80	1.24
36.50	5.7	25.04	5.82	1.15	142.73	36.67	0.24	0.25	0.97	1.06	0.92
37.00	5.3	25.08	4.62	1.13	132.92	25.87	0.40	0.27	0.95	1.04	0.91
38.00	5.4	26.00	4.60	1.14	140.40	29.90	0.27	0.16	1.26	0.85	1.48
39.00	5.6	24.64	4.80	1.16	137.98	27.84	0.42	0.29	0.96	0.87	1.10

40.00	5.9	23.64	5.90	1.16	139.48	33.63	0.48	0.19	1.10	0.86	1.28
36.00	5.1	24.48	4.68	1.14	124.85	29.95	0.34	0.22	0.85	0.89	0.96
40.50	5.8	24.48	5.25	1.03	141.98	27.83	0.33	0.47	1.03	0.93	1.11
39.00	5.3	25.25	4.64	1.15	133.83	30.16	0.32	0.24	0.88	0.91	0.97
36.00	5.4	24.81	5.68	1.16	133.97	30.67	0.36	0.36	1.17	0.99	1.18
37.50	5.5	22.80	6.00	1.14	125.40	34.20	0.36	0.27	0.94	0.99	0.95
38.00	5.6	22.64	4.68	1.16	126.78	29.48	0.28	0.35	1.19	0.86	1.38
40.00	5.7	24.81	5.70	1.14	141.42	33.06	0.33	0.30	1.06	0.84	1.26
39.00	5.8	23.64	4.80	1.16	137.11	30.72	0.40	0.20	1.10	0.92	1.20
40.00	5.7	25.50	6.00	1.02	145.35	30.60	0.35	0.46	1.13	0.84	1.35
38.00	5.3	24.49	5.48	1.15	129.80	32.33	0.39	0.26	1.03	1.07	0.96
37.00	5.8	25.25	5.64	1.13	146.45	34.97	0.26	0.29	1.09	0.84	1.30
38.00	4.0	24.00	5.64	1.03	96.00	32.15	0.37	0.37	1.04	0.85	1.22
47.00	7.0	24.64	4.16	1.05	172.48	21.63	0.37	0.40	1.06	0.99	1.07
40.00	5.9	25.81	5.36	1.15	152.28	28.41	0.36	0.27	0.97	1.04	0.93
39.00	5.4	23.08	4.84	1.16	124.63	28.07	0.24	0.28	1.20	0.87	1.38
37.00	5.3	26.00	4.96	1.14	137.80	29.26	0.40	0.25	0.93	0.83	1.12
38.50	6.0	24.48	5.81	1.04	146.88	27.89	0.46	0.45	1.07	0.89	1.20

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ETHICS COMMITTEE CERTIFICATE

Name of the Candidate	:	Dr.V.Nisha
Course	:	PG in MD., Anaesthesia
Period of Study	:	2016-2019
College	:	MADURAI MEDICAL COLLEGE
Research Topic	:	A study of correlation of preoperative ultrasonographic airway assessment in prediction of the Difficult airway
Ethical Committee as on	:	10.07.2018

The Ethics Committee, Madurai Medical College has decided to inform that your Research proposal is accepted.

Member Secretary   Chairman   Dean / Convenor

Prof Dr V Nagaraajan
M.D., MNAMS, D.M., Dsc.,(Neuro), Dsc (Hon)
CHAIRMAN
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