"ACCURACY OF PREOPERATIVE ULTRASONOGRAPHIC AIRWAY ASSESSMENT IN PREDICTING DIFFICULT LARYNGOSCOPY IN ADULT PATIENTS"

By

Dr. SINCHANA B

DISSERTATION SUBMITTED TO SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION AND RESEARCH CENTER, KOLAR, KARNATAKA

In partial fulfillment of the requirements for the degree of

DOCTOR OF MEDICINE

IN

ANAESTHESIOLOGY

Under the Guidance of

Dr. KIRAN N

Professor DA, MD

DEPARTMENT OF ANAESTHESIOLOGY,

SRI DEVARAJ URS MEDICAL COLLEGE,

TAMAKA, KOLAR-563101

APRIL 2022

SRI DEVARAJ URS MEDICAL COLLEGE,

TAMAKA, KOLAR-563101

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Date :

Place :

Dr. KIRAN N DA,MD
Professor,
Department of Anesthesiology,
Sri Devaraj Urs Medical College,
Tamaka, Kolar.

SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION AND RESEARCH CENTER, TAMAKA, KOLAR, KARNATAKA

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Dr. RAVI M D.A, DNB, MNAMS
Professor & HOD
Department of Anaesthesiology,
Sri Devaraj Urs Medical College,
Tamaka, Kolar

Date:
Place: Kolar

Dr. P N SREERAMULU
Principal,
Sri Devaraj Urs Medical College
Tamaka, Kolar

Date:
Place: Kolar

SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION AND RESEARCH CENTER, TAMAKA, KOLAR, KARNATAKA

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Date:

Place: Kolar

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Sri Devaraj Urs Medical College,

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Professor, Department of Anaesthesiology, Sri Devaraj Urs Medical College, R.L. Jalappa Hospital & Research Centre, Tamaka, Kolar-563101

Head of the Department

Head, Department of Anaesthesiology, Sri Devaraj Urs Medical College, R.L. Jalappa Hospital & Research Centre, TAMAKA, KOLAR-563 101

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Date: **Dr SINCHANA B**

Place: Kolar

ABBREVATIONS

USG	Ultrasound
CL	Cormack and Lehane
DSHB	Thickness of anterior neck soft tissue in transverse view at level of hyoid bone (minimal distance from hyoid bone to the skin)
DSEM	Thickness of anterior neck soft tissue in transverse view at level of thyrohyoid membrane (distance from skin to epiglottis midway between hyoid bone and thyroid cartilage)
ROC	Receiver operating characteristic
AUC	Area under curve
ETT	Endotracheal tube
T	Time
f	Frequency of sound
Hz	Hertz
m/sec	Meters per second
PZT	Lead Zirconate titanate
B Mode	Brightness mode
2D	Two Dimensional
BURP	Backward, upward, rightward pressure
OELM	Optimal external laryngeal manipulation
A-M	Air-Mucosa
CTM	Cricothyroid membrane
cm	Centimeter
mm	Millimeter
ASA	American Society of Anaesthesiologists
SD	Standard deviation
MP	Mallampati grade
BMI	Body Mass Index
DSAC	Distance from skin to anterior commissure of the vocal cords
ANS-VC	Anterior neck soft tissue thickness at the level of vocal cords
MMP	Modified Mallampati Class

TMD	Thyromental distance
Pre-E/E-VC	Depth of pre epiglottic space /distance from epiglottis to midpoint of distance between the vocal cords
HDMR	Hyomental distance ratio
PEA	Pre epiglottic area of anterior cervical soft tissue thickness at the level of thyrohyoid membrane
THM	Thyrohyoid membrane
VC	Vocal cords
SED	Skin to epiglottis distance
DST	Distance between skin and thyroid cartilage
DTE	Distance between thyroid cartilage and epiglottis
TT	Tongue thickness
Inj	Injectable
mg	Milligram
No.of	Number of
Kg/m^2	Kilogram per meter square
IV	Intravenous
OSA	Obstructive sleep apnea

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ABSTRACT

ACCURACY OF PREOPERATIVE ULTRASONOGRAPHIC AIRWAY ASSESSMENT IN PREDICTING DIFFICULT LARYNGOSCOPY IN ADULT PATIENTS

BACKGROUND AND OBJECTIVES:

At present , neck ultrasonography is used as a tool in predicting difficult airway. There are no standardized ultrasonographic criteria which help to predict difficult airway .Objective is to ultrasonographically assess anterior neck soft tissue thickness preoperatively based on 2 parameters-DSHB(minimal distance from hyoid bone to skin) and DSEM(distance from skin to epiglottis midway between hyoid bone and thyroid cartilage) and find out if the above two USG parameters can predict difficult airway in adults by correlating with CL grading.

MATERIALS AND METHODS:

After obtaining ethical committee clearance and patient consent, this study was conducted on 96 patients aged between 18-60 years belonging to ASA- I and II admitted for elective surgery under general anaesthesia with endotracheal intubation at R. L. Jalappa Hospital and Research centre, Tamaka, Kolar in the period from January 2020 to May 2021. Exclusion criteria were patients with anticipated difficult airway cases like obesity, pregnancy ,head and neck anatomical pathologies , maxillofacial anomalies and edentulous patients .Sonography of airway was first performed preoperatively by an anaesthesiologist along with noting down the standard clinical tests like Mallampati grading .Sonography of the airway included two parameters –DSHB and DSEM . Patient was later classified as easy or difficult laryngoscopy on the basis of USG parameters criteria from literature available .

DSHB >0.66cm - predicted to be difficult airway and DSHB <0.66cm - predicted to be easy.

DSEM >2.03cm- predicted to be difficult airway and DSEM <2.03cm - predicted to be easy.

After induction of anesthesia , direct laryngoscopy performed in the sniffing position by another anaesthesiologist using appropriate size Macintosh blade and Cormack Lehane grade noted. CL grade I and II considered to be easy laryngoscopy .

Quantitative data was presented by Mean SD confidence interval ,qualitative data was presented in percentage and P values less than 0.05 considered statistically significant. To determine discriminative power of individual tests,receiver operating characteristic (ROC)curve , area under curve (AUC) with 95%confidence interval was noted .

RESULTS:

The two USG parameters –DSHB ,DSEM may be used to predict difficult laryngoscopy in adult patients as there is a very strong statistical significance between the two. Out of the two ,DSHB seems to have a better diagnostic value in our study.

CONCLUSION:

To conclude , our study showed that USG parameters DSHB and DSEM may aid in predicting difficult laryngoscopy as a strong statistical significance was present between sonographic measurements and CL grading. Also ,DSHB appeared to have a better diagnostic value for prediction of difficult airway .

KEY WORDS: Difficult laryngoscopy ,Ultrasonographic airway assessment

INTRODUCTION

Airway management is an important component of clinical anaesthesia and it involves the maintenance of patient's airway to ensure proper gas exchange via mask ventilation or through an airway device.[1]Unpredictable difficult laryngoscopies can adversely affect ventilation and intubation .Difficult laryngoscopy and intubation is estimated to be 1.5-13 %.[2] 28% of deaths related to anesthesia are due to ineffective mask ventilation or inability to intubate .If difficult airway is anticipated before induction of anaesthesia ,it allows proper planning with regard to proper equipment ,technique and involve experienced anaesthesiologists in managing difficult airway. There are various methods for prediction of difficult airway but nothing are completely accurate .[3]

Cormack and Lehane grading has been used to grade difficulty of laryngoscopy which is more reliable to predict difficult airway .But this is an invasive procedure which cannot be carried out in awake patients or for preanaesthetic airway evaluation in patients with no previous history of endotracheal intubation.[1]

With advancement in technology in hospitals, availability of portable USG machines ,anesthesiologists can use USG as a clinical tool for assessing airway , to rule out difficult airway to prevent the scenario of cannot ventilate and cannot intubate .[3]

At present , ultrasonography is used as a tool for predicting difficult airway .However, there are no standardized ultrasonographic criteria for prediction of difficult airway. There are various anatomical parameters to evaluate the ease of endotracheal intubation .However , their measurements are subjective depending on the observer and hence have lesser sensitivity and specificity .[3]

Ultrasonography can yield detailed anatomic information and may assist other methods in prediction of difficult airway. Anterior soft tissue thickness of neck significantly predicted difficult intubation and can be an important aid for an anaesthesiologist.[4]

The present study will be done using two USG measurements to predict difficult laryngoscopy in adult patients .

The 2 parameters chosen will be –

1. Thickness of anterior neck soft tissue in transverse view at level of hyoid bone -DSHB (minimal distance from hyoid bone to the skin)

2. Thickness of anterior neck soft tissue in transverse view at level of thyrohyoid membrane -DSEM (distance from skin to epiglottis midway between hyoid bone and thyroid cartilage)

We have applied the two above mentioned parameters in our population ,which is quite different to western population with respect to body weight , thickness of anterior ,muscle mass ,build ,etc .We have documented the reliability of USG in predicting difficult airway .

So far only few studies have been done to show the correlation between ultrasonography of airway and difficult intubation.

In our institution, we did not have any studies done on ultrasonography of airway to predict difficult airway.

AIMS AND OBJECTIVES

1. To ultrasonographically assess anterior neck preoperatively based on 2 parameters

- DSHB- Thickness of anterior neck soft tissue in transverse view at the level of hyoid bone (minimal distance from hyoid bone to the skin)
- DSEM-Thickness of anterior neck soft tissue in transverse view at the level of thyrohyoid membrane (distance from the skin to epiglottis midway between hyoid bone and thyroid cartilage)

2. To find out if the above two USG parameters can predict difficult airway in adults by correlating with Cormack and Lehane grading.

ANATOMY OF THE AIRWAY

INTRODUCTION:

- The air passage begins from the nose and ends at bronchioles and is required to deliver humidified and filtered respiratory gases to and from alveoli .
- Anaesthesiologists use airway passages to deliver anaesthetic gases to alveoli and maintain transport of gases simultaneously.
- Access to the airway is achieved by airway devices such an endotracheal tube (ETT) that is introduced directly into the upper airway.
- Hence it is crucial to understand airway structures.
- The airway is divided into upper airway extending from nose to glottis and lower airway that includes trachea ,bronchi,bronchioles.[5]

ANATOMY OF THE UPPER AIRWAY:

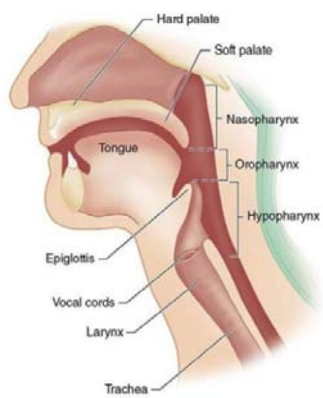


FIG 1: ANATOMY OF AIRWAY

- The two openings to airway are- the nose that leads to nasopharynx and mouth that leads to oropharynx.
- The two openings are separated anteriorly by palate and posteriorly joined in the palate.

- Pharynx - common pathway for respiratory gases and food and extends from base of skull to cricoid cartilage anteriorly and inferior border of sixth vertebra posteriorly.
- Widest level of pharynx is at hyoid bone (5cm) and narrowest level is at esophagus (1.5cm).
- Pharynx is divided into nasopharynx , oropharynx and laryngopharynx.
- Nasopharynx has respiratory function , extending from nasal septum and turbinates to soft palate.
- Oropharynx has digestive function , extending from below soft palate to epiglottis.
- Laryngopharynx is in between fourth and sixth cervical vertebra , extending upto cricoid cartilage and at this point it tapers and continues with the esophagus.[5,6]

LARYNX :

Larynx is a complex structure made up of muscles ,ligaments ,cartilages that serve as an inlet to trachea .[7]

LOCATION , EXTENT& SIZE :

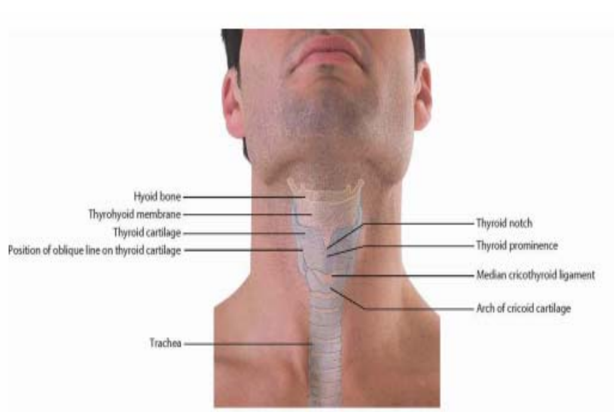


FIG 2: LOCATION OF LARYNX

- Extends from the tongue to the trachea.
- Situated in anterior midline of upper part of neck.
- Lies in front of third to sixth vertebra in adult males and is higher in children and adult females
- Till puberty ,male and female larynx are alike in size. After puberty, larynx grows rapidly and becomes larger than female .[8,9]

SKELETON OF THE LARYNX

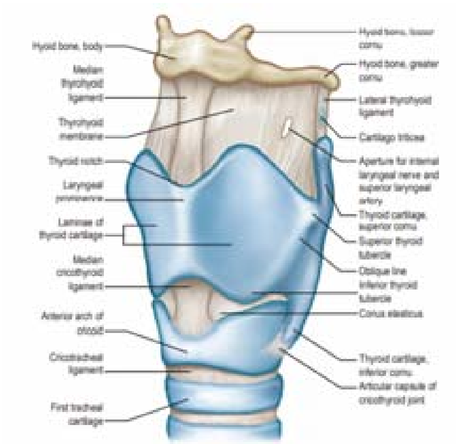


FIG 3:ANTEROLATERAL VIEW OF LARYNGEAL CARTILAGES AND

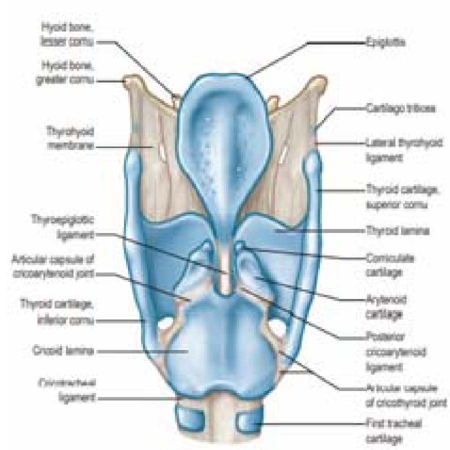


FIG 4:POSTERIOR VIEW OF LARYNGEAL CARTILAGES AND LIGAMENTS

- Formed by a series of cartilages which are connected to one another by ligaments and fibrous membranes and are moved by a number of muscles.
- Hyoid bone is attached to the larynx but is a separate structure with distinctive functional roles.[8,10,11]

CARTILAGES

3 unpaired cartilages	Thyroid cartilage
	Cricoid cartilage
	Epiglottis
3 paired cartilages	Arytenoids
	Corniculate
	Cuneiform

TABLE 1: CARTILAGES OF LARYNX[8]

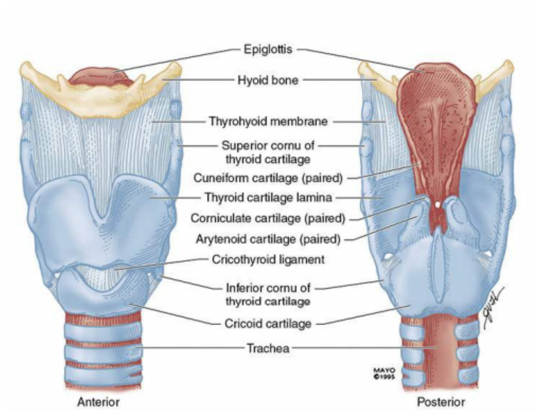


FIG 5: CARTILAGES OF LARYNX

- Cartilages are joined by ligaments, membranes ,synovial joints .
- Suspended by hyoid bone via thyrohyoid ligaments and thyrohyoid membrane.[8,10,11]

EPIGLOTTIS

- Thin, leaf like plate of elastic cartilage.
- Extends upwards behind the tongue and hyoid body and the base of tongue .
- Its broad free upper end-directed upwards, forming the upper boundary of the laryngeal inlet.

- Its lower end (stalk /petiolus)- long and pointed and connected to posterior surface of angle of thyroid by the elastic thyroepiglottic ligament .
- The anterior surface of epiglottis is connected to base of tongue by a median glossoepiglottic fold and two lateral glossoepiglottic folds .
- The depression on each side of the median fold is called vallecula.
- Sides of the epiglottis are attached to arytenoid cartilages by aryepiglottic folds.
- Functions of the epiglottis –During deglutition ,the hyoid bone moves upwards and forwards and hence the epiglottis is bent posteriorly due to passive pressure from the tongue and active contraction of the aryepiglottic muscles. Normally, the epiglottis diverts food and liquids away from the laryngeal inlet and into the food channels.
- It is not essential for respiration or phonation.[8,10,11]

THYROID CARTILAGE

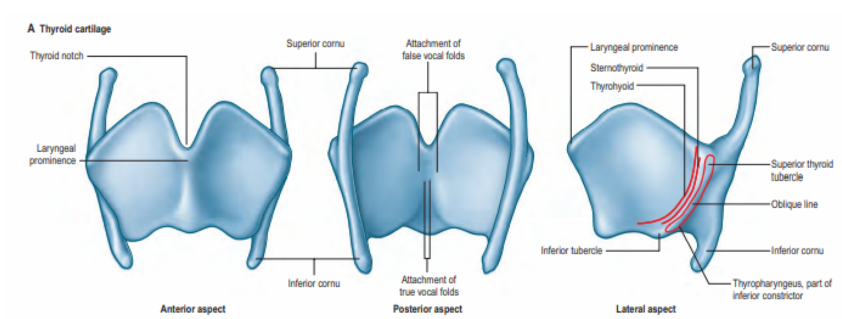


FIG 6: THYROID CARTILAGE

- The largest laryngeal cartilage.
- Most prominent and acts as a shield to protect larynx from the front.
- Consists of two quadrilateral laminae that meet in the front at an angle called thyroid angle.

- This angle is more prominent in males and is called the Adam's apple. The angle is approximately 90° in men and 120° in women.
- The laminae are separated by a V-shaped superior thyroid notch /incisure.
- Each lamina provides insertion to the following three muscles- palatopharyngeus, salpingopharyngeus, stylopharyngeus.
- Outer surface of each lamina provides attachment to the following three muscles-sternothyroid, thyropharyngeus and thyrohyoid.
- Posterior surface of thyroid cartilage provides attachment to following- thyroepiglottic ligament, a pair of vestibular ligaments ,a pair of vocal ligaments .
- Anteriorly, the thyroid cartilage is connected to the cricoid cartilage by the median cricothyroid ligament that is the thickened medial portion of the conus elasticus. [8,9,10,11]

CRICOID CARTILAGE

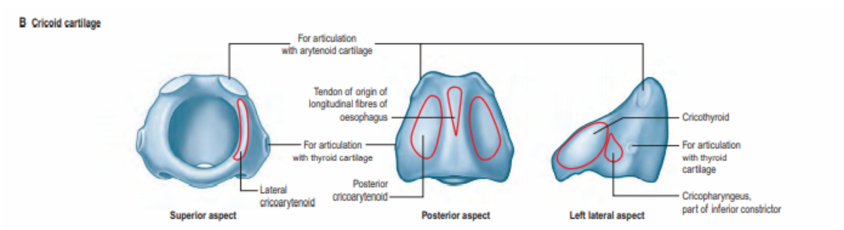


FIG 7: CRICOID CARTILAGE

- Signet shaped ring of cartilage at C6 vertebra .
- Completely encircles lumen of larynx and is attached below to trachea.
- Articulates with thyroid cartilage and arytenoid cartilages by synovial joints.
- Lower border of cricoid articulates with inferior thyroid cornu. It is horizontal and joined to the first tracheal cartilage by the cricotracheal ligament .

- The superior border of cricoid runs obliquely at the back, and gives attachment anteriorly to the thick median cricothyroid ligament and laterally to the conus elasticus and lateral cricoarytenoid.[8,9]

ARYTENOID CARTILAGE

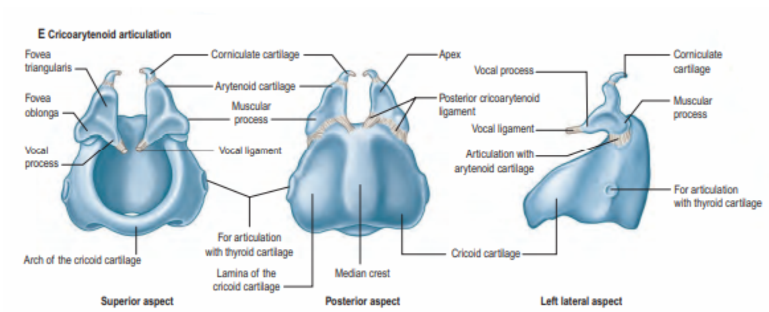


FIG 8: ARYTENOID CARTILAGE

- Articulate with the lateral parts of upper border of the cricoid lamina .[8,10,11]

CORNICULATE CARTILAGES (Of Santorini)

- Two small conical nodules of elastic cartilage that articulate with the apices of the arytenoid cartilages.
- Lie in the posterior parts of the aryepiglottic folds.[8,10,11]

CUNEIFORM CARTILAGES (Of Wrisberg)

- Two tiny ,elongated, rod like nodules of elastic cartilage lying in posterior parts of aryepiglottic folds just above corniculate cartilages.[8,10,11]

JOINTS OF THE LARYNX:

Cricothyroid joint
Cricoarytenoid joint
Arytenocorniculate joint

TABLE 2 : JOINTS OF LARYNX[8]

All three joints are paired

CRICOTHYROID JOINT

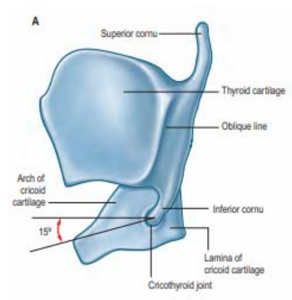


FIG 9: CRICOTHYROID JOINT

- A plane synovial joint between the inferior cornua of the thyroid cartilage and cricoid cartilage.
- Permits two kinds of movement –rotatory movement and gliding movement .
- Effect of these movements -to lengthen the vocal folds, provided the arytenoid cartilages are stabilized at the cricoarytenoid joint. It may also increase vocal fold tension. [8,10,11]

CRICOARYTENOID JOINT

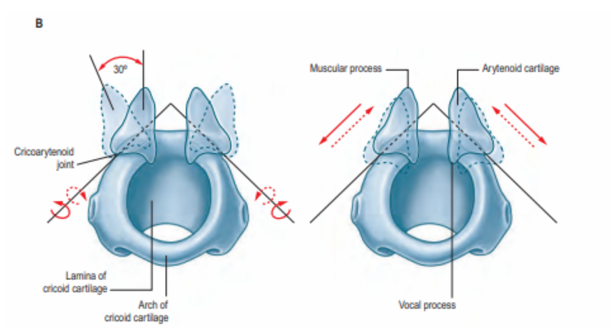


FIG 10: CRICOARYTENOID JOINT

- A tiny plane synovial joint between lateral parts of upper border of lamina of cricoid cartilage and base of arytenoids.

- Permits two types of movements- rotatory movement and gliding movement .
- The 'rest' position of the cricoarytenoid ligament is a major determinant of position of a denervated vocal cord.[8,10,11]

TABLE 3: LIGAMENTS AND MEMBRANES OF LARYNX[8]

	EXTRINSIC	INTRINSIC
MEMBRANES	Thyrohyoid membrane	Conus elasticus
	Cricotracheal membrane	Quadrangular membrane
LIGAMENTS	Median and lateral thyrohyoid ligament	Vocal ligament
	Cricothyroid ligament	Vestibular ligament
	Cricotracheal ligament	

EXTRINSIC LIGAMENTS AND MEMBRANES

THYROHYOID MEMBRANE

- A broad, fibroelastic layer.
- Extends from upper border of thyroid cartilage to upper border of hyoid bone.
- The thyrohyoid membrane is pierced on either side by the superior laryngeal vessels and internal laryngeal nerves .
- Its inner surface is related to lingual surface of epiglottis and piriform fossae of the pharynx. [8,10,11]

HYOEPIGLOTTIC LIGAMENT

- It connects the posterior part of hyoid with anterior surface of upper part of epiglottis.

THYROEPIGLOTTIC LIGAMENT

- It connects lower end of epiglottis to the posterior surface of the thyroid angle.

CRICOTRACHEAL LIGAMENT

- It connects the cricoid to the first tracheal cartilage.

CRICOTHYROID LIGAMENT

- It connects the lower border of thyroid cartilage to the cricoid cartilage in the midline.[8,10,11]

INTRINSIC LIGAMENTS AND MEMBRANES

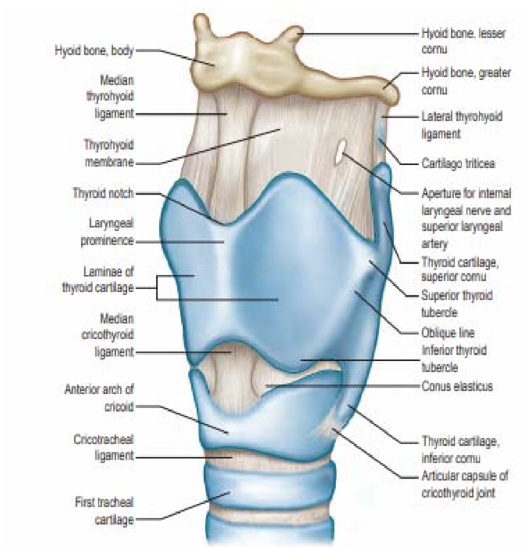


FIG 11: ANTEROLATERAL VIEW OF LARYNGEAL LIGAMENTS AND CARTILAGES

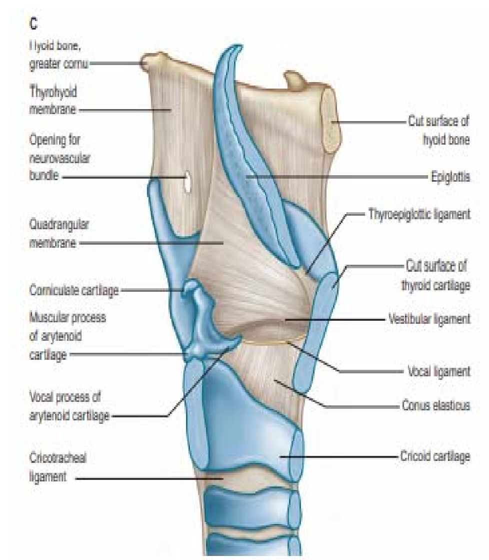


FIG 12: QUADRANGULAR MEMBRANE VIEWED FROM LEFT SIDE

- They are parts of a broad sheet of fibroelastic tissue that form the inner tube of the laryngeal cavity outside its mucosal lining.

- It is interrupted on each side by the sinus of the larynx called as quadrangular membrane.
- The part below the sinus is called cricovocal membrane /conus elasticus.

- CONUS ELASTICUS :

a. It maximizes the efficient flow of air towards the rima glottidis during phonation.
b. It is thickened to form the vocal ligament .
c. The fold of mucous membrane over vocal ligament is called vocal fold.

- QUADRANGULAR MEMBRANE :

a. Extends from side of epiglottis to arytenoids .
b. Its lower edge is free and attached anteriorly to posterior surface of thyroid cartilage and posteriorly to lateral surface of arytenoids cartilage .

- VESTIBULAR LIGAMENT :

  Extends anteroposteriorly from posterior surface of thyroid cartilage to lateral surface of arytenoids.[8,10,11]

LARYNGEAL CAVITY

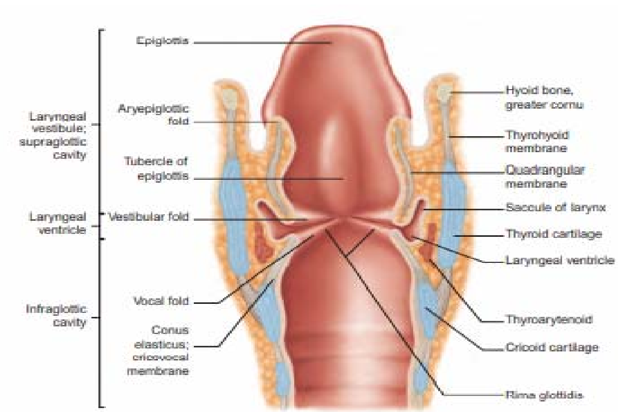


FIG 13 : CAVITY OF LARYNX

- Extends from the laryngeal inlet opening into the laryngopharynx down to lower border of cricoid cartilage, where it continues into the lumen of the trachea.
- Two pairs of folds mucous membrane extend on each side posteroanteriorly from arytenoid cartilage to thyroid cartilage .
- Upper fold : Produced by vestibular ligament and called vestibular folds /false vocal cords.
- Space in between vestibular folds is called rima vestibuli .
- True vocal cords - primary source of phonation.
- When vestibular folds come together they prevent liquids and food to enter the larynx and air from leaving lungs when a person holds his breath.
- Lower fold: Produced by vocal ligaments and vocalis muscle and called as true vocal cords .They extend from thyroid angle to vocal processes of arytenoids .
- RIMA GLOTTIDIS: Narrowest part of laryngeal cavity and the space between right and left vocal folds.
- VESTIBULE : Portion of the laryngeal cavity above the glottis.
- SUBGLOTTIS : Portion inferior to the vocal cords.
- Anterior commissure -The site where vocal cords meet anteriorly.[8,10,11]

GLOTTIS:

- Space between two vocal cords.
- Divided into two regions:

a. Anterior intermembranous part(3/5th) and is formed by the underlying vocal ligament.

b. Posterior intercartilaginous part(1/5th) formed by the vocal processes of the arytenoid cartilages.

- Narrowest part of the larynx, having a diameter of 23 mm in adult males and 17mm in adult females.
- Its width and shape change with the movements of vocal cords and arytenoid cartilages during respiration and phonation.[8,10,11]

LARYNGOSCOPIC EXAMINATION

- The inlet of larynx , structures around it ,and cavity of larynx can be visualized using fibreoptic endoscopy .
- Tubercle of the epiglottis is seen.
- The aryepiglottic folds can be traced posteromedially from the epiglottis.
- Cuneiform and corniculate projections can be recognized.
- Pearly white vocal cords and pink vestibular folds are visible.
- When rima glottidis is wide open- anterior arch of cricoid cartilage, the tracheal mucosa and cartilages may be seen.[8,10,11]

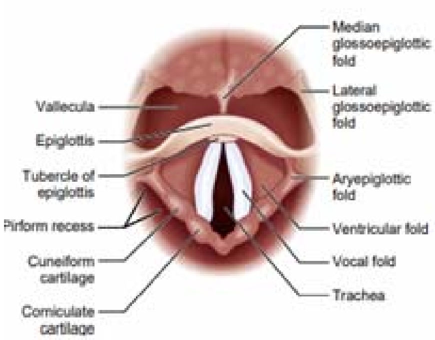


FIG 14: LARYNX VIEWED FROM HYPOPHARYNX

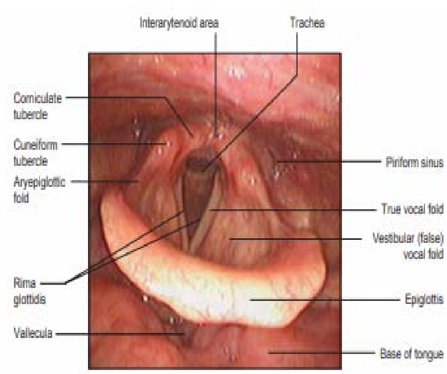


FIG 15: STRUCTURES AS VIEWED THROUGH FIBEROPTIC ENDOSCOPE

TABLE 4 : EXTRINSIC AND INTRINSIC MUSCLES OF LARYNX[8]

EXTRINSIC MUSCLES OF LARYNX	INTRINSIC MUSCLES OF LARYNX
Palatopharyngeus Stylopharyngeus Salpingopharyngeus	MUSCLES THAT OPEN OR CLOSE LARYNGEAL INLET : Oblique arytenoids-closes laryngeal inlet Aryepiglotticus- closes laryngeal inlet Thyroepiglotticus-opens laryngeal inlet
Thyrohyoid Sternothyroid	MUSCLES THAT ABDUCT /ADDUCT VOCAL CORDS : Posterior cricoarytenoids–abduct vocal cords Lateral cricoarytenoids–adduct vocal cords Transverse cricoarytenoid–adduct vocal cords
	MUSCLES THAT INCREASE / DECREASE TENSION OF THE VOCAL CORD: Cricothyroid –tenses vocal cord Vocalis-tenses vocal cord Thyroarytenoid-relaxes vocal cord

BLOOD SUPPLY OF LARYNX:

ARTERIAL SUPPLY:

- Above vocal cord –by superior laryngeal artery, branch of superior thyroid artery
- Below vocal cord –by inferior laryngeal artery, branch of inferior thyroid artery

VENOUS DRAINAGE:

- Superior laryngeal vein-drains into superior thyroid vein
- Inferior laryngeal vein-drains into inferior thyroid vein

LYMPHATIC DRAINAGE OF LARYNX:

- Above the vocal cords-Drain the supraglottic part of larynx ,runs along the superior laryngeal artery, pierces the thyrohyoid membrane and drains into upper deep cervical lymph nodes. They also communicate with lymphatics at base of the tongue.
- Below the vocal folds- Pierce the cricothyroid membrane ,travel through the conus elasticus and reach the prelaryngeal (Delphian) ,paratracheal and pretracheal lymph nodes. Some other lymph vessels run along the inferior laryngeal artery and drain into the lower deep cervical nodes.

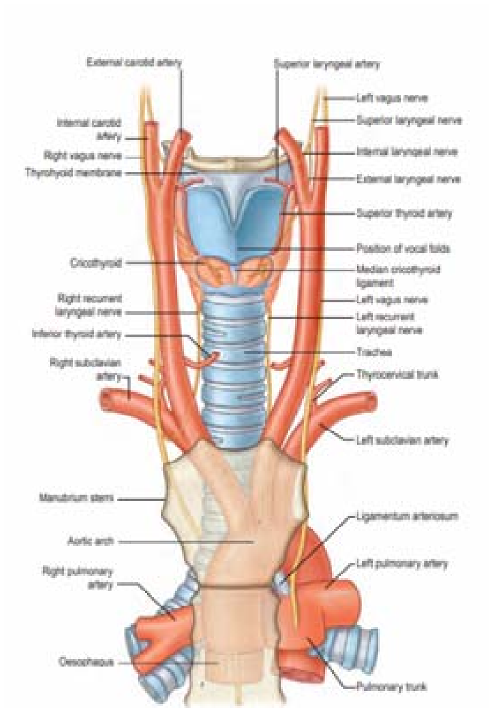


FIGURE 16: BLOOD SUPPLY OF LARYNX

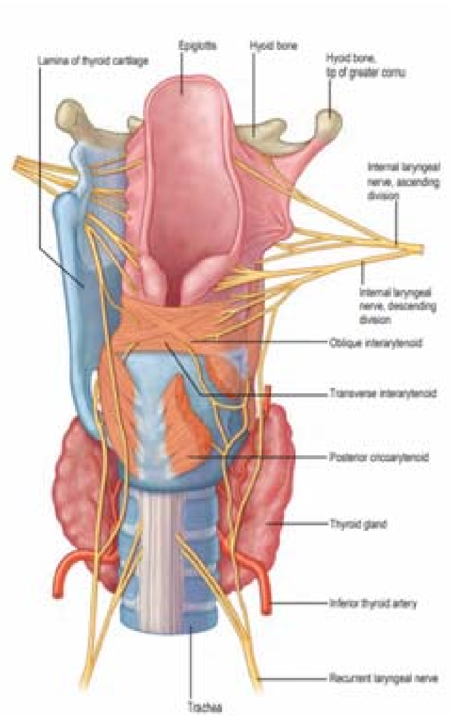


FIGURE 17: NERVE SUPPLY OF LARYNX

NERVE SUPPLY OF LARYNX:

- By internal and external branches of superior laryngeal nerve, recurrent laryngeal nerve and sympathetic nerves.
- Internal laryngeal nerve is described as sensory nerve, the external laryngeal nerve as motor nerve, and the recurrent laryngeal nerve as mixed nerve.
- Internal laryngeal nerve is sensory down to the vocal cords, the recurrent laryngeal nerve is sensory below the vocal cords, and overlap is between the areas innervated by the two nerves at the vocal cords.
- Many anastomoses are present between the internal, external and recurrent laryngeal nerves that are present on posterior surface of the larynx and this forms laryngeal plexus which is parallel to the pharyngeal plexus.[8,10,11]

FUNCTIONS OF LARYNX:

- Respiration-Acts as an air passage.
- Protection-Acts as a sphincter at the inlet of lower respiratory tract to protect trachea and bronchial tree from entry of any other material other than air .In this way,it prevents fluid and food to be aspirated into the trachea.
- Phonation-Acts an organ of phonation, hence also called as voice box.
- Deglutition-Upward and downward movement of larynx helps in swallowing.[8,9,10,11,12]

<u>**PHYSICS OF ULTRASOUND**</u>

INTRODUCTION

- Ultrasound is an interactive imaging approach where the operator keeps the ultrasound probe in contact with the patient and observes for real time images of internal anatomy.[13,14]
- Ultrasound provide high resolution assessment of soft tissues.
- Advantages –quick , safe ,repeatable , widely available , portable and gives real time dynamic images .[14]

<u>**PROPERTIES**</u>

- Ultrasound imaging is formed due to scattering of sound energy by material interfaces with discrete properties through interactions by acoustic physics.
- When mechanical energy travels through matter ,it produces an alternating compression and rarefaction .As a result ,sound is produced .
- There is limited physical displacement of the material through which sound is being transmitted and as a result , pressure waves are produced .
- The changes in pressure are plotted in form of sinusoidal waveform.[15]

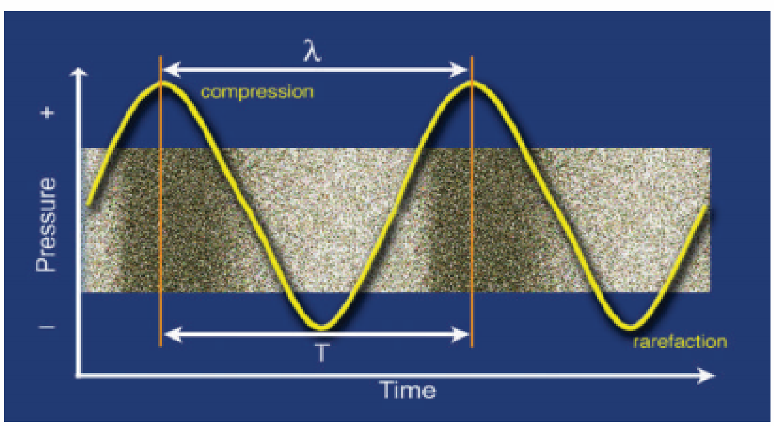


FIGURE 18: SOUND WAVES

- X axis –indicates time.
- Y axis -indicates pressure at a given point .
- The basic unit of measurement for sound is defined by change in pressure with time.
- Wavelength (λ)-The distance between corresponding points on the time pressure curve.
- Period -Time (T) to complete a single cycle.
- Frequency of sound (f)-The number of complete cycles in a unit of time.
- $f = 1/T$, or $f = T \times sec^{-1}$ (when period (T) is expressed in seconds).
- Hertz (Hz)-The unit of acoustic frequency.
- 1 Hz = 1 cycle per second.
- High frequencies are expressed in kilohertz (kHz; 1 kHz = 1000 Hz) or megahertz (MHz; 1 MHz = 1,000,000 Hz).
- From <1 Hz to $>100{,}000$ Hz (100 kHz) -Acoustic frequencies vary.
- 20 - 20,000 Hz- Human hearing
- Ultrasound differs from audible sound only in its frequency.
- Ultrasound - 500 -1000 times more than the sound humans normally hear.
- Sound frequencies ranges from 2 -15 MHz for diagnostic purposes.[15]

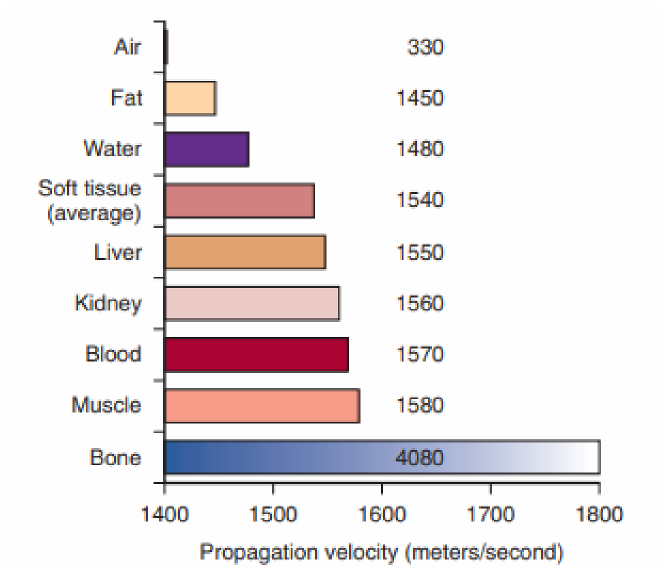


FIG 19: PROPAGATION VELOCITY

- PROPAGATION VELOCITY:

a. Brief bursts of energy are transferred into the body and it travels into tissues and the speed at which it travels is called propagation velocity.

b. It is determined by resistance of the medium to compression that is in turn is influenced by density of the medium and its stiffness/elasticity.

c. In the body, propagation velocity of longitudinal waves is a constant for a given tissue and not affected by the frequency or wavelength of the sound

d. In the body propagation velocity of sound is around 1540 m/sec.

e. Hence medical ultrasound devices base their measurements on propagation velocity of 1540 m/sec.[14,15]

PIEZOELECTRIC EFFECT:

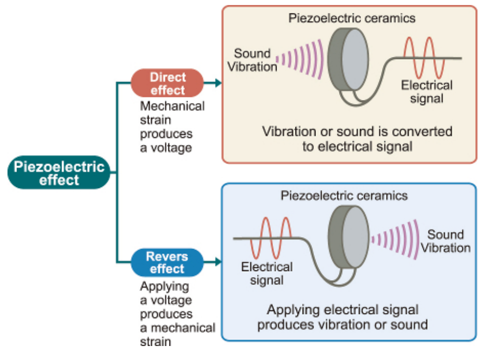


FIGURE 20 : PIZOELECTRIC EFFECT

- Discovered by Jacques Curie and Pierre in 1880.
- Certain crystals have the ability to generate vibrations and electrical charge to an applied pressure . These crystals are called pizoelectric crystals.
- Pizoelectric elements (Lead Zirconate titanate)(PZT) are the vibrating crystals that give rise to ultrasonic waves that are transmitted to a paired object.
- Then the waves that are reflected return to transducer and create mechanical distortion of the crystals .This is converted to an electric current via the same piezoelectric effect.
- The ultrasound machine's computer processor interprets electric current resulting in an image.
- Ultrasound transducer works on the principle of piezoelectric effect.[14,15,16,17]
- When there is both a delay in receiving echo by piezoelectric elements and the intensity of the echo ,it is used to produce a two dimensional ultrasound image called a B (brightness) mode image .[18]

INSTRUMENTATION:

All ultrasound scanners consist of the same following basic elements :

a. Ultrasound transducer

b. Transmitter/Pulser– to energise the transducer

c. Processor and receiver –to identify and amplify backscattered energy

d. Display –to present the ultrasound image in a form acceptable for analysis and interpretation[15]

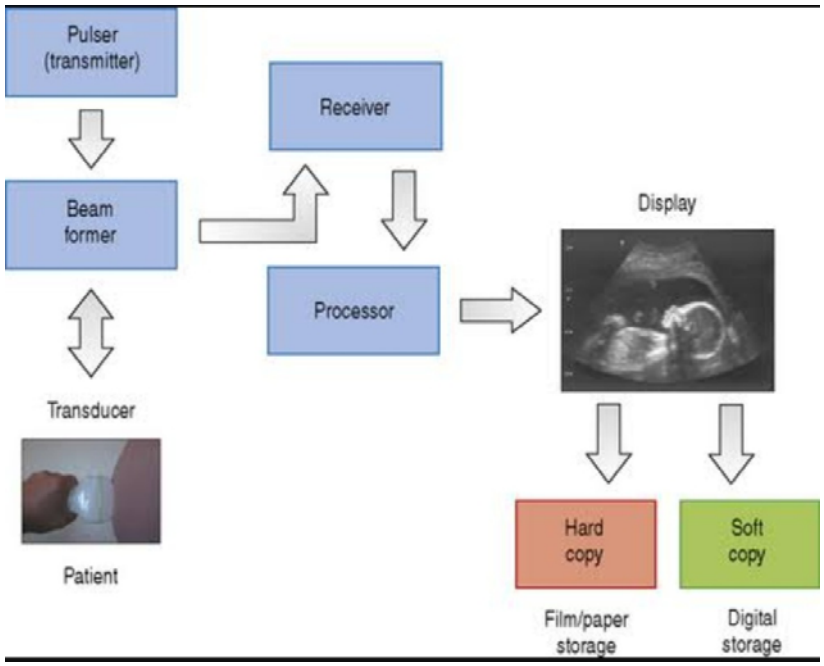


FIGURE 21: BASIC ELEMENTS OF ULTRASOUND MACHINE

TRANSDUCER:

- Any device that converts one form of energy to another is a transducer .
- The transducer converts electric energy to mechanical energy and vice versa.
- Ultrasound transducer works on the principle of piezoelectric effect.

- There are two functions of transducer:

a. Converts electric energy provided by transmitter to acoustic pulses aimed towards the patient.

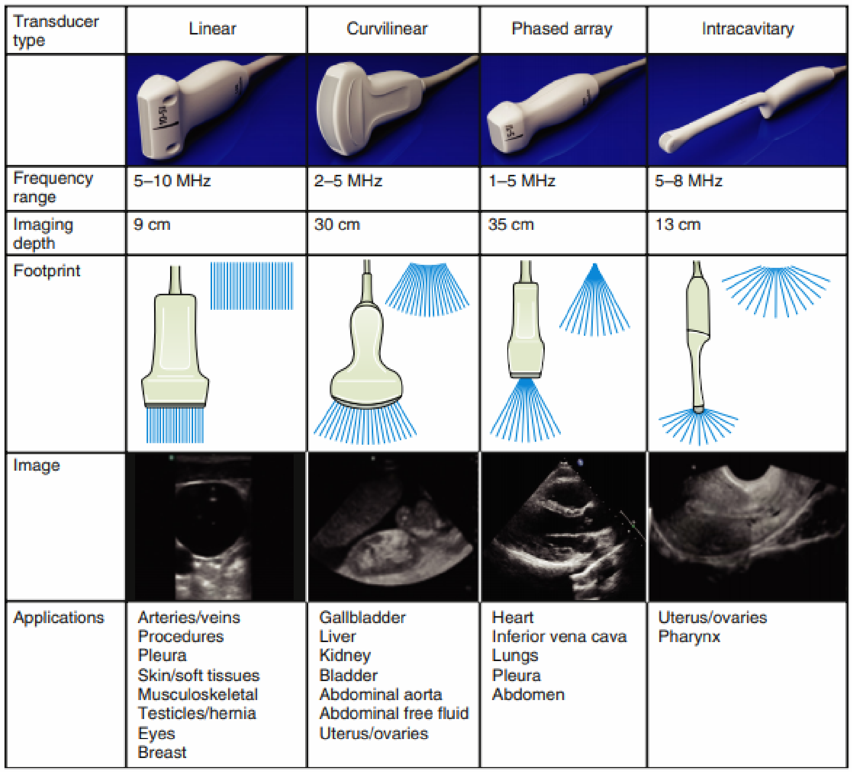
b. Acts as a receiver of reflected echoes that converts weak pressure changes into electric signals for processing.[16,17]

TYPES OF TRANSDUCER :

- Transducer is made up of many elements that are produced by accurate slicing of piezoelectric material into many small units ,each with its own electrodes .
- Transducer arrays are formed in variety of configurations :

1. Linear
2. Curvilinear
3. Phased
4. Annular

- The accurate timing of firing of combinations of elements in these arrays and interference of the wavefronts produced by the individual elements are used to change the direction of the ultrasound beam and this is used to provide generation of real time images.[15]



Transducer type	Linear	Curvilinear	Phased array	Intracavitary
Frequency range	5–10 MHz	2–5 MHz	1–5 MHz	5–8 MHz
Imaging depth	9 cm	30 cm	35 cm	13 cm
Footprint				
Image				
Applications	Arteries/veins Procedures Pleura Skin/soft tissues Musculoskeletal Testicles/hernia Eyes Breast	Gallbladder Liver Kidney Bladder Abdominal aorta Abdominal free fluid Uterus/ovaries	Heart Inferior vena cava Lungs Pleura Abdomen	Uterus/ovaries Pharynx

FIGURE 22: TYPES OF ULTRASOUND TRANSDUCER

- Higher frequency transducers - better for imaging superficial structures such as the musculoskeletal system.
- Lower frequency transducers- better for imaging deep structures, such as the abdomen.[15]

LINEAR ARRAY

- In these transducers, individual elements are arranged in rows.
- When these elements are fired in succession ,a series of parallel pulses is produced and each forms a line of sight perpendicular to the transducer face.
- The lines of sight merge to form field of view.
- It produces parallel scan lines which are transmitted perpendicularly to the transducer face.

- It has a rectangular image format.
- It has a flat transducer surface.
- Advantages are-precise anatomical details and good image quality across image depth and field of view.
- Disadvantage- limited field of view and depth.[13,14,15,16]

IMAGE DISPLAY :

Ultrasound signals maybe displayed in many ways mainly A mode, B mode ,M mode.[15]

B- MODE:

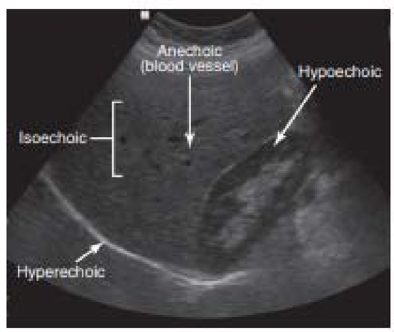


FIGURE 23: TWO DIMENSIONAL(B MODE)

- A cross sectional image is formed by echoes generated by reflection of ultrasound waves at tissues and scattered inside tissues .
- Every echo is displayed at a point in the image that corresponds to the point of its origin in the cross section .
- The brightness of image at every point is related to the amplitude of echo which gives rise to the term B –mode (brightness mode).
- Also known as 2D (Two dimensional)mode.
- The brightness of structures observed depends on the intensity of reflected signals.[13,16,19]

TABLE 5 : IMAGE TERMINOLOGY IN USG

IMAGE TERMINOLOGY	DESCRIPTION	APPEARANCE ON USG	EXAMPLE
Echogenic	A structure that produces echoes	White	Surface of bone
Hyperechoic	A structure that produces strong echoes compared to surrounding structures	White	Fat ,bone
Hypoechoic	A structure that produces weak echoes compared to surrounding structures	Dark gray	Fluid collections Blood in vessels
Isoechoic	A structure that produces echoes similar to surrounding structures		
Anechoic	A structure that does not produce echoes	Black	Lumen of blood vessels, bladder
Heterogeneous	An uneven texture pattern of a structure		
Homogeneous	An even ,smooth texture pattern of a structure		

TABLE 6: APPEARANCE OF DIFFERENT TISSUE TYPES ON USG

TISSUE	APPEARANCE ON USG
Muscle	Hypoechoic
Subcutaneous fat	Hypoechoic with characteristic interposed curved hyperechoic lines that are formed by connective tissue septa .Image quality of deeper structures is decreased due to fat which scatters ultrasonic waves
Tendon	Hyperechoic
Hyaline cartilage	Hypoechoic
Fibrocartilage	Hyperechoic with homogeneous texture
Bone	Hyperechogenic as USG waves are reflected back to the surface, underlying bone lacks signal
Nerve	Medium gray with heterogeneous texture. In long axis-Striated appearance due to their fascicular structure In short axis-Characteristic honeycomb appearance
Blood vessels	The lumen appears anechoic (black) that contrasts with the hyperechoic wall. Arteries are smaller than veins and have a thicker wall
Ligaments	Hyperechoic and in long axis, have a laminar appearance
Air	Anechoic
Fluid	Anechoic

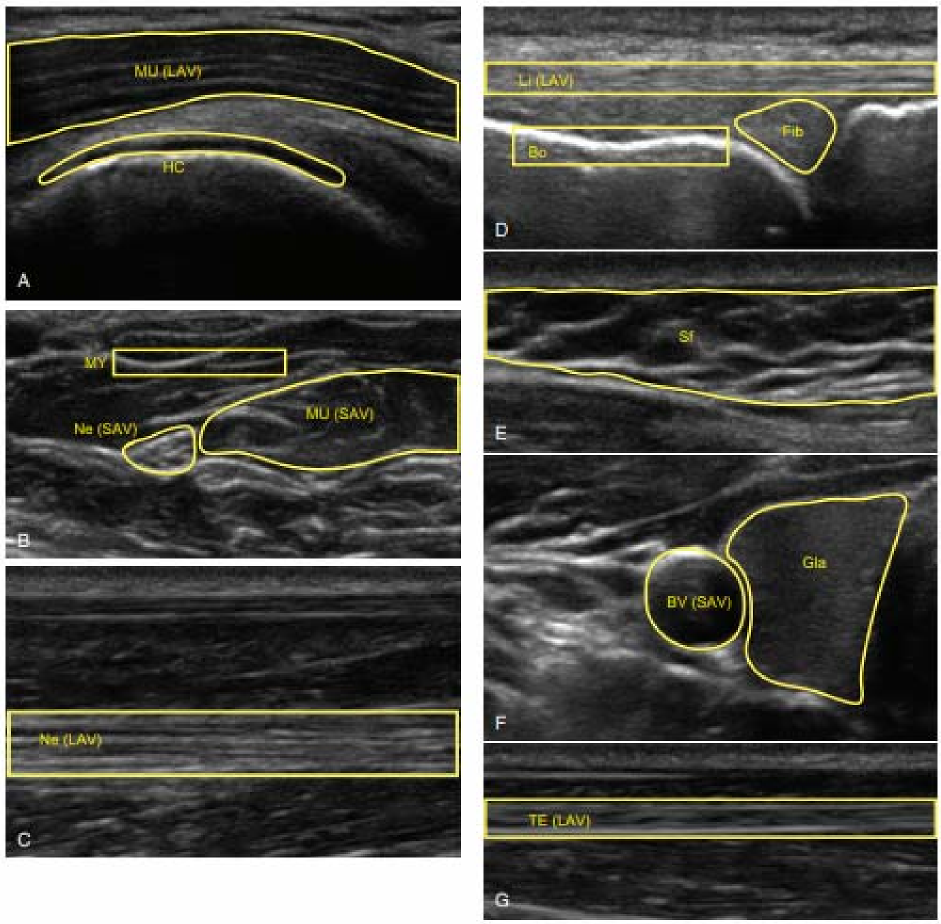


FIG 24: USG APPEARANCE OF DIFFERENT TISSUE TYPES

Bo-Bone	Li-Ligament
BV-Blood vessel	MU-Muscle
Fib-Fibrocartilage	MY-Myofascia
Gla-Gland	Ne-Nerve
HC-Hyaline cartilage	LAV-Long axis view
SAV-Short axis view	Sf-Subcutaneous fat
TE-Tendon	

EXAMINATION OF AIRWAY

The most important component of physical examination from an anesthesiologist point of view is airway examination.[7]

TABLE 7: COMPONENTS OF AIRWAY EXAMINATION[20]

SL NO	COMPONENTS
1	Length of upper incisors
2	Condition of teeth
3	Relationship of and ability to advance mandibular incisors in front of maxillary incisors
4	Interincisor gap
5	Mallampati grading
6	Shape of uvula
7	Compliance of mandibular space
8	Neck circumference
9	Thyromental distance
10	Neck mobility

TABLE 8: PREDICTORS OF DIFFICULT LARYNGOSCOPY[20]

SL NO	PREDICTORS
1	Small mouth opening
2	Mallampati Classification III /1V
3	Short ,thick neck
4	Limited cervical neck mobility
5	Short thyromental distance
6	Long upper incisors
7	Prominent overbite
8	Inability to protrude mandible
9	High arched palate

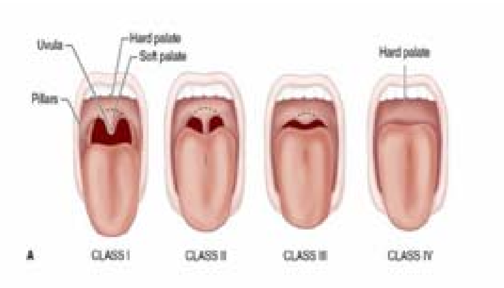


FIG 25: MALLAMPATI CLASSIFICATION

Class I: The entire palatal arch , including bilateral faucial pillars visible to the bases of pillars

Class II: Upper part of faucial pillars and most of uvula is visible

Class III: Only soft palate and hard palate is visible

Class IV: Only hard palate is visible

<u>OROTRACHEAL INTUBATION:</u>

<u>PREPARATION AND POSITIONING</u>

- There should be adequate preoxygenation and availability and proper functioning of all necessary equipment should be ensured— ETT ,laryngoscopes,stylets, an empty syringe to inflate the endotracheal tube cuff, suction apparatus and equipment for mask ventilation, including an oxygen source.
- For external laryngeal manipulation and stylet removal, a skilled assistant must be available.
- For a successful direct laryngoscopy , a line of sight from mouth to larynx has to be achieved.
- The classical model used to describe the anatomic relationships necessary to achieve this was proposed in 1944 by Bannister and Macbeth and includes the alignment of three anatomic axes—oral, laryngeal and pharyngeal axes.

- Sniffing position approximates this alignment .
- Maximal head extension at atlanto occipital joint brings oral axis closer into alignment.
- Alignment of pharyngeal and laryngeal axis is achieved by cervical flexion.[20,21]

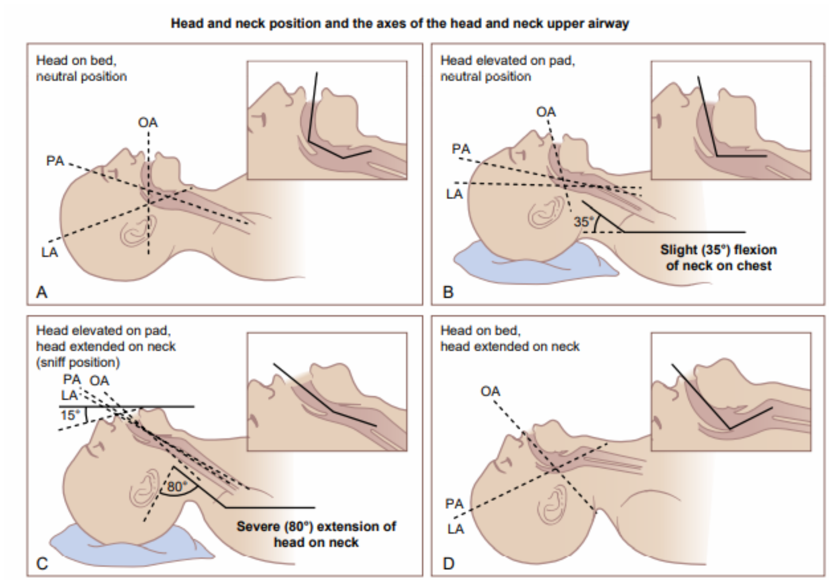


FIG 26: ALIGNMENT OF THREE AXES :ORAL ,PHARYNGEAL AND LARYNGEAL IN FOUR DIFFERENT HEAD POSITIONS

OA-Oral axis

PA-Pharyngeal axis

LA-Laryngeal axis

(A) Head in neutral position with marked non alignment of LA,PA,OA

(B) Head resting on a large pad , flexing the neck on chest and aligns LA with PA

(C) Head resting on a large pad , flexing the neck on chest. Accompanying head extension on the neck brings all three axes into alignment (Sniffing position)

(D) Head extension on the neck without accompanying head elevation on a pad results in non alignment of PA and LA with OA

TECHNIQUE OF OROTRACHEAL INTUBATION:

- The instrument used for intubation is a laryngoscope that is a handheld instrument made up of a blade attached to a handle with a light source.
- There are two types of blades available for direct laryngoscopy –the curved blade and straight blade .
- Most commonly used curved blade -Macintosh and straight blade is Miller. Both possess a flange to be used to retract the tongue laterally.
- For most adult patients ,a Macintosh size 3 is usually the proper size. For patients with a larger thyromental distance,larger blade is more appropriate. The blade is inserted in the right side of the mouth, and the flange is used to sweep the tongue to the left.
- The blade is advanced along base of tongue till the epiglottis is visualized, then tip of the blade is advanced further and placed in the vallecula.
- The glottic structures are exposed when a force is directed at 45^0up and away from the anaesthetist which indirectly lifts epiglottis by laying tension on the hyoepiglottic ligament.
- Force is to be applied using anterior deltoid and triceps and not by radial flexion of wrist .
- As soon as there is a complete view of the glottis, the endotracheal tube is held like a pencil with the right hand and placed in between vocal cords and into trachea.
- A stylet shaped into a hockey stick may be used to facilitate the passage of ETT as it provides an anterior angulation to the tip of ETT. [20,21]

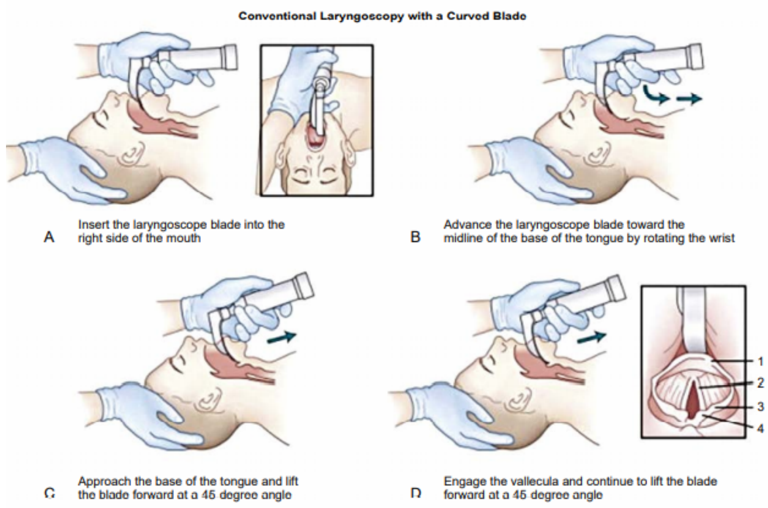


FIG 27 : TECHNIQUE OF DIRECT LARYNGOSCOPY

- Inadequate view of glottis is one of the reasons for difficulty in tracheal intubation .
- Cormack & Lehane developed a grading scale in 1984 to describe laryngoscopic views.

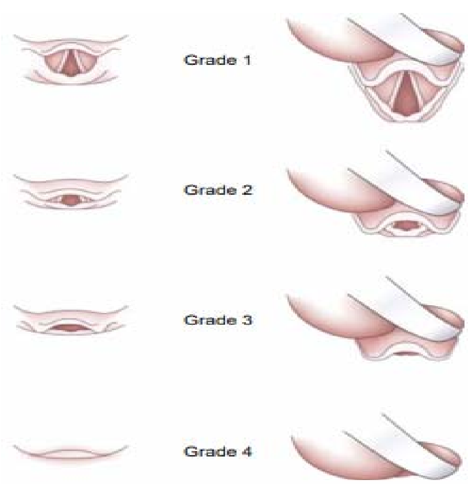


FIG 28: CORMACK LEHANE GRADING SYSTEM FOR DIRECT LARYNGOSCOPY

Grade 1: Visualisation of entire laryngeal aperture

Grade 2: Visualisation of only posterior portion of laryngeal aperture

Grade 3: Visualization of only epiglottis

Grade 4: No visualization of epiglottis

- Cormack Lehane Grade 1, 2- easy intubation
- Cormack Lehane Grade 3,4 -difficult intubation
- Yentis then modified the Cormack Lehane scoring system who described grade II be changed to IIA –partial view of glottis and IIB –only arytenoids or posterior cords are visible.
- To improve laryngeal view ,external laryngeal manipulation can be used.
- Backward, upward, rightward pressure (BURP maneuver) on thyroid cartilage is most commonly used. When the laryngoscopist uses his right hand to guide the position and an assistant exerts pressure on larynx , optimal external laryngeal manipulation (OELM) is achieved.
- Inadequate laryngeal view needs further verification by laryngoscopist as to whether patient is in optimal position , OELM is provided and if laryngoscope has not been too deeply placed .
- When glottic view is adequate, ETT is to be placed into right corner of the mouth and advanced in such a way that it stops the laryngoscope blade at the glottis and ensures that the glottic view is not obscured .The tip of ETT is advanced till proximal part of cuff is approximately 2cm beyond the vocal cords.[21]

ULTRASONOGRAPHY OF THE AIRWAY

INTRODUCTION

- Linear high frequency transducer- most suitable for imaging superficial airway structures.
- Low frequency transducer- most suitable for imaging submandibular and supraglottic regions via sagittal and parasagittal views as increased depth of penetration allows better visualization of deeper structures and wider field of view.

TABLE 9 : AIRWAY STRUCTURES AND THEIR APPEARANCE ON USG[22]

Bony structures	Mentum Rami of mandible Hyoid bone Sternum	Bright hyperechoic linear structures with hypoechoic acoustic shadow below
Cartilaginous structures	Thyroid Cricoid	Homogenously hypoechoic
Muscles & Connective tissue		Hypoechoic but more heterogenous striated appearance
Glandular structures	Submandibular gland Thyroid gland	Homogenous More hyperechoic compared to adjacent soft tissues
Air –mucosa interface (A-M interface)	Interface between mucosa lining upper airway tract and air within it	Bright hyperechoic linear appearance
Posterior pharynx Posterior commissure Posterior wall of trachea		Intraluminal air prevents visualization of these structures

- With conventional USG, the airway can be visualized from tip of the chin to midtrachea, along with the pleura and the diaphragm.[22]

FLOOR OF MOUTH :

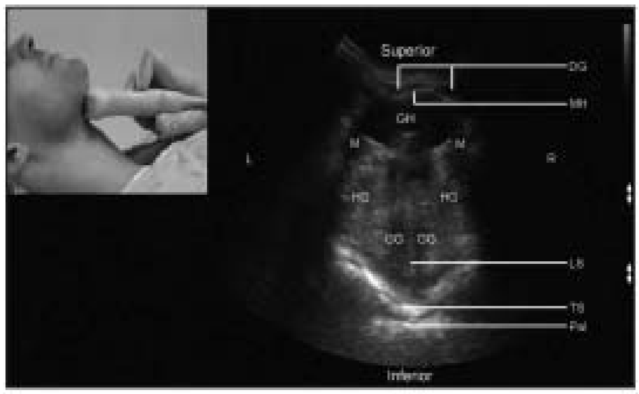


FIG 29: USG IN SUBMANDIBULAR POSITION (TRANSVERSE VIEW) SHOWING FLOOR OF MOUTH

MH- Mylohyoid muscle

DG- Digastric muscle

LS- Lingual septum

GG- Genioglossus

GH- Geniohyoid

HG- Hyoglossus

M- Mandible

Pal- Palate

TS- Tongue surface

- Visualised by placing transducer submentally in diagonal and vertical sections starting from mandible to hyoid bone.
- Muscles visualized in order-Platysma ,mylohyoid muscle , anterior belly of digastric muscle, posterior belly of digastric muscle ,geniohyoid muscle, genioglossus muscles .[22]

TONGUE:

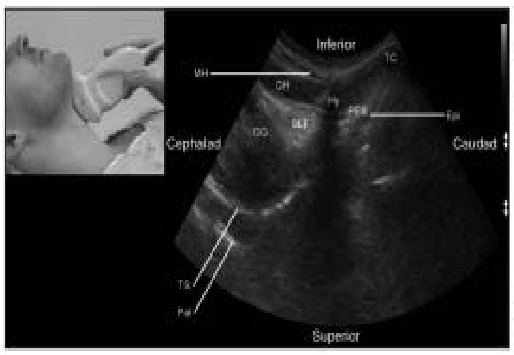


FIG 30:USG IN SUBMANDIBULAR POSITION (SAGITTAL VIEW)SHOWING FLOOR OF MOUTH AND TONGUE

FIG 31 : USG IN SUBMANDIBULAR POSITION (SAGITTAL VIEW) SHOWING MUSCLES OF TONGUE

Hy- Hyoid bone

Epi- Epiglottis

GG- Genioglossus

GH- Geniohyoid

MH- Mylohyoid

PES- Pre epiglottic space

Pal- Palate

SLF- Sublingual fat

TC- Thyroid cartilage

TS- Tongue surface

M- Mentum

- Tongue-Hypo/isoechoic structure.
- Tongue comprises of an anterior mobile part in the oral cavity and a fixed pharyngeal portion.
- The width of base of tongue is measured by identifying the two lingual arteries by USG Doppler and then calculate the distance between these arteries where they enter base of tongue.
- Palate can be visualized when the tongue is in contact with it.
- In the midline , in transverse plane , the valleculae and lingual tonsil can be visualised.
- Just below the hyoid bone ,the vallecula is seen.
- When the probe is angled upwards away from hyoid bone , the preglottic and paraglottic spaces and infrahyoid part of epiglottis can be seen.[22,23,24]

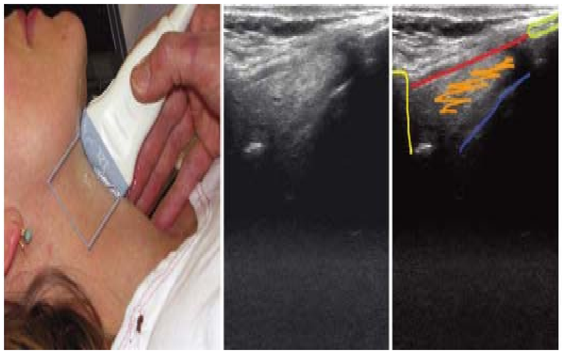
OROPHARYNX:

- Visualised by placing transducer vertically around 1 cm below external auditory canal.
- Thickness of lateral parapharyngeal wall and lateral pharyngeal border can be measured.[22,23,24]

HYPOPHARYNX:

- Ultrasonography through thyrohyoid membrane, cricothyroid membrane (CTM) , thyroid cartilage lamina and cricothyroid space can reveal hypopharyngeal tumors.[22,23,24]

HYOID BONE:



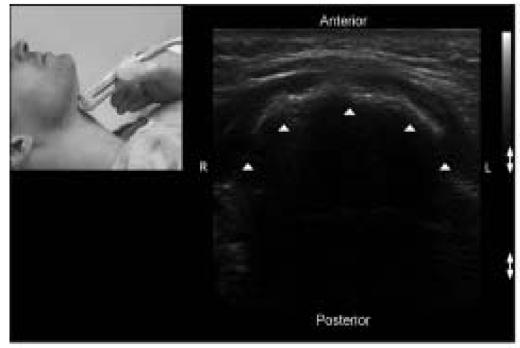


FIG 32 :USG IN SUBMANDIBULAR POSITION (SAGITTAL VIEW) SHOWING HYOID BONE

FIG 33 :USG IN SUBMANDIBULAR POSITION (TRANSVERSE VIEW) SHOWING HYOID BONE

- It is key landmark that separates upper airway into two areas to be scanned: the infrahyoid and suprahyoid regions.
- Suprahyoid region-floor of mouth , tongue, salivary glands.
- Infrahyoid region-thyrohyoid membrane, epiglottis, thyroid cartilage, vocal cords, cricoid cartilage ,cricothyroid membrane , trachea.
- Transverse view-Visualised as an inverted U–shaped, superficial, hyperechoic structure with posterior acoustic shadowing.
- Sagittal and parasagittal view -Visualised as a curved ,narrow ,hyperechoic structure that casts an acoustic shadow.[22,23,24]

LARYNX (THYROHYOID MEMBRANE, EPIGLOTTIS):

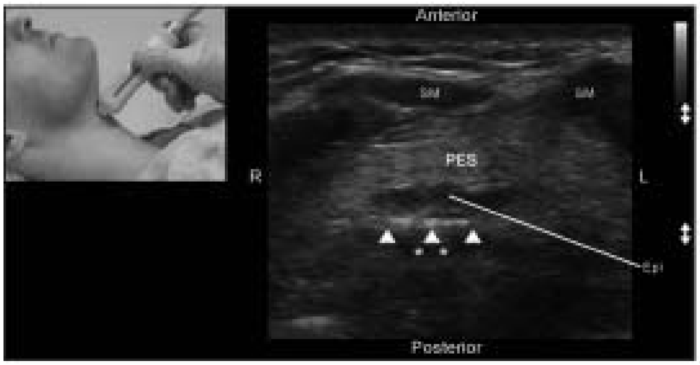


FIG 34 : USG IN TRANSVERSE VIEW SHOWING EPIGLOTTIS THROUGH THYROHYOID MEMBRANE

Epi- Epiglottis

PES- Pre epiglottic space

SM- Strap muscles

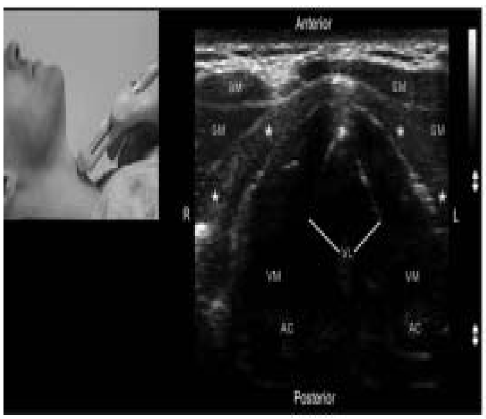
- High frequency transducer used for imaging .
- Thyrohyoid membrane- runs between lower border of hyoid bone and upper border of thyroid cartilage.
- Midline sagittal scan –In upper larynx from hyoid bone above to thyroid cartilage below reveals thyrohyoid ligament, pre epiglottic space with echogenic fat, and behind that a white line representing the epiglottis.
- Epiglottis-can be seen visualized through thyrohyoid membrane.
- Parasagittal view-Epiglottis is seen as a hypoechoic structure with a curvilinear shape.
- Transverse view -Epiglottis is seen as an inverted C

  Anteriorly- Hyperechoic, triangular pre epiglottic space

  Posteriorly- Hyperechoic air-mucosa interface
- Epiglottis can be identified well after tongue protrusion and swallowing .

- Cricothyroid region- Probe tilted upwards to visualize vocal cords and arytenoid cartilage. Probe can be moved distally to visualise the cricoid .
- Transverse view -Tonsils, base of tongue , vallecula, strap muscles, thyroid cartilage laminae, cricoid cartilage and posteriorly, the piriform sinuses and esophagus.[22,23,24]

THYROID CARTILAGE AND VOCAL CORDS:



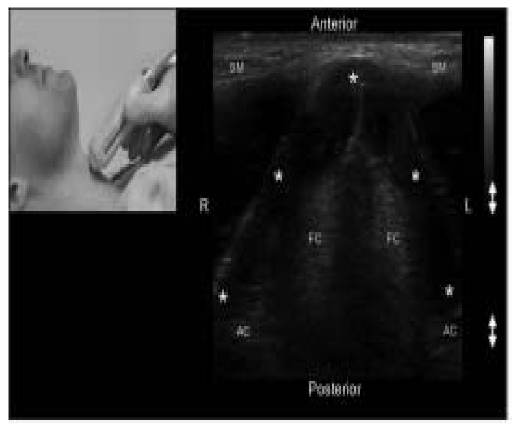


FIG 35 :USG IN TRANSVERSE VIEW AT THE LEVEL OF THYROID CARTILAGE SHOWING TRUE VOCAL CORDS AND VOCAL LIGAMENTS

FIG 36 :USG IN TRANSVERSE VIEW AT THE LEVEL OF THYROID CARTILAGE SHOWING FALSE VOCAL CORDS

AC- Arytenoid cartilage

SM- Strap muscles

VL- Vocal ligaments

VM – Vocalis muscle

FC- False cords

- Thyroid cartilage-seen as a linear hypoechoic structure highlighted by a bright A-M interface at the posterior surface.
- Vocal cords can be visualized at 3 levels: thyrohyoid membrane, thyroid cartilage , cricothyroid membrane .
- False and true vocal cords can be differentiated by moving transducer in cephalocaudad direction over thyroid cartilage.
- True vocal cords-seen as two triangular, hypoechoic structures (the vocalis muscles)and covered on either sides by hyperechoic vocal ligaments .
- They can be seen oscillating and move toward midline during phonation.
- False vocal cords- lie above and parallel to true vocal cords and are more hyperechoic and immobile during phonation .[22,23,24]

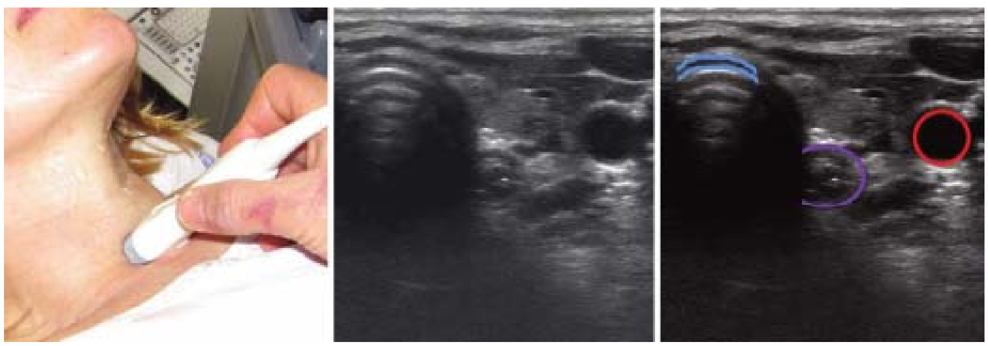
CRICOTHYROID MEMBRANE(CTM) AND CRICOID CARTILAGE:

FIG 37:USG AT MIDSAGITTAL PLANE SHOWING CRICOTHYROID MEMBRANE

CTM- Cricothyroid membrane
Green line- Thyroid cartilage
Dark blue line- Cricoid cartilage
Light blue line- Tracheal rings
Red line – Cricothyroid membrane
Orange line – Tissue air border
Brown line- Isthmus of thyroid gland

- Cricothyroid membrane –seen as hyperechoic band connecting hypoechoic thyroid and cricoid cartilage on sagittal and parasagittal view .
- Transverse view - Cricoid cartilage has an arch like appearance.
- Parasagittal view-Cricoid cartilage has a round, hypoechoic appearance.[22,23,24,25]

TRACHEA :



Light blue line- Tracheal cartilage

Purple line- Esophagus

Red line – Carotid artery

FIG 38: USG AT TRANSVERSE VIEW SHOWING TRACHEA AND ESOPHAGUS

- Upper limit of the trachea is marked by the cricoid cartilage that is thicker than tracheal rings.
- Visualised as a rounded, hypoechoic structure.
- With neck in mild extension, the first six tracheal rings can be visualized.
- Skin ,subcutaneous tissue , isthmus of thyroid and strap muscles cover the trachea .
- Strap muscles are visualized as hypoechoic and covered by cervical fascia that is seen as thin hyperechoic lines .

- Sagittal and parasagittal plane- Tracheal rings are hypoechoic and classically seen as a “string of beads”.
- Transverse view-Tracheal rings are seen as an inverted U highlighted by a hyperechoic A-M interface.[22,23,24]

FIG 39: ULTRASONOGRAPHY OF THE ANTERIOR NECK SOFT TISSUE THICKNESS - DSHB

FIG 40 :ULTRASONOGRAPHY OF THE ANTERIOR NECK SOFT TISSUE THICKNESS - DSEM

- The hyoid bone is identified as a curved echogenic structure with posterior acoustic shadow .
- The epiglottis is identified as a curvilinear hypoechoic structure with a bright posterior A-M interface and hyperechoic pre-epiglottic space.[24,25]

REVIEW OF LITERATURE

Komatsu R, Sengupta P et al in 2007 concluded in their study that thickness of pretracheal soft tissue at the level of vocal cords is not a good predictor of difficult laryngoscopy in obese patients (BMI>35)in the United States .[26]

Adhikari S, Zeger W, Schmier C et al in 2011 designed a study to determine usefulness of point of care ultrasound in the assessing difficult laryngoscopy in emergency room settings and concluded that sonographic measurements of anterior neck soft tissue (DSHB ,DSEM, thickness of tongue) were greater in difficult laryngoscopy and a cut off value of 2.8cm at thyrohyoid membrane can potentially be used to detect difficult laryngoscopy .Also ,clinical screening tests did not correlate with USG measurements.[27]

Wu J, Dong J, Ding Y et al in 2014 designed a study to determine if USG measurements -DSHB, DSEM and DSAC may be used to predict difficult laryngoscopy and concluded that the above parameters can independently predict difficult laryngoscopy. Combining these with screening tests may increase the ability in prediction of difficult laryngoscopy.[2]

Pinto J, Cordeiro L et al in 2016 designed a study to evaluate the use of DSEM for difficult laryngoscopy prediction and found that increasing DSEM is strongly associated with difficult laryngoscopy and a cut off value of 27.5mm was able to predict difficult laryngoscopy with an accuracy 74.3%,specificity 77.1% and sensitivity 64.7%.Also , DSEM may be used as a standalone screening test to predict difficult laryngoscopy and when combined with Mallampati score would considerably improve difficult airway prediction.[28]

Reddy AV, Aasim SA, Satya K et al in 2017 stated in their study that ultrasound is a useful tool in airway assessment considering USG parameters –DSHB,ANS-VC, E-VC and Pre-E alongside noting the CL grading .Here ANS-VC was a probable predictor of difficult intubation compared to other parameters.[29]

Saranya ,RajS,Lingraj Ket al in 2017 conducted a study to assess usefulness of ultrasonogram as a preoperative tool to identify difficult airway by including USG parameters DSHB ,DSEM and skin to tracheal ring thickness ,wherein it was noticed that ultrasound can be a reliable tool to identify difficult airway and there is a notable correlation between thickness of soft tissue at thyrohyoid membrane level and difficulty in intubation .[30]

Parameswari A, Govind M, Vakamudi Met al in 2017 devised a study to find the correlation between CL grade and preoperative USG parameters in adult patients and concluded that DSEM was a superior predictor of difficult laryngoscopy and when USG parameters were combined with Mallampati classification, sensitivity to predict difficult laryngoscopy was greater than a single parameter taken alone.[31]

Nazir I, Mehta Net al in 2018 designed a study that compared and correlated USG assessment of airway with Mallampati grading before induction of anaesthesia and also with CL grading classification during direct laryngoscopy under general anesthesia .They concluded that USG measurements were not very sensitive in predicting difficult laryngoscopy except for DSEM that had AUC of 0.772 and hence had the highest validity among parameters studied .[1]

Falcetta S, Cavallo S, Gabbanelli Vet al in 2018 evaluated the correlation between two USG measurements DSEM and PEA at level of thyrohyoid membrane and CL grading and they found that DSEM cut off value of 2.54cm and PEA cut off value of 5.04cm^2 may predict a CL grade atleast 2b at direct laryngoscopy .[32]

RavindranB, Magesh VM ,Vignesh Bet al in 2018 analysed pretracheal soft tissue thickness making use of ultrasonogram ,BMI and neck circumference in predicting intubation difficulties and concluded that they significantly predicted difficult intubation.[4]

Koundal V, Rana Set al in 2019 conducted a study that measured USG parameters preoperatively - DSHB ,DSEM, Pre-E/E-VC and clinical parameter considered was HDMR. They found that there was a strong positive correlation with Pre-E/E-VC ,DSEM and moderate negative correlation with HMDR that made them reliable predictors for difficult laryngoscopy.[33]

Yadav NK, Rudingwa P, Mishra SK in 2019 studied sensitivity and specificity of USG parameters DSHB , DSEM and tongue thickness in neutral and sniffing position and compared it to clinical parameters like inter incisor gap ,Mallampati classification ,thyromental ,sternomental distance and neck circumference and found that USG parameters had greater AUC than bedside clinical assessment tests that showed a greater validity to predict difficult laryngoscopy.[25]

Fulkerson JS, Moore HM et al in 2019 demonstrated a study which included USG parameters sonographic hyomental distance (HMD),anterior neck thickness at hyoid bone (HB),thyrohyoid membrane (THM)and vocal cords (VC), concluded that ultrasonography lacked utility in predicting difficult laryngoscopy in adult veteran surgical population.[34]

Kanoujiya J, Sancheti A, Swami S et al in 2019 designed a study to predict difficult laryngoscopy by USG guided evaluation of anterior soft tissue thickness ,revealing that USG measurements –DSHB,DSAC showed higher specificity and sensitivity for prediction of difficult laryngoscopy when compared to Modified Mallampati ,BMI and neck circumference.[3]

Alessandri F, Antenucci G et al in 2019 conducted a study to evaluate accuracy of preoperative ultrasound assessment of neck anatomy in predicting difficult mask ventilation and difficult laryngoscopy in elective ear, nose, throat surgery patients .Here, DSHB seemed to be better correlated with difficult mask ventilation and difficult laryngoscopy compared to other ultrasound measurements.[35]

Yildiz B, Cevik B et al in 2019 designed a study aimed to compare preoperative clinical tests and USG measurements of upper airway to predict difficult airway and concluded that USG measurements (PES,EVC,PES/EVC ratio) had no significance to predict difficult intubation.[36]

Daggupati H, Maurya I, Singh RD et al in 2020 designed a study that developed scoring system by incorporating only a single USG measurement –skin to epiglottis distance(SED) into three clinical predictors to assess in prediction of difficult intubation and observed that when SED is included along with clinical parameters ,it would be helpful in prediction of difficult intubation. [37]

Chan WH, Sung CW et al in 2020 conducted a study to find feasibility of USG for proper ETT size selection and preliminary recognition of difficult intubation among adults of Chinese ethnicity and considered two USG parameters-subglottic diameter and DSEM .They found that increased BMI and male sex were positively associated with larger subglottic diameter and increased DSEM. [38]

Ni H, Guan C, He G et al in 2020 designed a study to explore the value of laryngeal structure measurements DST (distance between skin and thyroid cartilage),DTE(distance between thyroid cartilage and epiglottis) and DSEM in parasagittal plane for predicting a difficult laryngoscopy which concluded that DSEM is an independent predictor of difficult laryngoscopy with a cut off of 2.36cm .[39]

Pedroso RT, Junior RC et al in 2020 investigated the validity of ultrasonography as a diagnostic tool for difficult intubation while comparing it with traditional clinical method of screening .Six USG parameters were included and it was spotted that greater distance of skin to hyoid and skin to epiglottis ,the greater the association with the difficulty of intubation.[40]

Senapathi TG, Wiryana M et al in 2020 stated in their study that USG parameter- skin to epiglottis distance of >26.05 mm is a risk factor for difficult intubation and this measurement has a sensitivity 69.4% and specificity of 93.5% to predict difficult airway in Indonesian population.[41]

Sharma A, Bhalla S in 2020 conducted a study in obese patients to ultrasonographically predict difficult laryngoscopy and arrived at the conclusion that ultrasonographically measured skin thickness at level of hyoid bone and vocal cords has got a good correlation with difficult intubation with thickness being significantly greater in difficult laryngoscopy group in contrast to easy laryngoscopy.[42]

Agarwal R, Jain G, Agarwal A et al in 2020 concluded in their study that DSHB had better accuracy than remaining three ultrasonographic parameters (DSEM, tongue thickness TT and invisibility of hyoid bone VH) in predicting difficult intubation. When all four parameters were used as a model ,it offered the best diagnostic value.[43]

Yadav U, Singh RB et al in 2020 conducted a study to evaluate effectiveness of airway sonographic parameters ANS-VC ,ANS-Hyoid, Pre-E/E-VC to predicting difficult laryngoscopy and found that they maybe helpful with ANS-VC being a better predictor for difficult airway compared to clinical parameters like MMP and TMD.[44]

Petrisor C,Tranca S,Szabo R et al in 2020 devised a study to describe correlation between clinically measured HMDR ($HDMR_{clin}$) and ultrasound measured HDMR ($HDMR_{echo}$) in patients with and without morbid obesity and found that the association was unremarkable in morbidly obese patients but moderate in morbidly obese patients.[45]

Abdelhady BS, Elrabiey MA et al in 2020 designed a study to correlate sonographically derived distance from skin to epiglottis with difficult laryngoscopy in Egyptian population and CL grading ,which concluded that difficult laryngoscopy group revealed greater thickness and hence may be used as a predictor of difficult laryngoscopy.[46]

Gupta M, Sharma S, Katoch S in 2021 conducted a study to evaluate role of ultrasound in prediction of difficult laryngoscopy with USG measurements-PES,HMD,DSHB and DSEM .They concluded that USG is a novel modality to predict difficult laryngoscopy and highest AUC was shown by DSEM,DSHB and PES. [47]

Dhaka S, Meena S et al in 2021 stated in their study that airway ultrasound is a promising technique to predict CL grading but a combination of clinical parameters and USG measurements is helpful for better prediction.[48]

METHODOLOGY

MATERIALS AND METHODS:

SOURCE OF DATA:

The study was conducted on 96 patients admitted for elective surgery under general anaesthesia with endotracheal intubation at R. L. Jalappa Hospital and Research centre, Tamaka, Kolar from January 2020 to May 2021.

Duration of study: From January 2020 to May 2021.

Sampling Method: All patients scheduled for general anaesthesia

METHOD OF COLLECTION OF DATA:

- Patients under general anaesthesia undergoing elective surgery were randomly selected
- Number of patients - 96
- Informed consent taken from the patients' attenders
- Result values was recorded using a Proforma

INCLUSION CRITERIA

1. Age 18 - 60 years
2. ASA physical status 1 or 2
3. Patients requiring endotracheal intubation under general anaesthesia for elective procedures

EXCLUSION CRITERIA

1.History of difficult intubation

2.Head and neck anatomical pathologies who are not able to extend their neck>30^0

3. Obesity (BMI>30kg/m^2)

4. Pregnant women

5. Maxillofacial anomalies

6. Edentalous patients

SAMPLING PROCEDURE :

1.Ultrasound machine with linear frequency probe 3-5 MHz frequency

2.Laryngoscope with McIntosh blade 3 or 4

Each patient was visited pre-operatively and procedure was explained. Written and informed consent was obtained. All the routine investigations required for pre-operative evaluation was done for the proposed surgery.

Ethical committee approval was taken to conduct the study.

Assessment of airway using USG was conducted preoperatively.

The patient was made to lie down in supine position with head in neutral position without any support underneath , chin lift ,looking straight with mouth closed and tongue touching floor of mouth and no movement .The linear high frequency probe was placed in submandibular area in midline. The thickness of anterior soft tissue (transverse view)was obtained at 2 levels –DSHB and DSEM.

PARAMETERS OBSERVED:

1. Thicknessof anterior neck soft tissue in transverse view at level of hyoid bone -DSHB (minimal distance from hyoid bone to skin)

2. Thickness of anterior neck soft tissue in transverse view at level of thyrohyoid membrane -DSEM (distance from skin to epiglottis midway between hyoid bone and thyroid cartilage)

After clinical and USG airway assessment , patients were classified as difficult or easy laryngoscopy .Criteria for USG parameters were selected based on literature available .[25]

- DSEM >2.03cm -predicted to be difficult airway
- DSEM <2.03cm - predicted to be easy airway
- DSHB >0.66cm -predicted to be difficult airway
- DSHB <0.66cm -predicted to be easy airway

On arrival in the operating room IV line was secured and patient was pre-medicated with Inj Glycopyrrolate 0.005mg/kg and Inj Fentanyl 2mcg/kg, pre-oxygenated for 3 minutes with 100% oxygen. Induction was done with Inj Propofol 2mg/kg and neuromuscular blockade was achieved with Inj Scoline 2mg/kg IV. Direct laryngoscopy was done by anaesthesiologist using an appropriate size curved Macintosh blade and Cormack Lehane grade noted. The intubating anaesthesiologist of not less than 3 years of experience ,was not involved in the preoperative sonographic and clinical airway assessment .CL grade I and II was considered to be easy laryngoscopy .After laryngoscopy , patient was intubated with appropriate sized endotracheal tube and allowed to start with surgery.

<u>STATISTICAL ANALYSIS:</u>

Study Design: Cross sectional study

Sample Size: 96

Sample size was calculated based on correlation between DSEM and DSHB (major outcome parameters of interest) in a study by Jinhong Wu ,Jing Dong , Yingchun

Ding , Jijian Zheng in 2014 with 90% power , alpha error of 5% ,assuming population correlation coefficient of 0.5% with sample size as 52.[2]

The collected data was coded in MS excel spread sheet and SPSS version 22 was used for analysis.

STATISTICAL METHODS

Quantitative data -Mean SD confidence interval

Qualitative data- Presented in percentage

P values less than 0.05 was considered statistically significant.

To determine discriminative power of individual tests, receiver operating characteristic (ROC)curve , area under curve (AUC) with 95%confidence interval was noted .

A graphical display of sensitivity and specificity is represented by ROC curve .AUC is a measure to assess validity of the test. AUC of 1 indicates perfect diagnostic test.

Sensitivity , specificity ,positive predictive value (PPV),negative predictive value (NPV)was used to compare categorical data.

FORMULA:

Formula:

$$n = \frac{[z_{1-\dot{\alpha}/2} + z_{1-\beta}]^2}{[FZ(\rho_1) - FZ(\rho_0)]^2} + 3$$

$$FZ(\rho_1) = \frac{1}{2}\ln\frac{[1+\rho_1]}{[1-\rho_1]} \qquad FZ(\rho_0) = \frac{1}{2}\ln\frac{[1+\rho_0]}{[1-\rho_0]}$$

Where ,

ρ_0=Population correlation coefficient

ρ_1=Sample correlation coefficient

$z_{1-\alpha/2}$= Desired confidence level

1-β=Power

RESULTS:

TABLE 10:

AGE DISTRIBUTION OF PATIENTS STUDIED

Age in Years	**No. of Patients**	**%**
<30	33	34.4
30-40	27	28.1
41-50	11	11.5
51-60	25	26.04
Total	**96**	**100.0**

Mean ± SD: 39.91±16.49

The observation of the study showed that maximum number of subjects were in the <30 years age group accounting to 34.4%(33 out of 96).The next common age group was 30-40 years accounting to 28.1 %.

FIGURE41 : BAR GRAPH SHOWING AGE DISTRIBUTION OF PATIENTS STUDIED

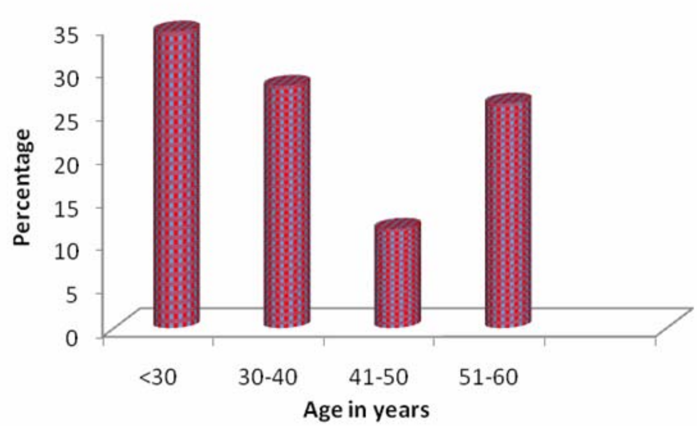


TABLE 11:

GENDER DISTRIBUTION OF PATIENTS STUDIED

Gender	No. of Patients	%
Female	55	57.3
Male	41	42.7
Total	**96**	**100.0**

In this study out of 96 patients,55(57.3%) were females and 41(42.7%)were males where females showed more predominance.

FIGURE 42 : PIE CHART SHOWING GENDER DISTRIBUTION OF PATIENTS STUDIED

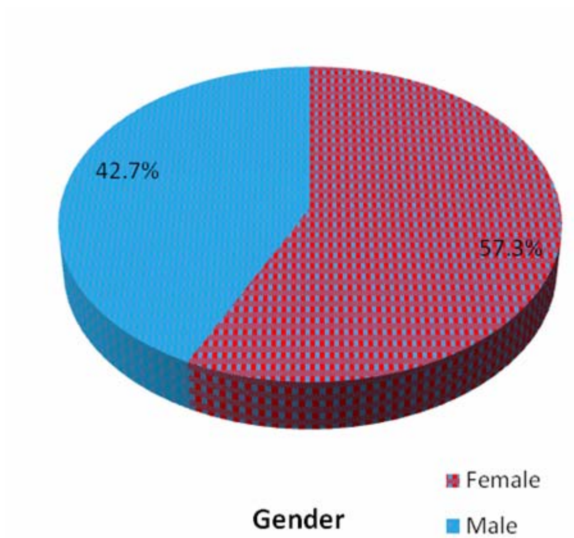


TABLE 12:

BODY MASS INDEX (Kg/m^2)- FREQUENCY DISTRIBUTION OF PATIENTS STUDIED

Body Mass Index(Kg/m^2)	No. of Patients	%
<18.5	4	4.2
18.5-24.9	70	72.9
25.0-29.9	22	22.9
>30.0	0	0.0
Total	**96**	**100.0**

Among Body Mass Index distribution, 70 patients (72.9%) were in the 18.5-24.9 kg/m^2 group and the next common being in 25.0-29.9 kg/m^2 accounting to 22 patients (22.9%).

FIGURE 43 : BAR GRAPH SHOWING BODY MASS INDEX (Kg/m^2) FREQUENCY DISTRIBUTION IN PATIENTS STUDIED

TABLE 13:

ASA GRADE- FREQUENCY DISTRIBUTION OF PATIENTS STUDIED

ASA GRADE	No. of Patients	%
I	64	66.7
II	32	33.3
Total	**96**	**100.0**

The study had 64 patients (66.7%) of ASA grade I and 32 patients (33.3%) of ASA grade II.

FIGURE 44 : PIE CHART SHOWING ASA GRADE DISTRIBUTION OF PATIENTS STUDIED

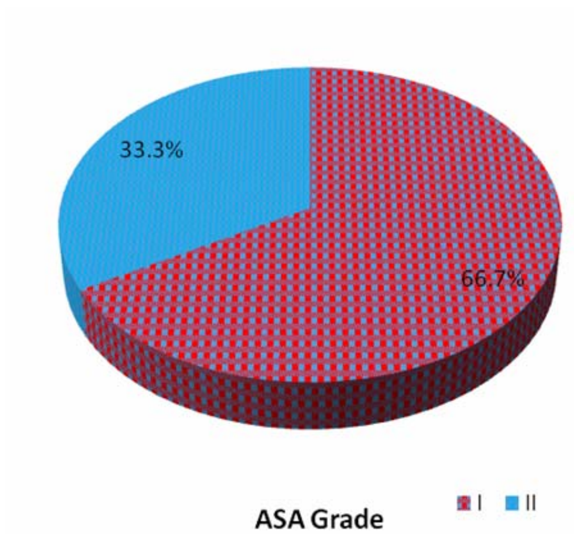


TABLE 14 :

SURGERY

NAME OF SURGERY	No. of Patients	%
CYST EXCISION AND BIOPSY	1	1.0
DECOMPRESSION AND SPINAL FUSION	1	1.0
DECOMPRESSION+FUSION+IMPLANT	1	1.0
DIAGNOSTIC LAPARASCOPY	1	1.0
DL SCOPY+BIOPSY	1	1.0
EXCISION BIOPSY	5	5.2
EXCISION BIOPSY OF LYMPH NODES	1	1.0
EXPLORATION +TENDON REPAIR+NERVE REPAIR	1	1.0
EXPLORATORY LAPAROTOMY	1	1.0
EXPLORATORY LAPAROTOMY AND PROCEED	1	1.0
FESS	7	7.3
IMPLANT REMOVAL	1	1.0
IMPLANT REMOVAL FROM LEFT CLAVICLE	1	1.0
INCISION AND DRAINAGE	1	1.0
L5-S1 SPINAL FUSION	1	1.0
LAPARASCOPIC APPENDICECTOMY	2	2.1
LAPARASCOPIC CHOLECYSTECTOMY	15	15.6
LAPARASCOPIC CHOLECYSTECTOMY +MESH REPAIR	1	1.0
LEFT CORTICAL MASTOIDECTOMY +	3	3.1

TYMPANOPLASTY		
LEFT MASTOIDECTOMY +TYMPANOPLASTY	7	7.3
LEFT NEPHRECTOMY	1	1.0
LUMPECTOMY	1	1.0
MASTOID EXPLORATION	1	1.0
MESH REPAIR	3	3.1
MESHPLASTY	1	1.0
MICROLARYNGEAL SURGERY	2	2.1
MICROVASCULAR DECOMPRESSION	1	1.0
NASAL BONE REDUCTION	1	1.0
PLANECTOMY+TURBINECTOMY	1	1.0
RIGHT BELOW KNEE AMPUTATION	1	1.0
RIGHT CANAL WALL DOWN MASTOIDECTOMY	1	1.0
RIGHT CORTICAL MASTOIDECTOMY + TYMPANOPLASTY	1	1.0
RIGHT MASTOIDECTOMY +TYMPANOPLASTY	2	2.1
RIGHT MODIFIED RADICAL MASTOIDECTOMY	1	1.0
ROTATIONAL FLAP	1	1.0
SEPTOPLASTY	11	11.5
SEPTOPLASTY WITH FESS	3	3.1
SEPTORHINOPLASTY	1	1.0
SPINAL FUSION WITH IMPLANT	4	4.2
TONSILLECTOMY	5	5.2
Total	**96**	**100.0**

From the above table it was detected that the patients selected for performing ultrasonography of airway underwent different surgical procedures .Hence there was no bias in selection of patients as per surgery. But it was detected that 15 patients (15.6%) out of 96 patients underwent laparascopic cholecystectomy.

TABLE 15:

MP GRADE - DISTRIBUTION OF PATIENTS STUDIED

MP GRADE	No. of Patients	%
I	38	39.6
II	33	34.4
III	25	26.0
Total	**96**	**100.0**

The study revealed that out of 96 patients ,38 patients (39.6%)had a Mallampati grade I, 33 patients (34.4%)had a Mallampati grade II, 25 patients (26%)had a Mallampati grade III.

FIGURE 45 : BAR GRAPH SHOWING MALLAMPATI GRADE OF PATIENTS STUDIED

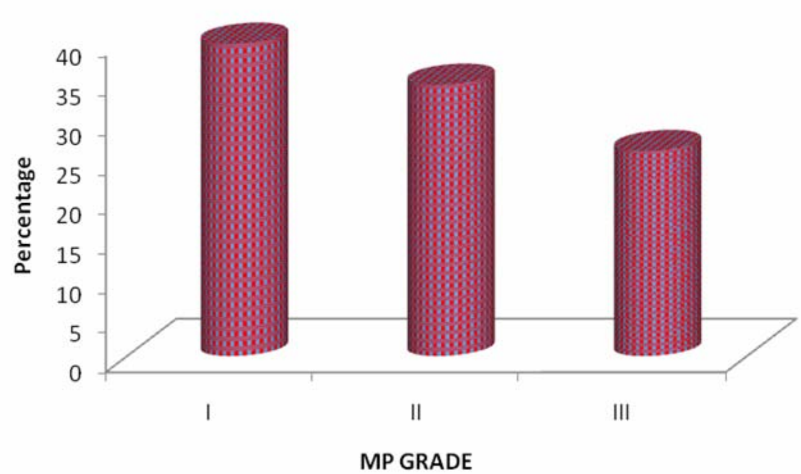


TABLE 16:

DSHB (cm)- FREQUENCY DISTRIBUTION OF PATIENTS STUDIED

DHSB(cm)	No. of Patients	%
<0.66	79	82.3
>0.66	17	17.7
Total	**96**	**100.0**

The study showed that distance from skin to hyoid(DSHB) value was <0.66 cm in 79 patients (82.3%) and >0.66 cm in 17 patients (17.7%) out of the total 96 patients.

FIGURE 46 : PIE CHART SHOWING DSHB DISTRIBUTION OF PATIENTS STUDIED

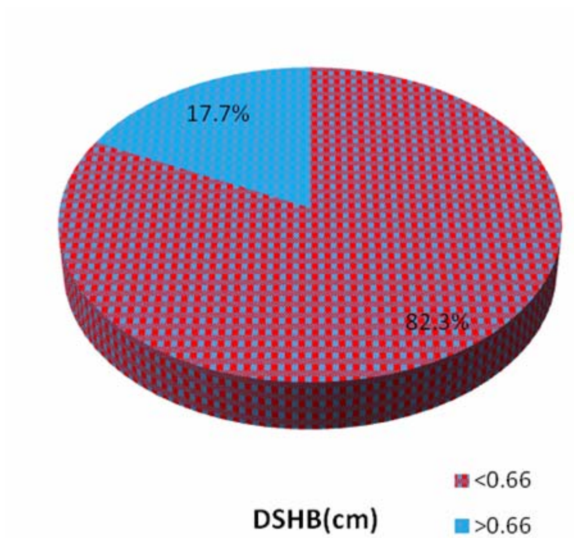


TABLE 17:

DSEM (cm)- FREQUENCY DISTRIBUTION OF PATIENTS STUDIED

DSEM(cm)	No. of Patients	%
<2.03	90	93.8
>2.03	6	6.3
Total	96	100.0

The study showed that distance from skin to epiglottis (DSEM) value was <2.03 cm in 90 patients(93.8%) and > 2.03 cm in 6 patients(6.3%) out of the total 96 patients.

FIGURE 47 : PIE CHART SHOWING DSEM DISTRIBUTION OF PATIENTS STUDIED

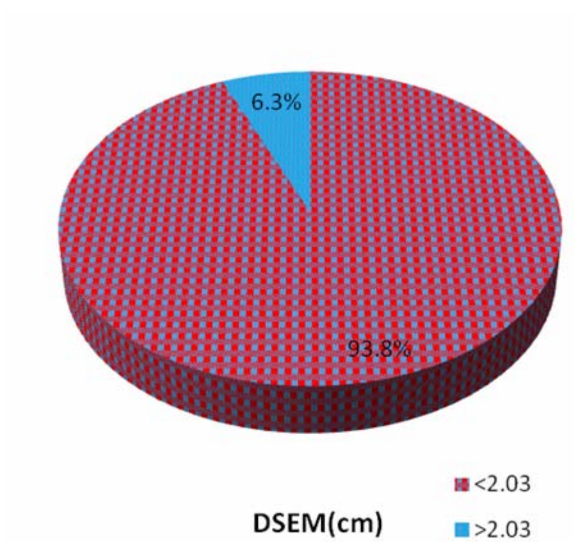


TABLE 18:

CL GRADE- FREQUENCY DISTRIBUTION OF PATIENTS STUDIED

CL GRADE	No. of Patients	%
I	43	44.8
II	45	46.9
III	8	8.3
Total	**96**	**100.0**

With respect to Cormack Lehane grading during direct laryngoscopy ,the study showed that 43 patients (44.8%) had CL grade I, 45 patients (46.9%) had CL grade II and 8 patients (8.3%) had CL grade III.

FIGURE 48 : BAR GRAPH SHOWING CL GRADE- FREQUENCY DISTRIBUTION OF PATIENTS STUDIED

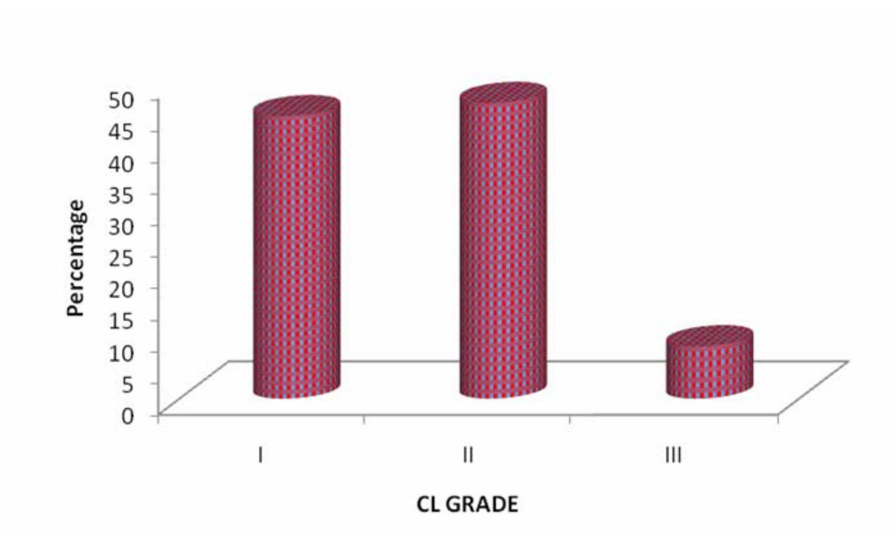


TABLE 19:

ASSOCIATION OF USG PARAMETERS DSEM AND DSHB IN RELATION TO MP GRADE :

Variables	MP GRADE		Total	P Value
	EASY INTUBATION	**DIFFICULT INTUBATION**		
DSHB(cm)				
• <0.66	59(83.1%)	20(80%)	79(82.3%)	0.727
• >0.66	12(16.9%)	5(20%)	17(17.7%)	
DSEM(cm)				
• <2.03	65(91.5%)	25(100%)	90(93.8%)	0.334
• >2.03	6(8.5%)	0(0%)	6(6.3%)	
Total	**71(100%)**	**25(100%)**	**96(100%)**	

Chi-Square Test/Fisher Exact Test

From the above table , it is observed that there were a total of 25 patients which as per MP grading were difficult intubations ,of which5 patients (20%) had DSHB value >0.66cm and no patients had DSEM value of >2.03cm .The P value for association of DSEM and DSHB in relation to MP grade was 0.727 and 0.334 respectively .Hence ,there was no statistical significance between the two USG parameters and MP grade.

FIGURE 49 : BAR GRAPH SHOWING ASSOCIATION OF DSHB IN RELATION TO MP GRADE OF PATIENTS STUDIED

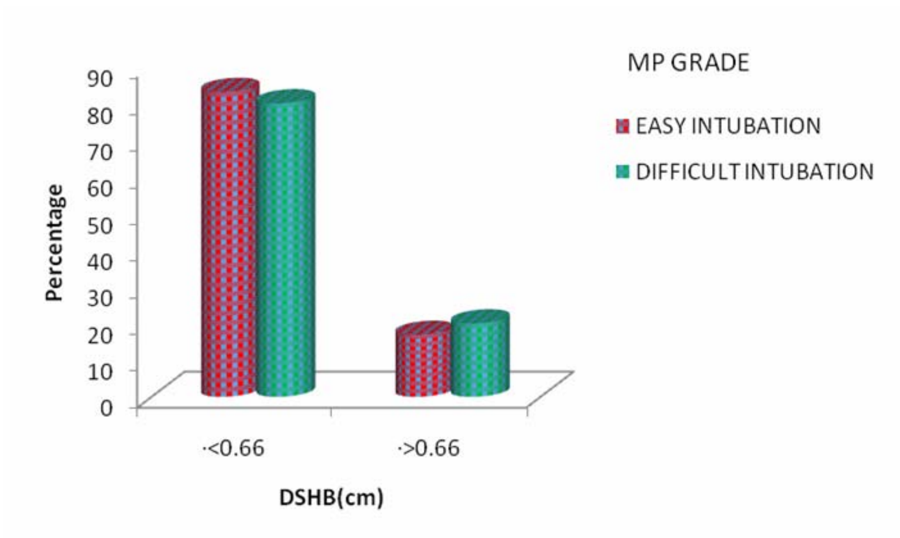


FIGURE 50 : BAR GRAPH SHOWING ASSOCIATION OF DSEM IN RELATION TO MP GRADE OF PATIENTS STUDIED

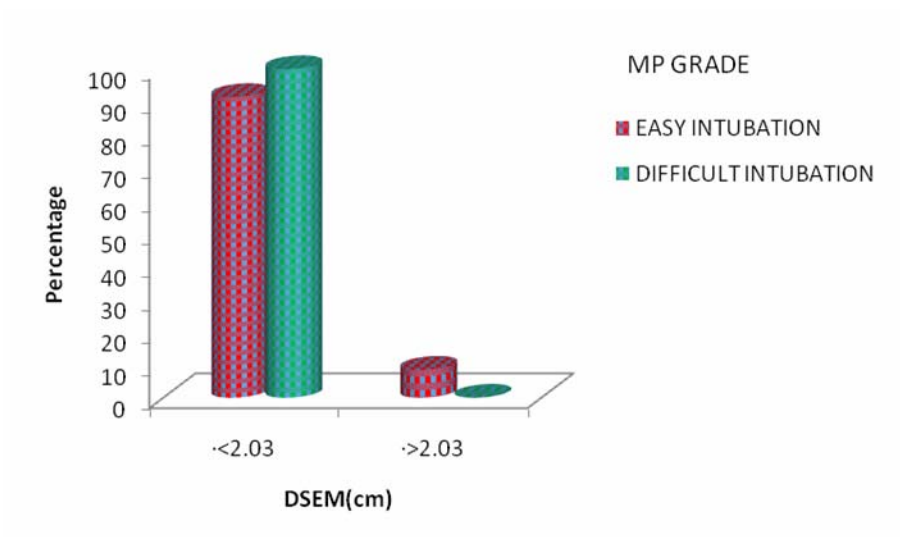


TABLE 20:

ASSOCIATION OF DSHB AND DSEM IN RELATION TO CL GRADE:

Variables	**CL GRADE**		**Total**	**P Value**
	EASY LARYNGOSCOPY	**DIFFICULT LARYNGOSCOPY**		
DSHB(cm)				
• <0.66	78(88.6%)	1(12.5%)	79(82.3%)	<0.001**
• >0.66	10(11.4%)	7(87.5%)	17(17.7%)	
DSEM(cm)				
• <2.03	86(97.7%)	4(50%)	90(93.8%)	<0.001**
• >2.03	2(2.3%)	4(50%)	6(6.3%)	
Total	**88(100%)**	**8(100%)**	**96(100%)**	

All Chi-Square Test

From the above table , it is observed that there were a total of 8 patients which as per CL grading were difficult laryngoscopy ,of which 7 patients (87.5%) had DSHB value >0.66cm and 4 patients(50%) had DSEM value of >2.03cm .The P value for association of both DSEM and DSHB in relation to CL grade was <0.001.Hence ,this showed that there was a strong statistical significance showing strong association between DSHB and DSEM and CL grade.

FIGURE 51 : BAR GRAPH SHOWING ASSOCIATION OF DSHB IN RELATION TO CL GRADE OF PATIENTS STUDIED

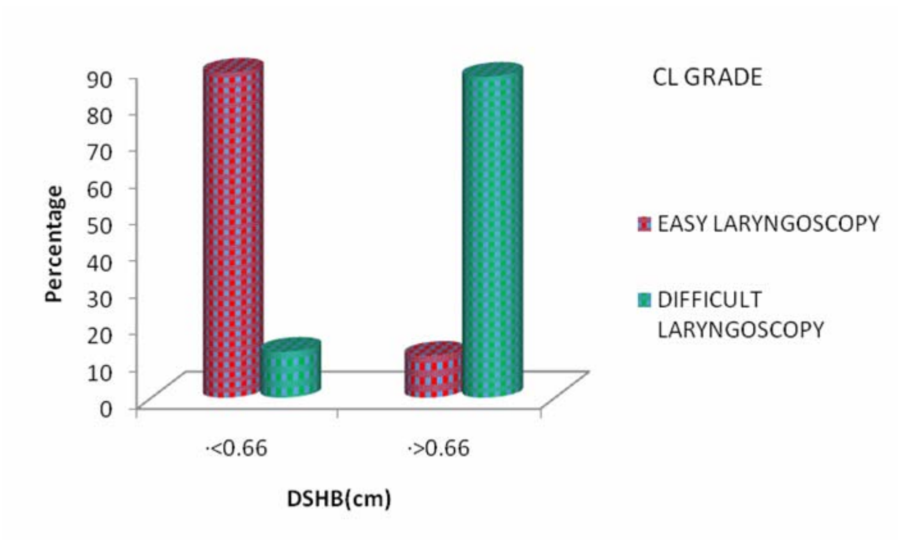


FIGURE 52 : BAR GRAPH SHOWING ASSOCIATION OF DSEM IN RELATION TO CL GRADE

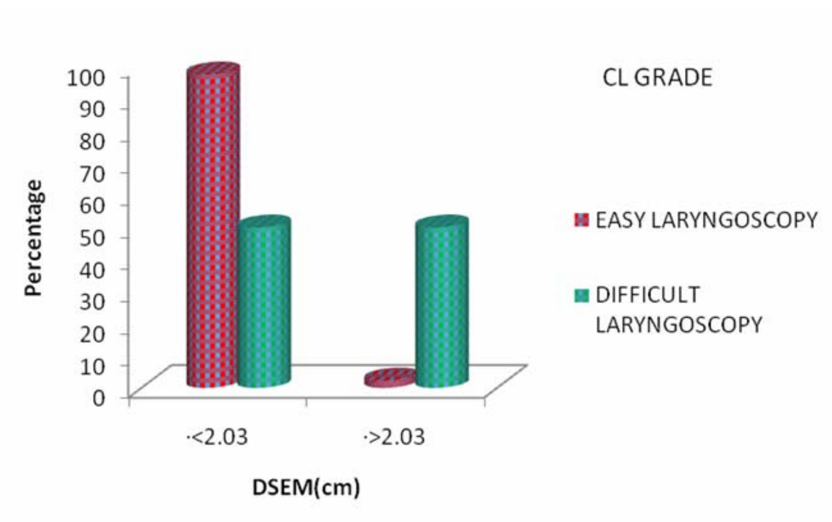


TABLE 21:

MP GRADE- FREQUENCY DISTRIBUTION IN RELATION TO CL GRADE OF PATIENTS STUDIED

MP GRADE	CL GRADE		Total
	EASY LARYNGOSCOPY	DIFFICULT LARYNGOSCOPY	
EASY INTUBATION	65(73.9%)	6(75%)	71(74%)
DIFFICULT INTUBATION	23(26.1%)	2(25%)	25(26%)
Total	**88(100%)**	**8(100%)**	**96(100%)**

P=1.000, Not Significant, Fisher Exact Test

This table shows that out of 96 patients ,the number of predicted difficult intubations according to MP grade was 25 patients but the number of difficult laryngoscopy according to CL grade was 8 patients. The P value showing the association between MP grade and CL grade was 1.000 (not statistically significant).

FIGURE 53 :BAR GRAPH SHOWING MP GRADE- FREQUENCY DISTRIBUTION IN RELATION TO CL GRADE

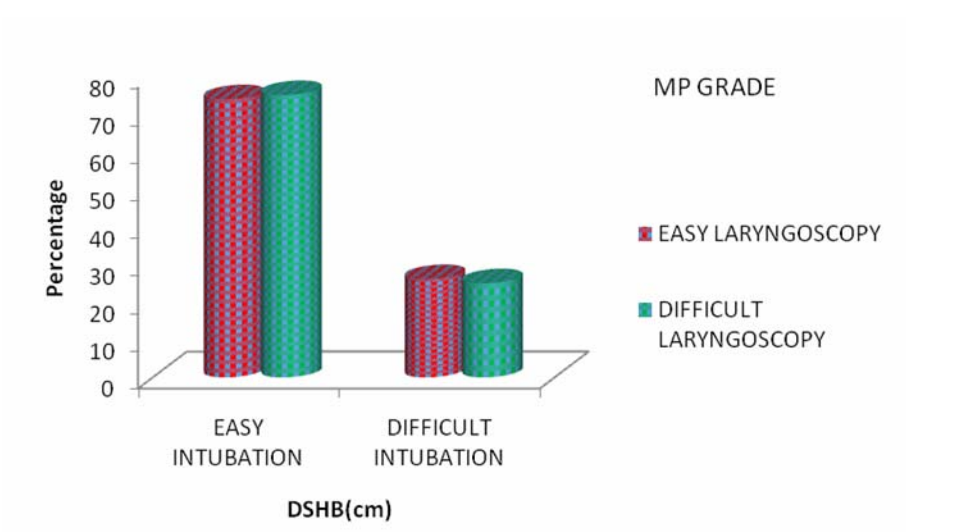


TABLE 22:

COMPARISON OF CLINICAL VARIABLES ACCORDING TO CL GRADE OF PATIENTS STUDIED

Variables	**CL GRADE**		**Total**	**P Value**
	EASY LARYNGOSCOPY	**DIFFICULT LARYNGOSCOPY**		
Age in Years	40.09±16.89	38±11.95	**39.92±16.49**	0.733
BMI(Kg/m^2)	23.06±2.63	25.56±3.45	**23.27±2.77**	0.014*

This table shows that there was a moderate statistical significance noted between BMI and CL grade(P value of 0.014). There was no statistical significance between age and CL grade(P value of 0.733).

FIGURE 54 : BAR DIAGRAM SHOWING COMPARISON OF AGE (IN YEARS) ACCORDING TO CL GRADE OF PATIENTS STUDIED

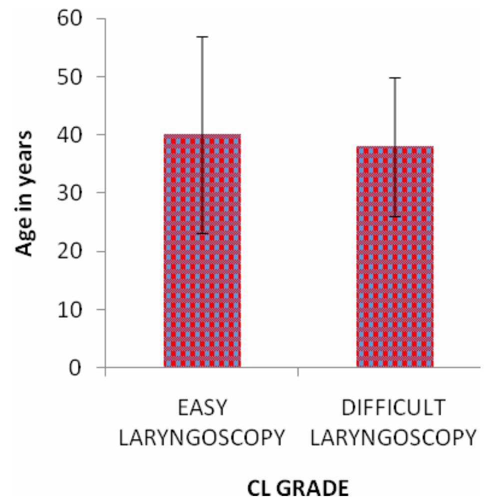


FIGURE 55 : BAR DIAGRAM SHOWING COMPARISON OF BMI (IN Kg/M^2) ACCORDING TO CL GRADE OF PATIENTS STUDIED

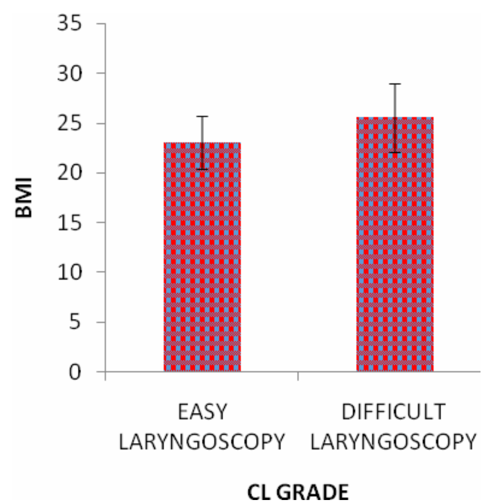


TABLE 23 :

COMPARISON OF CLINICAL VARIABLES ACCORDING TO MP GRADE OF PATIENTS STUDIED

Variables	MP GRADE		Total	P Value
	EASY INTUBATION	DIFFICULT INTUBATION		
Age in Years	38.35±16.48	44.36±16.04	39.92±16.49	0.118
BMI(Kg/m^2)	22.81±2.74	24.59±2.48	23.27±2.77	0.005**

This table shows that there was strong statistical significance noted between BMI and MP grade(P value of 0.005). There was no statistical significance between age and MP grade(P value of 0.118).

FIGURE 56 : BAR DIAGRAM SHOWING COMPARISON OF AGE (IN YEARS) ACCORDING TO MP GRADE OF PATIENTS STUDIED

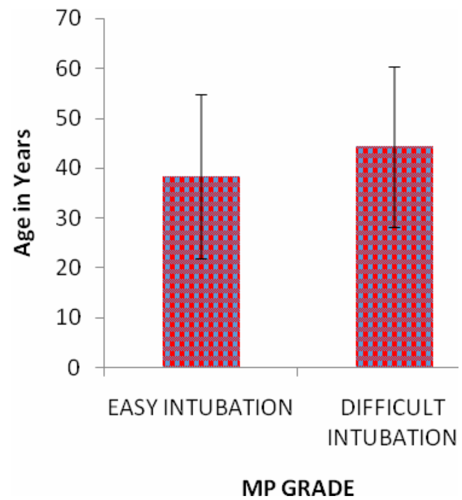


FIGURE 57 : BAR DIAGRAM SHOWING COMPARISON OF BMI (IN KG/M^2) ACCORDING TO MP GRADE OF PATIENTS STUDIED

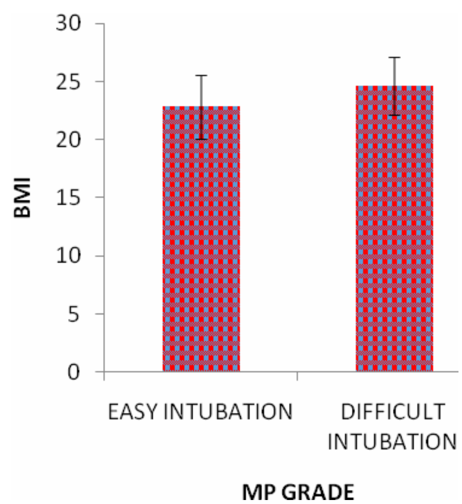


TABLE 24:

ROC CURVE ANALYSIS

Variables	ROC results in prediction of Difficult Laryngoscopy				Cut-off	AUROC	SE	P value
	Sensitivity	Specificity	LR+	LR-				
DSHB(cm)	100.00	82.95	5.87	0.00	>0.64	0.974	0.019	<0.001**
DSEM(cm)	75.00	89.77	7.33	0.28	>1.98	0.888	0.063	<0.001**

Diagnostic values based on Area under curve:

0.9-1.0 - Excellent test

0.8-0.9 -Good test

0.7-0.8 -Fair test

0.6-0.7 - Poor test

0.5-0.6-Fail

According to this table ,DSHB is having a better diagnostic value to predict difficult laryngoscopy(Area under ROC is 97.4%) compared to DSEM with 88.8% Area Under ROC (Receiving Operating Characteristic curve).

DSHB has better sensitivity (sensitivity of 100%) compared to DSEM (sensitivity of 75%) whereas ,DSEM has better specificity (specificity of 89.77%) compared to DSHB (specificity of 82.95%).

FIGURE 58 : ROC CURVE FOR ULTRASOUND MEASUREMENT DSHB

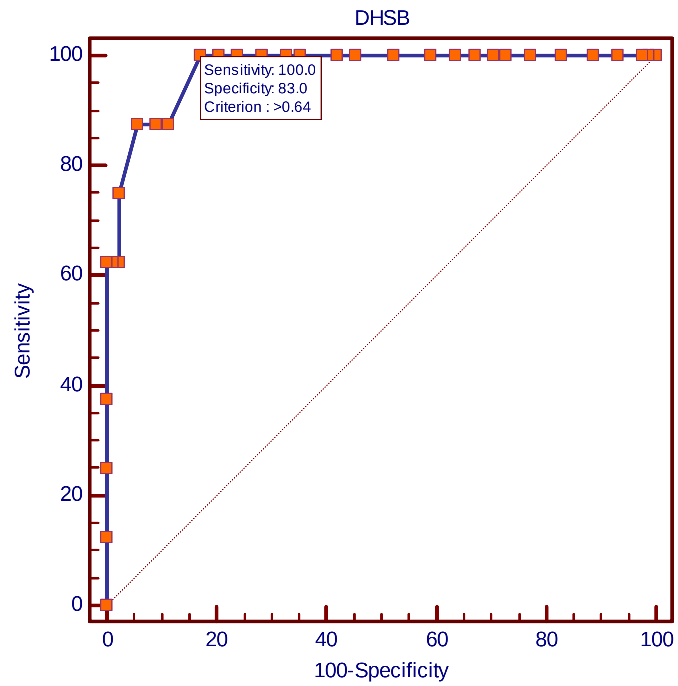
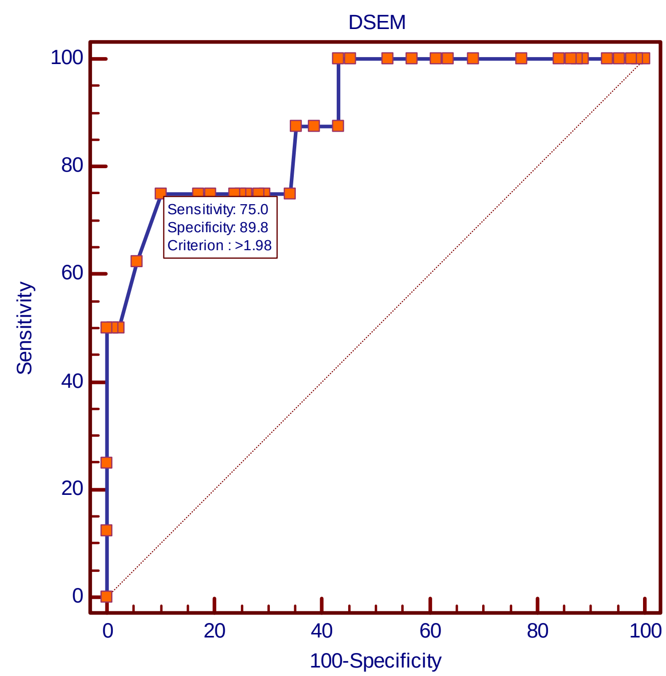


FIGURE 59 : ROC CURVE FOR ULTRASOUND MEASUREMENT DSEM



SIGNIFICANT FIGURES

+ Suggestive significance (P value: $0.05<P<0.10$)

* Moderately significant (P value: $0.01<P \le 0.05$)

** Strongly significant (P value : $P\le0.01$)

DISCUSSION

Securing the airway to establish alveolar ventilation without pulmonary aspiration forms an important part in the practice of clinical anaesthesia .Despite taking all measures ,adverse respiratory events occurs in the perioperative period that represents one of the prime causes of clinical malpractice for anesthesia related incidents. At the time of induction of anaethesia ,there can be a difficulty in achieving adequate ventilation or of performing endotracheal intubation that may result in the catastrophic situation of cannot intubate /cannot ventilate .

Several risk factors have been recognized to aid in anticipating difficult airway. They include demographic variables (age,sex,race),body mass index (BMI),obstructive sleep apnea (OSA) ,facial abnormalities , Mallampati class III or IV, limited cervical mobility ,small mouth opening , high arched palate ,short thyromental distance and neck circumference .[49]Adhikari S et al conducted a study which showed that screening tests such as Mallampati classification, thyromental distance, interincisor gap and neck mobility have poor sensitivity to predict difficult laryngoscopy.[27]

Since the introduction of ultrasound, technology has been incorporated into daily practice by various medical specialities .Most of the anaesthesia departments now have their own ultrasound machines at their disposal .Initially ,USG was used by the anaesthesiologists to aid in performing regional nerve blocks and securing arterial and central lines .Newer models are compact and portable and can be incorporated into operating room .Hence , anaesthesiologists expanded their knowledge of USG techniques into evaluation of airway .This maybe a useful adjunct to conventional clinical screening tools as it provides visualization of real time anatomy and structures of the airway.[22,49,50,51]

Many studies have been done after the pilot study by Adhikari S etal[27] ,on finding the utility of USG to aid airway assessment ,to compare and contrast numerous USG parameters and use of specific USG parameters in head and neck cancers .

As airway ultrasound was not routinely performed in our institute for predicting difficult laryngoscopy ,we conducted this study to determine two chosen USG parameters (DSHB,DSEM) performed preoperatively can predict difficult laryngoscopy by correlating with CL grading in adult patients.

A prospective cross sectional study conducted on 96 patients under general anaesthesia admitted for elective surgery with endotracheal intubation at R. L. Jalappa Hospital and Research centre, Tamaka, Kolar from January 2020 to May 2021 .

In this study we first performed USG of the airway preoperatively alongwith noting down the standard clinical tests like Mallampati grading .USG of the airway included two parameters –DSHB (Thickness of anterior neck soft tissue in transverse view at the level of hyoid bone or the minimal distance from hyoid bone to the skin) and DSEM (Thickness of anterior neck soft tissue in transverse view at the level of thyrohyoid membrane or the distance from the skin to epiglottis midway between hyoid bone and thyroid cartilage).Anticipated difficult airway cases like obesity ,pregnancy ,head and neck anatomical pathologies , maxillofacial anomalies and edentulous patients were excluded from the study.

USG was performed in the neutral position. The patient was then classified as easy or difficult laryngoscopy based on USG parameters criteria from literature available .

DSHB >0.66cm was predicted to be difficult airway and DSHB <0.66cm was predicted to be easy .

DSEM >2.03cm was predicted to be difficult airway and DSEM <2.03cm was predicted to be easy.

The anaesthesiologist performing the USG airway was not included in the operating room .After induction of anesthesia , direct laryngoscopy was performed in the sniffing position by an anaesthesiologist using an appropriate size curved Macintosh blade and the Cormack Lehane grade was noted. The intubating anaesthesiologist was not involved in the preoperative clinical and sonographic airway assessment and had not less than 3 years of experience .CL grade I and II was considered to be easy laryngoscopy .

Demographic data:

The demographic parameters of this study consisted of age, sex and BMI. It showed that most patients belonged to <30 years age group(34.4%). Number of female patients were more than males (57.3%).Among Body Mass Index distribution, maximum number of patients (72.9%) were in the 18.5-24.9 kg/m^2 group .The demographic profile of this study were comparable to similar studies and there was no significant differences on statistical comparison.

Type of surgery :

From the study it was seen that the patients selected for performing ultrasonography of airway included a variety of pathological conditions and they underwent different surgeries .Hence there was no bias in selection of patients.

Clinical screening test (Mallampati grading) :

From the study ,it was noted that 39.6%had a Mallampati grade I, 34.4%had a Mallampati grade II and 26%had a Mallampati grade III. Hence the anticipated difficult airway according to clinical bedside screening test was 26% (25 patients).

Value of Sonographic parameter DSHB :

The study showed that DSHB value was <0.66 cm in 79 patients (82.3%) and >0.66 cm in 17 patients (17.7%) out of the total 96 patients.

Value of Sonographic parameter DSEM:

The study showed that DSEM value was <2.03 cm in 90 patients(93.8%) and > 2.03 cm in 6 patients(6.3%) out of the total 96 patients.

CL grade observed in direct laryngoscopy:

The study showed that 43 patients (44.8%) had CL grade I, 45 patients (46.9%) had CL grade II and 8 patients (8.3%) had CL grade III. Hence 8 patients (8.3%) fell into the category of difficult laryngoscopy.

Association of sonographic parameters DSEM and DSHB in relation to MP grade :

The study revealed that out of a total of 25 patients which were predicted to be difficult intubations as per MP grading , 5 patients (20%) had DSHB value >0.66cm and no patients had DSEM value of >2.03cm .The P value for association of DSHB and DSEM in relation to MP grade was 0.727 and 0.334 respectively .Hence ,there was no statistical significance between the two USG parameters and MP grade.

Association of DSEM and DSHB in relation to CL grade:

The study revealed that out of 8 patients which were difficult laryngoscopy as per CL grading , 7 patients (87.5%) had DSHB value >0.66cm and 4 patients(50%) had

DSEM value of >2.03cm .The P value for association of both DSEM and DSHB in relation to CL grade was <0.001 .Hence , there was a strong statistical significance between the two USG parameters and CL grade.

Comparison of clinical variables (Age, BMI) according to CL grade of patients:

The study showed that there was a moderate statistical significance noted between BMI and CL grade(P value of 0.014). There was no statistical significance between age and CL grade(P value of 0.733).

Comparison of clinical variables (Age, BMI) according to MP grade of patients:

The study showed that there was a strong statistical significance noted between BMI and MP grade(P value of 0.005) .There was no statistical significance between age and MP grade (P value of 0.118).

ROC curve analysis to compare the two USG parameters DSHB and DSEM:

The study revealed that DSHB is having a better diagnostic value in predicting difficult laryngoscopy with AUC 97.4% when compared to DSEM with 88.8% AUC .Also , DSHB has better sensitivity (sensitivity of 100%) compared to DSEM(sensitivity of 75%) whereas ,DSEM has better specificity (specificity of 89.77%) compared to DSHB (specificity of 82.95%).

Hence ,the study showed that USG parameters DSHB and DSEM may aid in predicting difficult laryngoscopy supported by the strong statistical significance between the two. Also ,DSHB appeared to have a better diagnostic value to predict difficult airway .

In the study conducted by Saranya ,Raj S et al ,[30]they performed USG airway preoperatively of anterior neck soft tissue thickness at three levels-hyoid bone ,thyrohyoid membrane and suprasternal notch. They compared this to CL grade at direct laryngoscopy .The demographic variables were age,sex and BMI .They found that there was increased thickness at all three levels corresponding to increase in difficulty of intubation .This was similar in our study but we had considered only two parameters showing similar results .On ROC curve analysis ,USG measurement made at thyrohyoid membrane was found to be very sensitive and specific with 2.08cm marking the difference between easy and difficult laryngoscopy .But in our study measurement at hyoid bone was of better diagnostic value.

In the study conducted by Yadav NK ,Rudingwa P et al ,[25]they measured anterior neck soft tissue at the level of hyoid bone ,thyrohyoid membrane and tongue thickness and compared this to CL grade at intubation. They performed USG in neutral and sniffing position unlike in our study where USG was performed only in neutral position. This gave varied results in USG measurements in both positions , where it was seen that cut off value obtained from ROC curve for DSHB in neutral and sniffing position was 0.66cm,0.77cm respectively while it was 2.03cm,1.9cm for DSEM in neutral and sniffing position respectively. Also ,USG proved to be better than clinical parameters (interincisor gap, Mallampati grade, neck circumference ,thyromental and sternomental distance).In our study, we had similar results but we had considered only Mallampati grade .

In the study conducted by Yadav U,Singh R et al,[44]they conducted a study to find effectiveness of sonographic parameters ANS-hyoid, ANS-VC, Pre-E/E-VC that were different from the parameters chosen by us. Clinical parameters included Mallampati classification ,thyromental distance and hyomental distance while we considered only Mallampati classification. Their study revealed that there was significant statistical difference between patients with easy and difficult laryngoscopy and the highest sensitivity was shown by ANS-VC and AUC while hyomental distance showed the highest specificity.

The results of our study can be supported by the anatomical model described by Greenland et al[52] and Adnet et al[53] .Based on this model ,upper airways are shaped by two curves , the oropharyngeal /primary curve and pharyngo-glossic-tracheal /secondary curve .An adequate visualization of the larynx needs both the curves to be aligned with the visual axis .[52]A greater skin to epiglottis distance can be due to a higher upwards concavity of oropharyngeal /primary curve that causes lesser visualization of the glottis.[32] Also, the laryngoscope blade needs to lift the tissue at hyoid bone and hence a higher CL grade is anticipated with increase in tissue thickness .[25]Hence increasing anterior soft tissue thickness at the level of hyoid bone and thyrohyoid membrane (DSHB and DSEM) can mean higher CL grading.

LIMITATIONS OF THE STUDY

Several limitations could be noted in this study and can be both anaesthetist and patient related .Most important is the experience and ability of anaesthesiologist in intubation .Also ,different anaesthetists subjectively graded laryngoscopic view. The position of patient in neutral and sniffing both should be considered as it changes the laryngoscopic view for the intubating anaesthesiologist .The application of BURP maneuver improves the laryngoscopic view .

Experience of the anaesthesiologist performing ultrasound scan is vital .The amount of pressure applied on the tissue while performing the scan also changes the neck thickness .

Lastly , only two USG parameters were taken into consideration .Inclusion of more parameters will throw light upon how effective sonography of airway is in predicting difficult airway.

CONCLUSION

From our study we could conclude that sonographic measurements DSHB and DSEM can be used to predict difficult laryngoscopy in adult patients as there was significant statistical significance between the USG measurements and Cormack Lehane grading with P value <0.001.Of the two parameters , DSHB seems to have a better diagnostic value for prediction of difficult airway in our study as supported by the AUC of 97.4% compared to DSEM with AUC of 88.8% .DSHB has better sensitivity (sensitivity of 100%) and DSEM has better specificity (specificity of 89.77%).

In our institute , we did not have any studies performed on airway ultrasonography to predict difficult airway and hence a combination of sonographic and physical tests may further improve diagnostic value to identify cases of difficult intubation.

SUMMARY:

It was a prospective cross sectional study conducted on 96 patients admitted for elective surgery at R. L. Jalappa Hospital and Research centre, Tamaka, Kolar in the period from January 2020 to May 2021 .It included patients aged 18 -60 years ,ASA physical status 1 or 2 under general anaesthesia with endotracheal intubation for elective procedures.

Sonography of airway was first performed preoperatively by an anaesthesiologist alongside the standard clinical tests like Mallampati grading .Sonography of the airway included two parameters –DSHB (Thickness of anterior neck soft tissue in transverse view at level of hyoid bone or minimal distance from hyoid bone to the skin) and DSEM (Thickness of anterior neck soft tissue in transverse view at level of thyrohyoid membrane or the distance from skin to epiglottis midway between hyoid bone and thyroid cartilage).USG was performed in the neutral position. Patient was classified as easy or difficult laryngoscopy according to USG parameters criteria from literature available .

DSHB >0.66cm predicted to be- difficult airway

DSHB <0.66cm predicted to be -easy airway

DSEM >2.03cm predicted to be- difficult airway

DSEM <2.03cm predicted to be- easy airway

After induction of anesthesia , direct laryngoscopy performed in the sniffing position from another anaesthesiologist using appropriate size Macintosh blade and Cormack Lehane grade was noted. CL grade I and II was considered to be easy laryngoscopy .

The study showed that most patients belonged to<30 years age group (34.4%). Number of female patients were more than males (57.3%).Among Body Mass Index distribution, maximum number of patients (72.9%) were in the 18.5-24.9 kg/m^2group

The study showed that DSHB value was <0.66 cm in 79 patients (82.3%) and >0.66 cm in 17 patients (17.7%) out of the total 96 patients.

The study showed that DSEM value was <2.03 cm in 90 patients(93.8%) and > 2.03 cm in 6 patients(6.3%) out of the total 96 patients.

The study showed that 43 patients (44.8%) had CL grade I, 45 patients (46.9%) had CL grade II and 8 patients (8.3%) had CL grade III. Hence 8 patients (8.3%) fell into the category of difficult laryngoscopy.

Association of sonographic parameters DSHB , DSEM in relation to MP grade of patients :

With a total of 25 patients which were predicted to be difficult intubations as per MP grading , 5 patients (20%) had DSHB value >0.66cm and no patients had DSEM value of >2.03cm .The P value for association of DSEM and DSHB with reference to MP grade was 0.727 and 0.334 respectively .Hence ,there was no statistical significance between the two USG parameters and MP grade.

Association of DSEM and DSHB in relation to CL grade :

With a total of 8 patients which were difficult laryngoscopy as per CL grading , 7 patients (87.5%) had DSHB value >0.66cm and 4 patients(50%) had DSEM value of >2.03cm .The P value for association of both DSHB and DSEM in relation to CL grade was <0.001 .Hence , a strong statistical significance was seen between the USG parameters and CL grade.

ROC curve analysis to compare the two USG parameters DSHB and DSEM:

The study revealed that DSHB is having a better diagnostic value for prediction of difficult laryngoscopy with AUC 97.4% when compared to DSEM with 88.8% AUC .Also ,DSHB has better sensitivity (sensitivity of 100%) compared to DSEM(sensitivity of 75%) whereas ,DSEM has better specificity (specificity of 89.77%) compared to DSHB (specificity of 82.95%).

To conclude , our study showed that USG parameters DSHB and DSEM may aid in predicting difficult laryngoscopy as a strong statistical significance was present between sonographic measurements and CL grading. Also ,DSHB appeared to have a better diagnostic value for prediction of difficult airway .

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ANNEXURES

ANNEXURE – I

PROFORMA

"ACCURACY OF PREOPERATIVE NECK ULTRASOUND IN PREDICTING DIFFICULT LARYNGOSCOPY IN ADULT PATIENTS"

INVESTIGATORS: DR. SINCHANAB, Dr.KIRAN N

NAME: AGE: SEX: WEIGHT: HEIGHT: BMI:

HOSPITAL NO: ASA GRADE:

DIAGNOSIS:

OPERATION:

PRE ANAESTHETIC-EVALUATION:

Airway Examination:

Mallampati grading :

USG NECK :

1. Thickness of anterior neck soft tissue in transverse view at the level of hyoid bone - DSHB (minimal distance from hyoid bone to the skin)

2. Thickness of anterior neck soft tissue in transverse view at the level of thyrohyoid membrane -DSEM (distance from the skin to epiglottis midway between hyoid bone and thyroid cartilage)

DSHB: mm

DSEM: mm

Cormack Lehane grading noted during time of intubation : Grade

ANNEXURE II

PATIENT INFORMATION SHEET

Title of the study: **ACCURACY OF PREOPERATIVE ULTRASONOGRAPHIC AIRWAY ASSESSMENT IN PREDICTING DIFFICULT LARYNGOSCOPY IN ADULT PATIENTS**

The main objective of the study is to assess anterior neck by ultrasonography preoperatively based on 2 parameters-

DHSB- Thickness of anterior neck soft tissue in transverse view at the level of hyoid bone (minimal distance from hyoid bone to the skin)

DSEM-Thickness of anterior neck soft tissue in transverse view at the level of thyrohyoid membrane(distance from the skin to epiglottis midway between hyoid bone and thyroid cartilage)

Purpose of the research:

Cormack and Lehane grading has been used to grade difficulty of laryngoscopy. The present study will be using two USG parameters to predict difficult laryngoscopy in adult patients.

The 2 parameters chosen will be –

1. Thickness of anterior neck soft tissue in transverse view at the level of hyoid bone- DHSB(minimal distance from hyoid bone to the skin)
2. Thickness of anterior neck soft tissue in transverse view at the level of thyrohyoid membrane- DSEM (distance from the skin to epiglottis midway between hyoid bone and thyroid cartilage)

We would like to document the reliability of USG in predicting difficult airway .

Procedures and Protocol:

This study will be conducted on patients admitted for elective surgery done under general anaesthesia with endotracheal intubation at R.L.Jalappa Hospital and Research centre, Tamaka, Kolarduringtheperiodfrom January2020toMay2021.

The patient will be made to lie down in supine position with head in neutral position without any support underneath , chin lift and looking straight with mouth closed and tongue touching floor of mouth and no movement. The linear high frequency probe will be placed in the sub mandibular area in midline. The thickness of anterior soft tissue(transverse view)will be obtained at 2 levels –DSHB and DSEM.

Each patient will be visited pre-operatively and procedure will be explained. Written and informed consent will be obtained. All the routine investigations required for pre-operative evaluation will be done for the proposed surgery. Ultrasound guided assessment of airway will be conducted preoperatively.

On arrival in the operating room IV line will be secured and the patient will be pre-medicated with Inj Glycopyrrolate 0.005mg/kg and Inj Fentanyl 2mcg/kg,pre-oxygenated for 3minutes with 100% oxygen. Induction will be done with Inj Prop of ol2mg/kg and neuromuscular blockade will be achieved with InjScoline 2mg/kg i.v.Direct laryngoscopy will be done by an anaesthesiologist using an appropriate size curved Macintosh blade and the Cormack Lehane grade will be noted. After laryngoscopy , patient will be intubated with appropriate sized endotracheal tube and allowed to start with the surgery.

Reimbursements: You will not be given money or gifts to take part in this research.

Confidentiality: We will not be sharing the identity of the participant. The information we collect from you will be kept confidential and only researchers involved in this project will have access to it.

Right to RefuseorWithdraw: Youdonothavetotakepartinthisresearchifyoudonotwish to do so and you can refuse to participate.

WhomtoContact:Ifyouhaveanyquestionsyoumayaskusnoworlater,evenafterthestudy has started, you may contact the following person:

<u>For more information</u>:

Dr. Sinchana.B

Post Graduate in Anaesthesiology

Sri Devaraj Urs Medical

College, Tamaka,

Kolar.Mobile-

9448232163

Email – sinchana993@gmail.com

Dr. Kiran N

Professor of Anaesthesiology

Sri Devaraj Urs Medical

College, Tamaka,

Kolar.Mobile –

9740468460

Email – dr.nkiran@gmail.com

ANNEXURE III

INFORMED CONSENT SHEET

Title of the study: **ACCURACY OF PREOPERATIVE ULTRASONOGRAPHIC AIRWAY ASSESSMENT IN PREDICTING DIFFICULT LARYNGOSCOPY IN ADULT PATIENTS**

Date: ....

I.......................................aged ....after being explained in my own vernacular language about the purpose of the study and the risks and complications of the procedure, hereby give my valid written informed consent without any force or prejudice for ultrasonographic airway assessment and its relation to Cormack Lehane grading. The nature and risks involved have been explained to me to my satisfaction.I have been explained in detail about the study being conducted. I have read the patient information sheet and I have had the opportunity to ask any question. Any question that I have asked has been answered to my satisfaction. I consent voluntarily to participate as a participant in this research. I hereby give consent to provide my history, undergo physical examination, undergo the procedure, undergo investigations and provide its results and documents etc. to the doctor/ institute etc. All the data may be published or used for any academic purpose. I will not hold the doctors/ institute etc responsible for any untoward consequences during the procedure /study.

A copy of this informed consent form and patient information sheet has been provided to the participant.

(Signature & Name of Pt. Attendant)

(Patient/Guardian) (Relation with

patient)

Witnesses

1.

2.

Signature Investigator

KEY TO MASTER CHART

SL NO	Serial number
yrs	Years
M	Male
F	Female
BMI	Body Mass Index
Kg/m^2	kilogram per meter square
ASA	American Society of Anaesthesiologists Physical status
MP	Mallampati grade
cm	Centimetre
CL	Cormack Lehane grade
DSHB	Thickness of anterior neck soft tissue in transverse view at level of hyoid bone (minimal distance from hyoid bone to the skin)
DSEM	Thickness of anterior neck soft tissue in transverse view at level of thyrohyoid membrane (distance from skin to epiglottis midway between hyoid bone and thyroid cartilage)

MASTER CHART

SL NO	UHID NO	AGE (yrs)	SEX	BMI(kg/m2)	ASA GRADE	DIAGNOSIS	NAME OF SURGERY	MP GRADE	DHSB(cm)	DSEM(cm)	CL GRADE
1	805386	20	M	25.39	I	ALLERGIC RHINITIS +BILATERAL INFERIOR TURBINATE HYPERTROPHY	PLANECTOMY+TURBINECTOMY	II	0.48	1.99	II
2	864485	60	F	21.28	II	CHOLELITHIASIS	LAPARASCOPIC CHOLECYSTECTOMY	II	0.65	1.86	II
3	807152	60	M	23.52	II	WET GANGRENE OF RIGHT FOOT	RIGHT BELOW KNEE AMPUTATION	II	0.51	1.91	I
4	810696	25	F	22.51	I	ACUTE CALCULOUS CHOLECYSTITIS	LAPARASCOPIC CHOLECYSTECTOMY	I	0.61	1.79	I
5	812893	23	F	22.13	I	LEFT SIDED ADNEXAL MASS FOR EVALUATION	DIAGNOSTIC LAPARASCOPY	I	0.57	1.78	I
6	819844	52	M	23.85	I	LEFT SUPRACLAVICULAR LYMPH NODES	EXCISION BIOPSY OF LYMPH NODES	III	0.48	1.87	II
7	849069	57	M	22.8	I	CALCULOUS CHOLECYSTITIS	LAPARASCOPIC CHOLECYSTECTOMY	II	0.62	1.86	I
8	832401	40	M	23.89	I	LACERATED WOUND OVER FOREHEAD	ROTATIONAL FLAP	II	0.56	1.66	I
9	825935	30	M	20.41	I	ZONE 5 FLEXOR TENDON INJURY WITH ULNAR NERVE INJURY	EXPLORATION +TENDON REPAIR+NERVE REPAIR	I	0.47	1.96	I
10	721939	60	M	26.02	I	LUMBAR CANAL STENOSIS	DECOMPRESSION+FUSION+IMPLANT	III	0.63	1.66	I
11	827962	19	F	18.07	I	FIBROADENOMA LEFT BREAST	EXCISION BIOPSY	I	0.59	1.68	I
12	782674	35	M	29.45	II	LEFT CSOM	LEFT MASTOIDECTOMY +TYMPANOPLASTY	III	0.7	2.01	III
13	852258	60	M	24.51	II	L3-L4 LISTHESIS WITH IVDP	DECOMPRESSION AND SPINAL FUSION	II	0.53	1.86	II
14	856184	56	F	22.51	II	RIGHT SEROUS CYSTADENOMA OF OVARY	EXPLORATORY LAPAROTOMY AND PROCEED	II	0.5	1.78	II
15	675570	26	F	22.08	I	CALCULOUS CHOLECYSTITIS	LAPARASCOPIC CHOLECYSTECTOMY	I	0.49	1.68	I
16	891754	26	M	20.33	I	DEVIATED NASAL SEPTUM TO LEFT	SEPTOPLASTY	I	0.51	1.66	I
17	893862	30	F	21.5	I	GRANULOMATOUS MASTITIS OF LEFT BREAST	LUMPECTOMY	I	0.69	1.74	I
18	894543	59	F	22.13	II	CALCULOUS CHOLECYSTITIS	LAPARASCOPIC CHOLECYSTECTOMY	II	0.59	1.99	II
19	877109	22	M	20.76	I	LEFT CSOM	LEFT MASTOIDECTOMY +TYMPANOPLASTY	III	0.57	1.78	I
20	881506	50	F	24.21	I	RIGHT CSOM	RIGHT MASTOIDECTOMY +TYMPANOPLASTY	II	0.62	1.69	II
21	885722	35	F	17.81	II	BILATERAL NASAL POLYPOSIS	FESS	I	0.5	1.65	I
22	890078	32	F	15.91	I	DEVIATED NASAL SEPTUM TO LEFT	SEPTOPLASTY	I	0.47	1.57	I
23	878239	55	F	20.58	I	GALL BLADDER POLYP	LAPARASCOPIC CHOLECYSTECTOMY	II	0.65	1.77	I
24	896085	35	F	20.36	I	EPIGASTRIC HERNIA	MESH REPAIR	I	0.54	1.89	II
25	863866	38	M	26.66	I	LIPOMA OVER LEFT SUPRACLAVICULAR REGION	EXCISION BIOPSY	II	0.84	1.99	III
26	855546	24	M	23.52	II	EXTERNAL DEFORMITY OF NOSE WITH DNS TO LEFT	SEPTORHINOPLASTY	I	0.7	1.87	II
27	803213	38	F	26.1	II	L4-L5 SPONDYLOLISTHESIS WITH SPINAL CORD STENOSIS	SPINAL FUSION WITH IMPLANT	II	0.56	1.55	II
28	878095	29	F	20.75	I	CALCULOUS CHOLECYSTITIS	LAPARASCOPIC CHOLECYSTECTOMY	I	0.47	1.98	I
29	877627	48	M	24.91	II	CALCULOUS CHOLECYSTITIS	LAPARASCOPIC CHOLECYSTECTOMY	III	0.64	1.77	II
30	884849	30	M	21.37	II	B/L CSOM	LEFT MASTOIDECTOMY +TYMPANOPLASTY	III	0.95	1.85	III
31	883664	40	F	23.43	I	BILATERAL NASAL POLYPOSIS	FESS	II	0.65	1.65	II
32	873038	45	F	23.28	II	FIBROADENOMA LEFT BREAST	EXCISION BIOPSY	III	0.59	1.91	II
33	879328	29	M	26.1	I	B/L CSOM	RIGHT MASTOIDECTOMY +TYMPANOPLASTY	II	0.61	2.01	II
34	880742	25	M	23.3	I	DEVIATED NASAL SEPTUM TO LEFT	SEPTOPLASTY	III	0.48	1.57	I
35	778705	38	F	24.82	II	CHOLELITHIASIS +UMBILICAL HERNIA	LAPARASCOPIC CHOLECYSTECTOMY +MESH REPAIR	II	0.58	1.99	II
36	874198	28	F	23.63	I	CHOLELITHIASIS	LAPARASCOPIC CHOLECYSTECTOMY	III	0.57	1.56	I
37	827142	20	F	24.56	I	RIGHT SINONASAL POLYPOSIS	FESS	I	0.48	2.09	I
38	889131	30	F	20.75	I	LEFT CSOM	LEFT MASTOIDECTOMY +TYMPANOPLASTY	I	0.51	1.69	I
39	885648	21	M	27.36	I	CHRONIC RHINOSINUSITIS +DNS TO LEFT	SEPTOPLASTY WITH FESS	III	0.56	1.98	I
40	881862	20	F	23.63	I	CHRONIC TONSILLITIS	TONSILLECTOMY	I	0.56	1.66	I

MASTER CHART

41	887809	37	M	25.95	I	PAPILLOMA RIGHT VOCAL CORD	MICROLARYNGEAL SURGERY	II	0.61	2.01	II
42	746374	26	F	23.28	I	CHRONIC TONSILLITIS	TONSILLECTOMY	II	0.5	1.68	I
43	871444	50	F	26.47	II	CALCULOUS CHOLECYSTITIS	LAPARASCOPIC CHOLECYSTECTOMY	III	0.64	1.74	II
44	877610	60	M	24.59	II	B/L CSOM	RIGHT CANAL WALL DOWN MASTOIDECTOMY	III	0.65	1.55	II
45	850217	44	F	21.28	I	DEVIATED NASAL SEPTUM TO LEFT WITH BILATERAL POLYPOSIS	SEPTOPLASTY WITH FESS	III	0.7	1.97	II
46	883505	20	F	21.64	II	LEFT EAR CSOM TUBOTYMPANIC TYPE	LEFT CORTICAL MASTOIDECTOMY + TYMPANOPLASTY	II	0.74	2.1	III
47	876817	29	F	23.43	I	RIGHT CSOM ATTICOANTRAL DISEASE	RIGHT MODIFIED RADICAL MASTOIDECTOMY	II	0.5	2.08	II
48	882717	42	M	24.91	II	L3-L4 LISTHESIS WITH IVDP	SPINAL FUSION WITH IMPLANT	III	0.54	1.92	II
49	889314	20	F	21.75	I	MYOCYSTICERCOSIS OVER LEFT ARM	EXCISION BIOPSY	I	0.5	1.58	I
50	870973	46	M	23.75	I	DEVIATED NASAL SEPTUM TO LEFT WITH BILATERAL POLYPOSIS	SEPTOPLASTY WITH FESS	III	0.55	1.78	II
51	864395	24	F	23.27	I	CHRONIC TONSILLITIS	TONSILLECTOMY	I	0.62	1.96	I
52	882815	28	M	24.15	I	NASAL BONE FRACTURE	NASAL BONE REDUCTION	I	0.4	1.65	I
53	842601	35	F	24.52	I	CHOLELITHIASIS	LAPARASCOPIC CHOLECYSTECTOMY	III	0.59	1.78	II
54	866829	25	F	20.41	I	PARAUMBILICAL HERNIA	MESH REPAIR	I	0.66	1.65	II
55	866239	38	F	23.66	I	B/L VOCAL CORD PALSY	DL SCOPY+BIOPSY	II	0.49	1.66	I
56	870436	55	F	20.36	II	UMBILICAL HERNIA	MESHPLASTY	I	0.55	1.63	I
57	559037	46	M	29.38	I	RIGHT EAR CSOM TUBOTYMPANIC TYPE	RIGHT CORTICAL MASTOIDECTOMY + TYMPANOPLASTY	III	0.53	1.45	II
58	892226	29	F	19.09	I	DEVIATED NASAL SEPTUM TO RIGHT	SEPTOPLASTY	I	0.55	1.98	I
59	893653	31	F	21.85	I	B/L CSOM	LEFT MASTOIDECTOMY +TYMPANOPLASTY	I	0.57	1.57	I
60	8811634	37	F	26.11	II	LEFT EAR CSOM TUBOTYMPANIC TYPE	LEFT CORTICAL MASTOIDECTOMY + TYMPANOPLASTY	III	0.63	1.66	II
61	887928	21	M	21.6	I	RECURRENT APPENDICITIS	LAPARASCOPIC APPENDICECTOMY	I	0.53	1.77	I
62	565266	21	F	22.01	I	DEVIATED NASAL SEPTUM TO RIGHT	SEPTOPLASTY	I	0.51	1.97	I
63	888245	24	F	24.36	I	CHRONIC TONSILLITIS	TONSILLECTOMY	I	0.65	1.68	I
64	894732	32	M	26.64	I	2YEAR OLD UNITED LEFT CLAVICLE FRACTURE WITH LCP IN SITU	IMPLANT REMOVAL FROM LEFT CLAVICLE	III	0.52	1.65	I
65	863732	50	F	25.83	II	LEFT EAR CSOM TUBOTYMPANIC TYPE	LEFT CORTICAL MASTOIDECTOMY + TYMPANOPLASTY	III	0.69	1.78	II
66	887628	21	M	22.8	I	RECURRENT APPENDICITIS	LAPARASCOPIC APPENDICECTOMY	I	0.57	1.96	I
67	867747	43	F	21.69	I	DERMOID CYST OVER SCALP	CYST EXCISION AND BIOPSY	II	0.65	2.27	III
68	882988	60	M	20.41	II	SEPTAL ABSCESS	INCISION AND DRAINAGE	III	0.54	1.88	II
69	882045	58	M	24.25	I	SYMPTOMATIC CHOLELITHIASIS	LAPARASCOPIC CHOLECYSTECTOMY	II	0.64	1.41	II
70	881938	40	F	23.85	I	FIBROADENOMA OF RIGHT BREAST	EXCISION BIOPSY	II	0.75	1.89	II
71	882109	31	M	25.95	I	B/L CSOM	LEFT MASTOIDECTOMY +TYMPANOPLASTY	III	0.63	1.99	II
72	862636	19	F	22.51	II	CHRONIC RHINOSINUSITIS	FESS	I	0.6	1.87	II
73	893472	28	F	22.08	II	DEVIATED NASAL SEPTUM TO RIGHT	SEPTOPLASTY	I	0.49	1.74	I
74	900579	60	F	20.33	II	L5-S1 LISTHESIS	L5-S1 SPINAL FUSION	II	0.56	1.9	II
75	898311	59	F	21.5	II	LEFT NON FUNCTIONING KIDNEY	LEFT NEPHRECTOMY	II	0.8	1.64	II
76	898941	60	F	22.13	II	OVARIAN MASS FOR EVALUATION	EXPLORATORY LAPAROTOMY	II	0.62	1.65	II
77	457660	25	M	22.49	I	3YR OLD UNITED FRACTURE OF RIGHT CLAVICLE WITH LCP IN SITU	IMPLANT REMOVAL	I	0.49	1.98	I
78	900441	60	F	24.21	II	CHOLELITHIASIS	LAPARASCOPIC CHOLECYSTECTOMY	III	0.66	1.96	II
79	892825	30	M	26.64	I	LEFT CSOM	MASTOID EXPLORATION	II	0.99	1.88	III
80	899547	55	M	28.35	II	C4-C5 IVDP WITH LEFT UPPER LIMB RADICULOPATHY	SPINAL FUSION WITH IMPLANT	II	0.84	2.1	III
81	904453	45	F	15.91	I	CHOLELITHIASIS	LAPARASCOPIC CHOLECYSTECTOMY	I	0.55	1.89	I
82	861295	53	M	26.02	I	BILATERAL NASAL POLYPOSIS	FESS	II	0.6	1.89	II
83	906720	60	M	27.36	II	RIGHT SINONASAL POLYPOSIS	FESS	II	0.59	1.64	II
84	857406	25	M	26.1	I	LEFT CSOM	LEFT MASTOIDECTOMY +TYMPANOPLASTY	I	0.47	1.86	II
85	896963	40	M	24.91	I	DEVIATED NASAL SEPTUM TO LEFT	SEPTOPLASTY	I	0.45	1.98	I
86	907192	59	F	20.58	II	LEFT SINONASAL POLYP WITH DNS TO RIGHT	SEPTOPLASTY	III	0.57	1.77	II

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87	906782	58	F	20.36	I	LEFT TRIGEMINAL NEURALGIA	MICROVASCULAR DECOMPRESSION	I	0.69	1.98	II
88	898841	35	F	23.43	I	CHRONIC TONSILLITIS	TONSILLECTOMY	I	0.52	1.79	I
89	808335	26	F	20.75	I	ALLERGIC RHINITIS	SEPTOPLASTY	I	0.49	1.74	I
90	907884	60	M	24.51	II	LEFT VALLECULA CYST	MICROLARYNGEAL SURGERY	II	0.56	1.94	II
91	905232	37	F	26.11	I	L4-L5 LISTHESIS WITH IVDP	SPINAL FUSION WITH IMPLANT	III	0.61	1.66	II
92	922430	30	F	15.91	I	DEVIATED NASAL SEPTUM	SEPTOPLASTY	I	0.58	1.56	I
93	861295	53	M	28.71	I	BILATERAL NASAL POLYPOSIS	FESS	I	0.98	2.23	III
94	906029	27	M	24.72	I	UMBILICAL HERNIA	MESH REPAIR	II	0.7	1.66	II
95	926708	40	F	28.57	II	CHOLELITHIASIS	LAPARASCOPIC CHOLECYSTECTOMY	II	0.59	2.01	II
96	922429	52	M	24.52	I	DEVIATED NASAL SEPTUM	SEPTOPLASTY	I	0.58	1.57	I