"CORRELATION OF ULTRASOUND GUIDED AIRWAY PARAMETERS TO THE CORMACK-LEHANE GRADING - A ONE YEAR HOSPITAL BASED PROSPECTIVE OBSERVATIONAL STUDY"

By

REG NO. BA0119001

Dissertation

Submitted to the
KLE Academy of Higher Education & Research
(Deemed-to-be-University), Belagavi, Karnataka
In Partial Fulfillment
of the requirements for the degree of

M.D.

in

ANAESTHESIOLOGY

DEPARTMENT OF ANAESTHESIOLOGY,

JAWAHARLAL NEHRU MEDICAL COLLEGE,

BELAGAVI, KARNATAKA

APRIL – 2022

KLE Academy of Higher Education & Research
(Deemed University), Belagavi, Karnataka

ENDORSEMENT

This is to certify that the dissertation entitled **"CORRELATION OF ULTRASOUND GUIDED AIRWAY PARAMETERS TO THE CORMACK-LEHANE GRADING - A ONE YEAR HOSPITAL BASED PROSPECTIVE OBSERVATIONAL STUDY"** is a bonafide research work done by REG**. NO. BA0119001.**

DR. RAJESH MANE MD, DNB
Professor and Head,
Department of Anaesthesiology,
J. N. Medical College,
Nehru Nagar, Belagavi – 10

Date:
Place: Belagavi

Dr. (Mrs) N.S. Mahantshetti **MD(paed)**
Principal,
J. N. Medical College,
Nehru Nagar, Belagavi – 10

Date:
Place: Belagavi

PLAGIARISM CERTIFICATE

KLE

JAWAHARLAL NEHRU MEDICAL COLLEGE

(Recognized by Medical Council of India, New Delhi)

Accredited 'A' Grade by NAAC (2nd Cycle) Placed in Category 'A' by MHRD (GoI)

Nehru Nagar, Belagavi- 590 010, Karnataka, INDIA

0831 - 2471350 0831 - 2470759 www.jnmc.edu principal@jnmc.edu

Ref No: MDC/PG/

Date: 16-11-2021

ACCEPTANCE LETTER

The softcopy of thesis entitled **"CORRELATION OF ULTRASOUND GUIDED AIRWAY PARAMETERS TO THE CORMACK-LEHANE GRADING- A ONE YEAR HOSPITAL BASED PROSPECTIVE OBSERVATIONAL STUDY."** has been submitted for Anti-Plagiarism check through Turnitin software. The scan has been carried out and the scanned output reveals a match percentage of **09%** which is within the acceptable limits of **10%** as per the guidelines given by UGC.

KAHER BELAGAVI J.N. MEDICAL COLLEGE

Dr. (Mrs.) N.S. Mahantashetti.
Chairperson-Antiplagiarism Committee &
Principal,
J. N. Medical College, Belagavi.

To,
Reg. No. BA0119001.
Postgraduate Student,
2019-20 Batch,
Department of Anesthesiology,
J. N. Medical College, Belagavi.

LIST OF ABBREVIATIONS USED

ANS-VC	-	Anterior neck soft tissue thickness at the level of vocal cords
ASA	-	American Society of Anaesthesiology
CL	-	Cormack Lehane
cms	-	Centimeters
CTM	-	Cricothyroid membrane
DI	-	Difficult intubation
DLT	-	Double lumen tube
DSAC	-	Distance between skin and anterior commissure
DSEM	-	Distance between skin and epiglottis
DSHB	-	Distance between skin and hyoid bone
ECG	-	Electrocardiograph
ETT	-	Endotracheal Tube
HMDR	-	Hyomental Distance Ratio
Hz	-	Hertz
IIG	-	Interincisor gap
IV	-	Intravenous
LMA	-	Laryngeal Mask Airway
MHz	-	MegaHertz

min	-	Minute
MMS	-	Modified Mallampati score
POCUS	-	Point of care ultrasound
Pre-E/E-VC	-	Ratio of Pre-epiglottic space to distance between epiglottis and mid-point of vocal cords
PNC	-	Percutaneous cricothyroidotomy
ROC	-	Relative operating characteristics
SMD	-	Sternomental distance
TMD	-	Thyromental distance
TM	-	Thyrohyoid membrane
US	-	Ultrasound
USG	-	Ultrasonograph

ABSTRACT

Title: Correlation of ultrasound guided airway parameters to the Cormack-Lehane grading - a one year hospital based prospective observational study.

Authors: Dr. Anshika Kataria, Dr. Chaitanya A. Kamat

Background and aims: Difficult as well as unsuccessful tracheal intubation after performing direct laryngoscopy is one of the most feared complication of general anaesthesia and is associated with serious morbidity and mortality. Ultrasound of the upper airway may prove to be a useful adjunct to traditional clinical assessment tools, as it has been successful in visualizing the proper anatomy and critical structures of the airway. We undertook this study to know the efficacy of ultrasound in determining parameters namely the ratio of pre-epiglottic depth to distance between epiglottis and mid-point of vocal cords (Pre-E/E-VC), hyomental distance ratio (HMDR) and the anterior neck soft tissue thickness at vocal cords level (ANS-VC) and correlating them to the CL grading to predict difficult airway.

Methodology: The present observational study was conducted in 60 ASA 1 and 2 patients, aged between 18-60 years posted for elective surgeries under general anaesthesia and endotracheal intubation using direct laryngoscopy in KLE’S Dr. Prabhakar Kore charitable hospital and medical research centre, Belagavi. All the patients underwent pre-intubation ultrasound assessment. All the data was combined and coded and analysis was done using the student’s unpaired ‘t’-test. Correlation between clinical outcomes and demographic characters were interpreted using the Chi-square test.

Results: In our study we observed that the ultrasound parameter of Pre-E/E-VC was highly convincing in correlation with the CL grading with sensitivity of 91.67% and diagnostic accuracy of 82%. It was also observed that among the demographic characteristics available none of them had a strong positive correlation as a predictor of difficult intubation.

Conclusion: To conclude, among the ultrasound parameters, Pre-E/E-VC ratio was highly significant in association to CL grading. A cutoff value of 1.55 for the ratio of Pre-E/E-VC entirely outlined the difficult (CL 3&4) and easy intubation (CL 1&2). Hence, point-of-care ultrasound should be included more in the pre-operative evaluation of a patient to predict with accuracy the presence of difficult airway and intubation.

Key words: Difficult airway, ultrasound,

CONTENTS

LIST OF TABLES

LIST OF GRAPHS

LIST OF FIGURES

LIST OF PHOTOGRAPHS

INTRODUCTION

Difficult as well as unsuccessful tracheal intubation after performing direct laryngoscopy is one of the most feared complication of general anaesthesia and is associated with serious morbidity and mortality.[1]

Any problem during intubation which was not anticipated or evaluated can lead to respiration related adverse outcome such as varying degrees of hypoxia, hypercarbia and rising level of consciousness in a paralysed patient.[2]

Several approaches have been initiated to remedy such issues and to identify those patients who'll pose as DI. The important ones are included in the pre-operative anaesthetic evaluation of the airway in those patients undergoing surgery. Earlier the airway examination was performed by single factors like the Mallampati classification, thyromental distances, movement of the head&neck and the inter-incisor gap. Although when it was understood that visualising larynx at the time of intubation may be difficult or dependent on other factors, the concept of multi-factorial analysis or examination came into picture.

Even after using varied methods, there seems to have been occurrences wherein a patient who was predicted to have an easy intubation have faced difficulties while performing the same and vice versa.[3]

Over the past few years, Ultrasonography is being recognised and applied in every field of anaesthesiology due to its practicality, ease and portability. There have been multiple studies and researches highlighting the importance of ultrasonography in patient examination and prediction of difficult intubations.

Upper airway ultrasonography is now a valued, noninvasive, easy-to-use, and portable point-of-care ultrasound (POCUS) utilised for evaluating and managing the airway even in situations where the airway anatomy might be distorted by either trauma or pathology.[4] Ultrasound (US) is useful in recognising the airway sonoanatomy by identifying several structures like the epiglottis, the thyroid-cartilage, cricoid cartilage, cricothyroid membrane, tracheal cartilages, and also the oesophagus.

This applied ultrasonographic evaluation of the airway anatomy helps the anaesthesiologist utilise the same for identifying difficult intubation, endotracheal tube (ETT) and Laryngeal mask airway (LMA) insertion and its depth, ultrasound-guided invasive techniques like PNC as well as tracheostomy, predicting post-extubation stridor and DLT size, and identifying upper airway abnormalities.

Extensive POCUS awareness, improved technological progressions, portability, and availability of ultrasound in most critical places, enabled upper airway ultrasound to become the potential first-line non-invasive airway assessment tool of the future.[4]

US is also being used to directly observe the ETT entering into the trachea or the oesophagus by transversely applying the probe at the suprasternal notch level at the time of direct laryngoscopy and intubation without having to confirm with ventilation or circulation.[5]

Ultrasonography can be used hand in hand with the traditional methods of assessment of difficult airway as it has been efficacious in imaging the proper anatomy and complex structures of the airway. USG has various benefits for imaging the anatomy airway and it must be used enthusiastically for obtaining maximal benefit in close association with the airway management, i.e., immediately before, during, or after airway interventions.

OBJECTIVE

To know the efficacy of the various ultrasound airway assessment measures like

i. ratio of pre-epiglottic space and the distance from the epiglottis to the mid-point between the vocal cords (Pre-E/E-VC),
ii. hyomental distance ratio (HMDR) and
iii. anterior neck soft tissue thickness at the level of vocal cords (ANS-VC).

and their correlation to the Cormack-Lehane grading to predict difficult laryngoscopy and intubation.

REVIEW OF LITERATURE

Preoperative evaluation of airway using conventional clinical tests is common in anaesthesiology practice but better predictability of the parameters can be done with accuracy using the point of care ultrasonography. Recently, ultrasound has been of paramount importance in assessment of difficult airway.

One of the initial studies undertaken in 2011 by Adhikari *et al,* demonstrated that sonographic measurements of anterior neck soft tissue thickness at the level of hyoid bone and thyrohyoid membrane can be used to distinguish difficult and easy laryngoscopies. The USG measurements of anterior neck soft tissue were greater in the difficult laryngoscopy group compared to the easy laryngoscopy group at the level of the hyoid bone and TM. Clinical screening tests did not correlate with US measurements, and US was able to detect difficult laryngoscopy, indicating the limitations of the conventional screening tests for predicting difficult laryngoscopy.[6]

In the year 2012, Wojtczak *et al,* studied obese patients who came with difficult and easy intubation by doing an US guided submandibular examination in supine position. The hyomental distances were measured in both neutral and hyper-extended position and the subsequent ratio was attained. The mean hyomental distance did not vary much in neutral position between the two groups, though the hyomental distance in the head-extended position did differ considerably. Tongue volumes and the volumes of the floor of the mouth muscle did not differ significantly between the two groups. This study showed that the hyomental distances may indicate difficult intubation.[7]

In the same year, Gupta *et al,* compared and correlated the ultrasonographic view of the airway and the Cormack Lehane grading of the direct laryngoscopy on patients undergoing elective surgery and general anaesthesia. They measured epiglottis to the mid-point of vocal folds distance, pre-epiglottic depth and time taken-up by the clinician to obtain the final ultrasonographic picture. All the measurements were then associated to the Cormack Lehane grading obtained while performing laryngoscopy and intubation. Based on the results it was observed that Pre-E/E-VC ratio had a strong positive correlation with the Cormack Lehane grading, concluding that the non-invasive ultrasonographic pre anaesthetic evaluation can supplement the currently available clinical tests and modalities.[8]

Next in 2014, Hui *et al*, did a prospective study proposing that in addition to the present available airway techniques, not being able to see the hyoid bone on the ultrasound image also provides additional proof for predicting a difficult laryngoscopic grade. Visualization of the hyoid employing US was correlated with a CL grade of 1–2 and had a positive correlation. The other methods had appreciable lower likelihood ratios and sensitivity. The resultant information indicates that sublingual ultrasonography is a viable instrument as an add on to the classical methods of airway assessment.[9]

Also, in relation to other ultrasonographic parameters, Wu *et al*, proposed that, ANS measured by US at hyoid bone, anterior commissure, and thyrohyoid membrane levels are absolute predictors of difficult intubation. Combining them with the US measurements may increase the chances of predicting difficult laryngoscopy. DSHB (distance between skin and hyoid bone); DSEM (distance between skin and epiglottis); DSAC (distance between skin and anterior commissure) and MMS (modified Mallampati score) were higher in the difficult laryngoscopy group. There was a strong positive association between DSEM and DSHB very small one between TMD and IIG.[10]

In the following year, Sharma *et al*, in a prospective study did comparative assessment of airway and their correlation with the view obtained by Cormack-Lehane grading at the time of intubation during general anaesthesia. Evaluation of the airway was undertaken by making the patient lie in both lateral and anterolateral position; visualising the neck anteriorly and laterally; maximal extension of head&neck; mouth opening and teeth & oral cavity. The aforementioned parameters were noted: a) Modified Mallampatti Test, b) TMD, c) Upper lip Bite Test, d) Head Extension and e) Wilson's criteria. After anaesthesia induction, laryngoscopy and intubation was done and CL grading was noted. They discovered that both Wilson score and neck extension were the two most definite individual parameters.[11]

HMDR was indicated as the best predictor of DI in 2016 by Kalezić *et al,* Similar results were obtained by other studies. For predicting DI, the modified Mallampati test was accurate whereas the original Mallampati test demonstrated poor performance. The results of the investigation displayed the reliability of the Mallampati score in predicting DI, and HMDR and HMDe (Hyomental distance in extreme head extension) stood out as significant predictors of DI.[12]

In the following year, Parameswari *et al,* in an observational research found that among all the sonographic parameters the distance of skin-epiglottis calculated at the THM level showed the highest correlation and sensitivity in identifying difficult laryngo-scopy. When used along-with other clinical parameter, in this case the modified Mallampatti classification, the sensitivity of both was observed as higher when compared to that of a single variable used.[13]

In a prospective study by Cristina Petrișor *et al* 2018, ultrasonography-assessed hyomental distance (HMD) ratio was done. Ratio of HMD in maximum hyperextension to that in the neutral position (HMDR2) was found to be more desirable in anticipating difficult intubation in obese population when compared to hyomental distance in the ramped position to that in the neutral position (HMDR1).[14]

In another prospective, observational study of 120 subjects by Rana *et al*, demonstrated that sonographic measurement of Pre-E/E-VC ratio and HMDR can be used to predict difficult airway and endotracheal intubation in otherwise healthy adults along with other physical indicators and examination of difficult airway. The HMDR showed a strong negative association with CL grading while the Pre-E/E-VC ratio had a strong prediction.[15]

Falcetta *etal*, in 2018 undertook a study in 301 patients aimed to determine the association between the anterior cervical soft tissues thickness at two levels, namely the thyrohyoid membrane that is the pre-epiglottic space and the vocal cords, measurement sonographically and the Cormack–Lehane grading obtained during the direct laryngoscopy. They observed that the pre epiglottic thickness at the level of thyrohyoid membrane was superior than that at vocal cords in determining the difficult laryngoscopy.[16]

In 2019 Koundal *et al,* measured ANS thickness at the level of hyoid bone (DSHB), epiglottis (DSEM), and Pre-E/E-VC sono-graphically. The HMDR was measured in both neutral and extended position. According to them, the highest sensitivity and negative predictive values were observed with the cut-off values of Pre–E/E-VC, DSEM, followed by HMDR and DSHB for predicting difficult laryngoscopy. The strong positive correlation of Pre–E/E-VC, DSEM, and moderate negative correlation of HMDR proved these USG parameters as reliable predictors for identifying difficult laryngoscopy.[17]

In 2019 Yadav *etal*, did a hypothesis to highlight the use of US in measuring the ANS thickness at various levels namely at THM hyoid level, and tongue thickness to predict difficult laryngoscopy and compare them with clinical parameters for airway assessment and its correlation with CL laryngoscope view. This study concluded that ultrasound measurements of soft tissue thickness of anterior neck at hyoid and thyrohyoid level and tongue thickness are more sensitive than conventional airway tests and can be used in combination with other bedside clinical tests for better prediction of difficult laryngoscopy.[18]

In the same year Kanoujia *etal*., studied 100 cases to predict difficult laryngoscopy using ultrasound and measured anterior neck soft tissue thickness. They noted that even though clinical parameter like Mallampatti grading was a good bedside predictor for difficult airway, the ultrasound guided measurement and assessment of the airway was more reliable indicator and more feasible in the pre operative check-up.[19] Similar results were observed in our study although Mallampatti grading was comparable in all the subjects and thyromental distance was a better clinical predictor.

Thus, taking into consideration the data available in literature with respect to the ultrasound measurements and clinical predictors, we undertook this study to evaluate their clinical efficacy in correlation to the CL grading in elective general surgeries requiring general anaesthesia with endotracheal intubation.

BASIC SCIENCE

Anatomy[20,21,22,23,24]

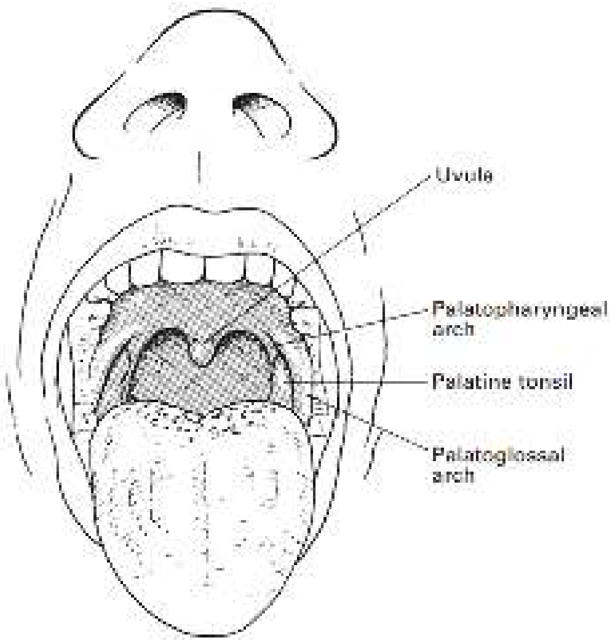


Figure 1: Anatomy of oral cavity

ORAL CAVITY

The oral cavity consists of vestibule and mouth.

Vestibule: It is a narrow space formed by lip and cheek and internally by gums and teeth. Vestibular wall is kept together by the facial muscles.

Oral cavity: It is confined in front by the maxillary and mandibular alveolar arch and teeth, hard and soft palate form the roof, anterior two-thirds of tongue and the reflection of its mucosa forwards onto the mandible below, and the oropharyngeal isthmus behind.

THE PALATE

Hard palate: It entails the palatine processes of the maxillae anteriorly and the horizontal plates of the palatine bones posteriorly. The mucous membrane is connected to the below lying periosteum tightly forming a single sheet, the mucoperiosteum.

Soft palate: It is a muscular curtain-like fold overhanging the hard palate (posterior border). Its free border bears the uvula in the center and merges on both the sides with the pharyngeal wall. Nasopharynx and oropharynx are separated by the soft palate. It controls the traffic between the air and food pathways.

Muscles of the palate: 5 in number

- The tensor palati,
- The levator palati,
- The palatoglossus,
- The palatopharyngeus
- The musculus uvulae

TONGUE:

It is a muscular organ.

It has two parts that are separated by sulcus terminalis

- o oral
- o Pharyngeal.

Attachment of the tongue's inferior surface to the mouth is by frenulum.

Muscles of the tongue:

- o Tongue is divided into left and right halves by a fibrous septum in the middle.
- o Each half consists of 4 intrinsic and 4 extrinsic muscles.

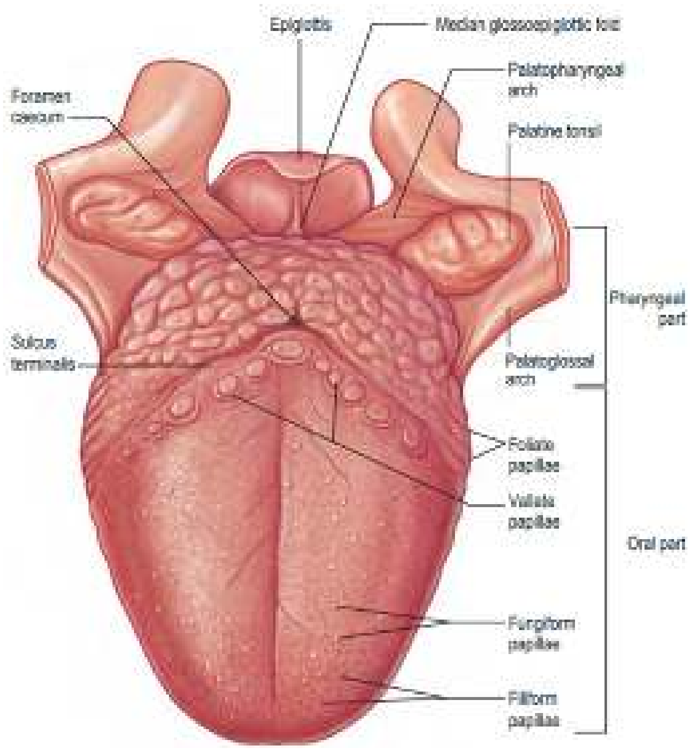


Figure 2: The dorsum of the tongue, adjoining palatoglossal and palatopharyngeal arches, and epiglottis. The palatine tonsils lie in the tonsillar recesses between the palatoglossal and palatopharyngeal arches.

Intrinsic muscles	Extrinsic muscles
Superior longitudinal	Genioglossus
Inferior longitudinal	Hyoglossus
Transverse	Styloglossus
Vertical	Palatoglossus

Table 1: Muscles of the tongue

- Nerve supply:
  - Motor: The muscles of the tongue (with the exception of palatoglossus), are supplied by the hypoglossal nerve.

Palatoglossus is supplied by the pharyngeal plexus

- Sensory: The anterior two-thirds (presulcal part) is derived from first arch mesenchyme. The nerve of general sensation to the anterior two-thirds is the lingual nerve.

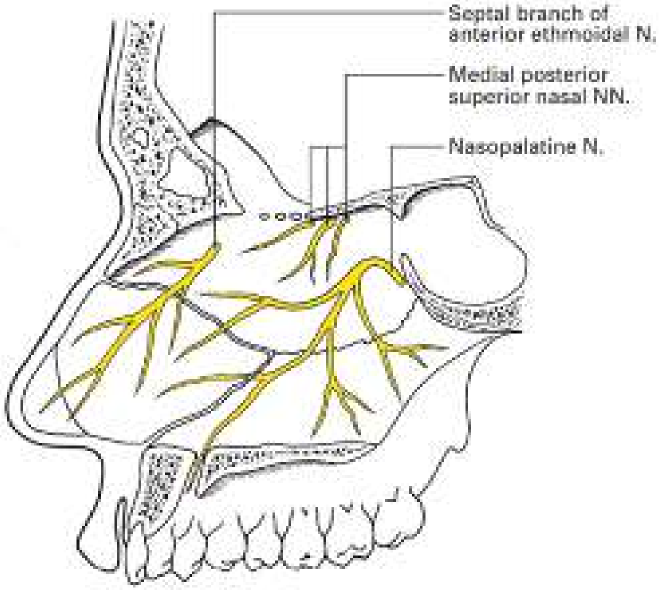
The posterior third (postsulcal part) from third arch mesenchyme. The nerve supplying both general and taste sensation to posterior two thirds is Glossopharyngeal nerve.

  - Taste sensation: Travels in the chorda tympani branch of the facial nerve
  - An additional area in the region of the valleculae is supplied by the internal laryngeal branch of the vagus nerve

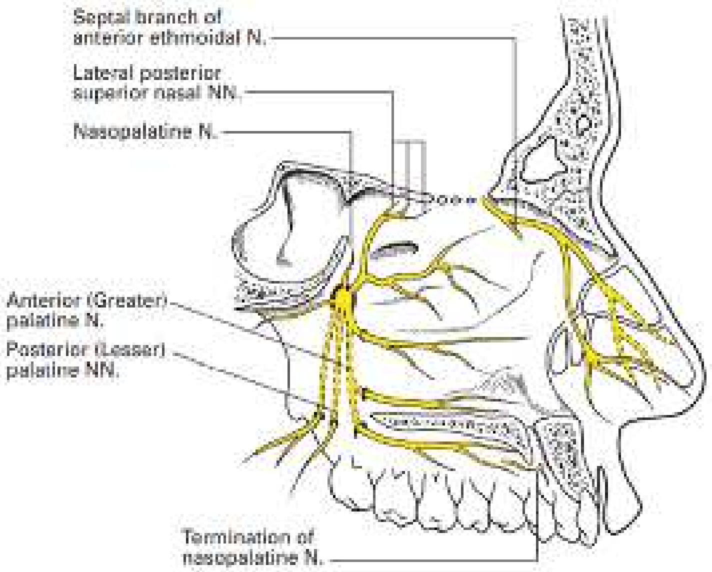
- Arterial supply:
  - External carotid artery's branches: The maxillary, facial and lingual arteries.
- Venous drainage:
  - Pterygoid plexus,
  - Tonsillar plexus and
  - Pharyngeal plexus.
- Lymphatic drainage:
  - Upper deep cervical lymph nodes.
  - Retropharyngeal lymph nodes.

THE NOSE

- It is divided into the external nose and the nasal cavity.
- External nose: made of nasal bones, the nasal part of frontal bone and the frontal processes of maxillae, cartilages in the lower part, and a small zone of fibrofatty tissue that forms the lateral margin of the nostril (the ala).
- The cavity of nose: subdivided by the nasal septum into two separate compartments that open to the exterior via the nares and into the nasopharynx by the choanae (the posterior nasal opening).
- Blood supply:
  - Arterial supply is by the anterior ethmoidal artery, posterior ethmoidal artery, maxillary artery, superior labial artery.
  - Venous drainage occurs through the sphenopalatine, facial and ophthalmic veins.
- Nerve supply:
  - The septum: nasopalatine nerve
  - The lateral wall: lateral posterior superior nasal nerve
  - The floor: anteriorly by the anterosuperior alveolar nerve and posteriorly by the greater palatine nerve
  - The vestibule: infra-orbital branch of the maxillary nerve
  - The paranasal sinuses: 1^{st} and 2^{nd} division of trigeminal nerve



A



B

Figure 3: The nerve supply of the a. nasal septum; b. lateral wall of the nose.

THE PHARYNX

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

Nasopharynx:

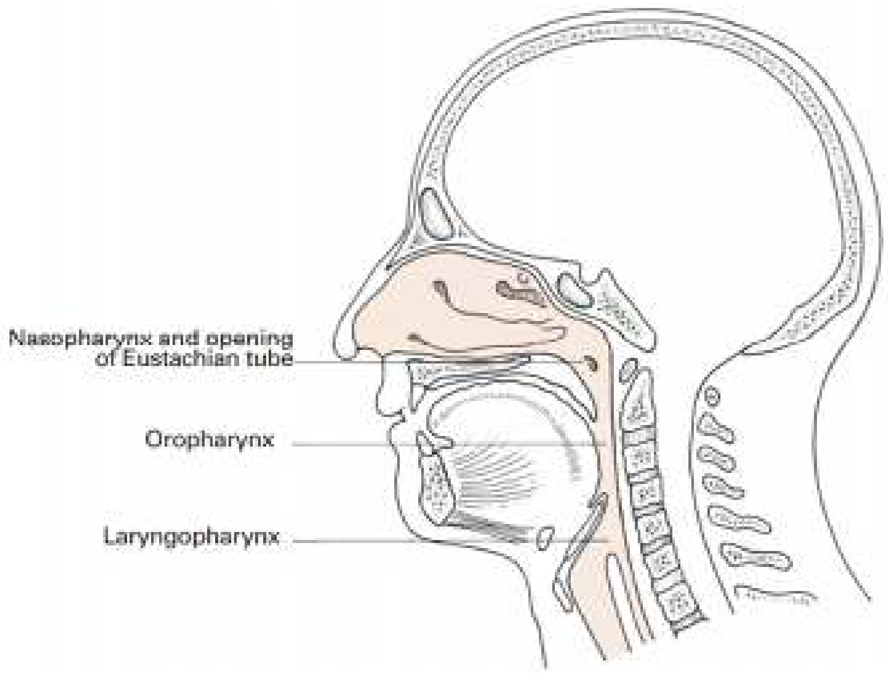


Figure 4: Anatomy of nasopharynx

- The nasopharynx lies behind the nasal cavity and the soft palate. It communicates with the oropharynx through the pharyngeal isthmus. Eustachian tube, adenoids, Fossa of Rossenmuller are the important structures present in nasopharynx.
- Extension:
  - Superior: Base of the skull.
  - Inferior: Soft palate's superior surface.

- It allows free passage for respiration.
- On each side the eustachian tube opens.

Oropharynx:

- The extension of oropharynx is from uvula to hyoid bone.
- The palatoglossal arch (that passes through the oropharyngeal isthmus) delineates the mouth and the oropharynx.
- Lateral wall: Palatopharyngeal arch and palatine tonsil

Laryngopharynx:

- It forms the posterior part of the pharynx in its entire length.
- Extension: superior – epiglottis (superior border), inferior – cricoid cartilage.
- Borders:
  - Superior: Lateral glosso-epiglottic folds - Delineates oro-pharynx and laryngo-pharynx
  - Inferior: continuous with oesophagus.
- On either side of the inlet of larynx lies the pyriform fossa. Its boundaries include:
  - Medial: Aryepiglottic fold.
  - Lateral: Thyroid cartilage and thyrohyoid membrane.

- Muscles of the pharynx:

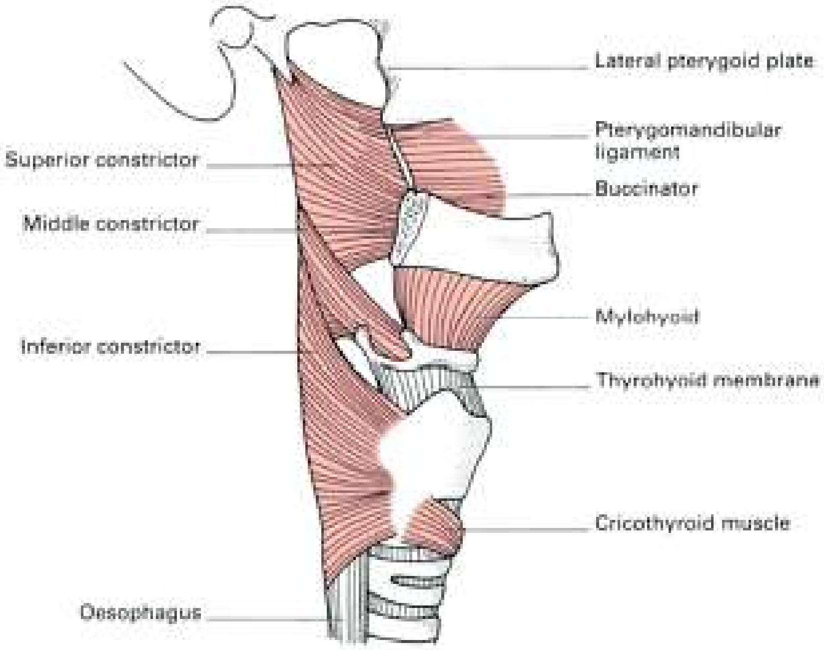


Figure 5: The constrictor muscles of pharynx

- Constrictors:
    - Superior,
    - Middle,
    - Inferior.
- Longitudinal muscle coat:
    - The Palato-pharyngeus muscle,
    - The Stylopharyngeus muscle, and
    - The Salphingo-pharyngeus muscle.
- Nerve supply of pharynx:
    - Motor: Glossopharyngeal nerve, cranial part of accessory nerve.
    - Sensory: General sensation is carried by the pharyngeal branches of glossopharyngeal nerve and palatine branches of maxillary nerve.

- Taste: The lesser petrosal nerve to the pterygopalatine ganglion (also has secretomotor innervations to the pharyngeal mucosa).

- Arterial supply:

The arterial supply is provided by the lingual, facial and maxillary arteries. Ascending pharyngeal as well as the superior thyroid artery also provides arterial supply.

- Venous drainage:
  - Venous drainage is by both the pterygoid and the pharyngeal plexus which further drains into the internal jugular vein.
- Lymphatic drainage:
  - Retropharyngeal lymph nodes
  - Upper deep cervical lymph nodes.

LARYNX:

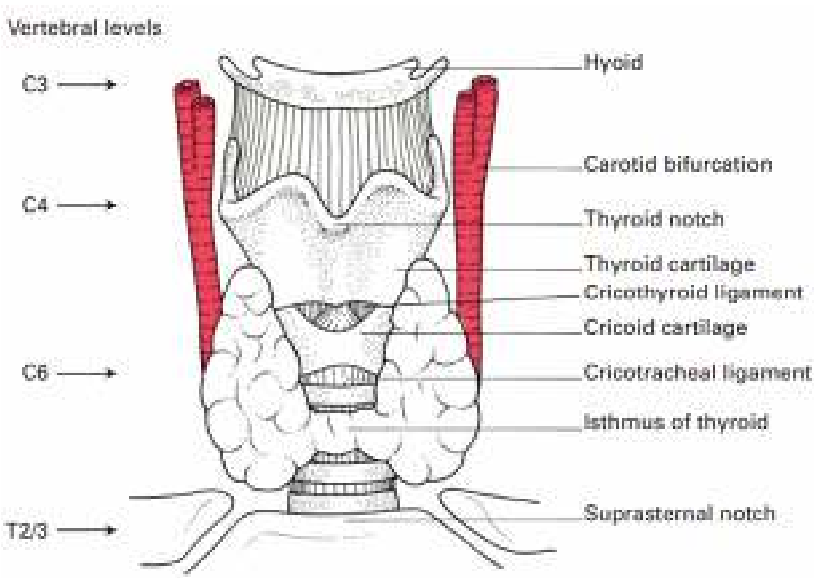


Figure 6: Anterior view of the larynx

The larynx is an air passage, a sphincter and an organ of phonation.

- Extension of larynx is from the tongue to the trachea.
- Superior: It forms the anterior wall of laryngo-pharynx.
- Inferior: Continues as trachea.
- Larynx moves on deglutition.
- It is present opposite to 3rd-6th cervical vertebrae in adult males and situated at higher level in children and adult females.

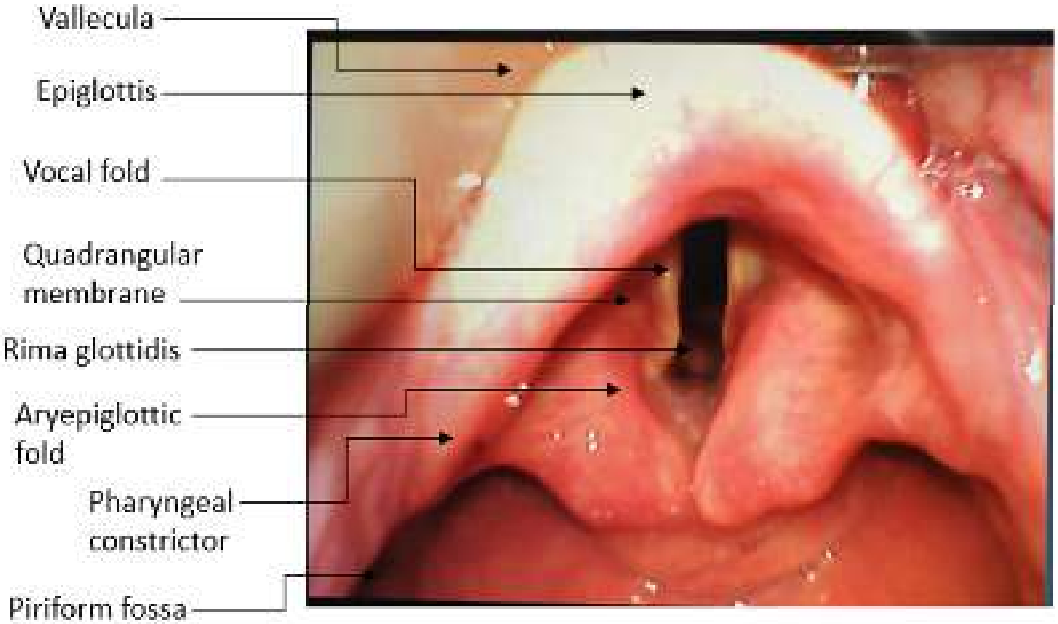


Figure 7: Interior view of the larynx - laryngoscopic view

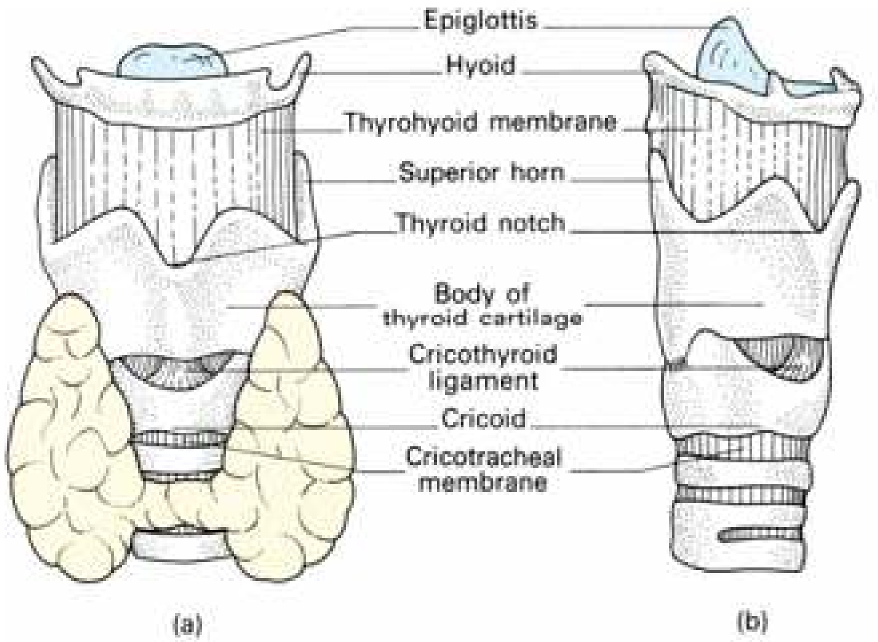


Figure 8: External views of the larynx: (a) anterior aspect; (b) anterolateral aspect with the thyroid gland and cricothyroid ligament removed.

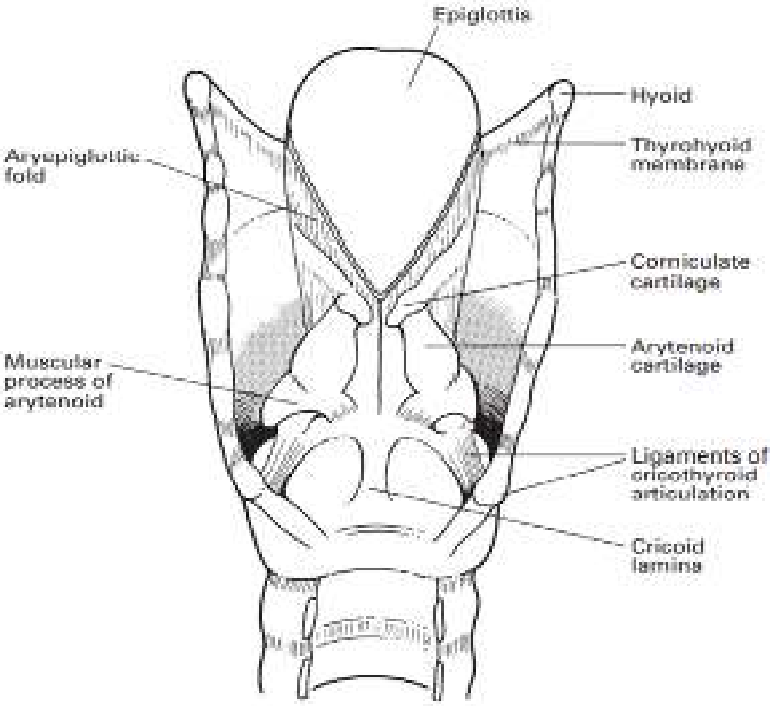
The laryngeal framework is formed by a set of cartilages connected to ligaments and fibrous membranes, and moved with help of numerous muscles. Cartilages:

Paired cartilages:

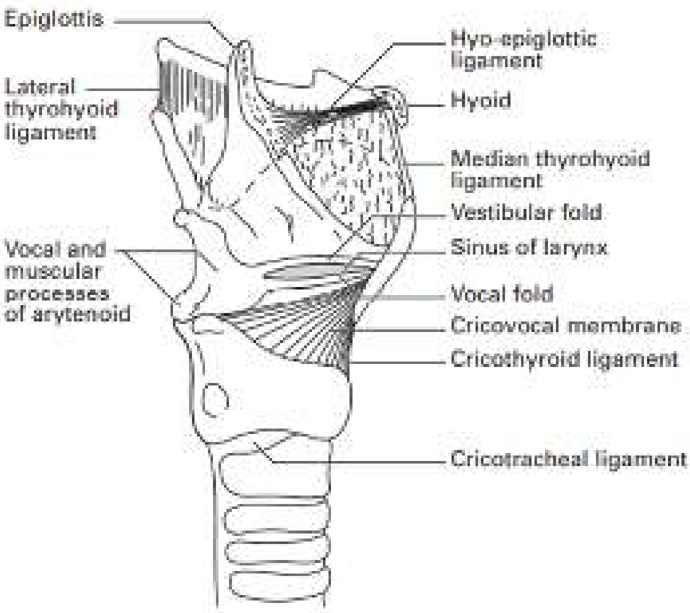
1. Arytenoid Cartilage
2. Corniculate Cartilage
3. Cuneiform Cartilage

Unpaired cartilages:

1. Epiglottis
2. Thyroid Cartilage
3. Cricoid Cartilage



a)



b)

Figure 9: The cartilages and ligaments of the larynx seen a) posteriorly, b) laterally.

Laryngeal joints

1. Cricothyroid joint
2. Cricoarytenoid joint

Laryngeal ligaments and membranes:

Extrinsic ligaments

1. Thyrohyoid membrane
2. Thyro and hyoepiglottic ligaments
3. Cricotracheal ligament

Intrinsic ligaments

1. Quadrate membrane
2. Cricothyroid membrane and conus elasticus.

Cavity of larynx

The larynx is divided into:

- Vestibule of larynx,
- Ventricle of the larynx and
- Infra-glottic part by the two mucous membrane folds.

Muscles of larynx

Intrinsic muscles of larynx

1. Oblique arytenoids and aryepiglotticus-sphincter action at the laryngeal inlet
2. Transverse arytenoids- Adductor of vocal cords
3. Posterior cricoarytenoid- Abductor of glottis
4. Lateral cricoarytenoid- Adducts the vocal cords
5. Cricothyroid - Elongates and tenses the vocal cords
6. Thyroarytenoid and vocalis- Relaxes the vocal cords
7. Thyroepiglotticus –Opens the inlet of the larynx.

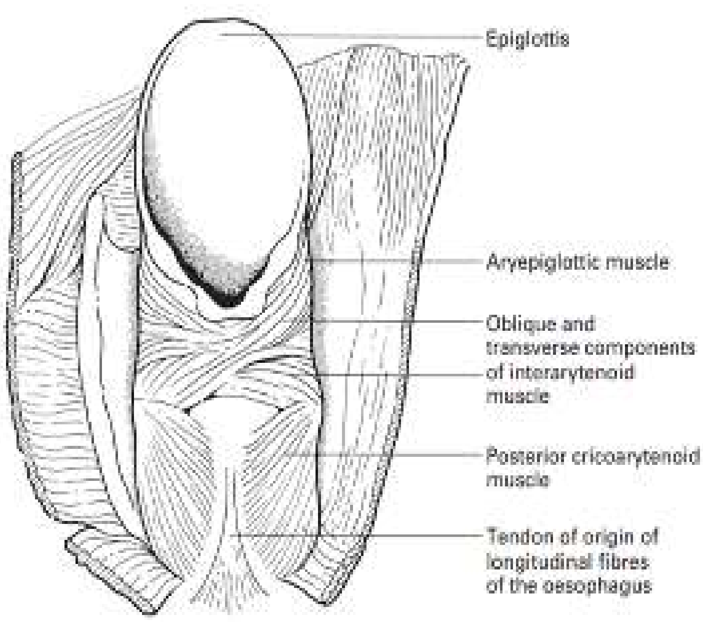


Figure 10: Intrinsic muscles of larynx

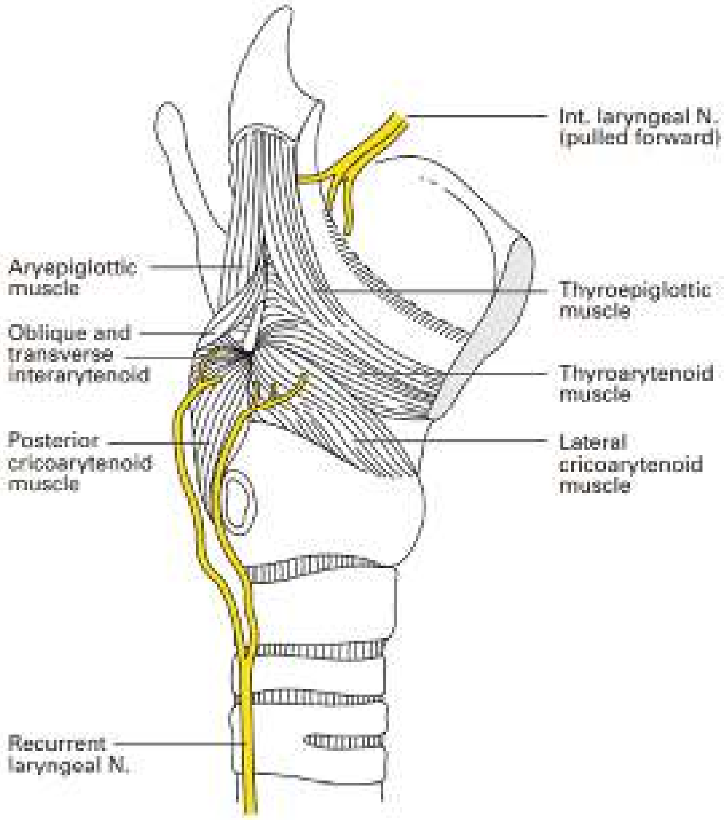


Figure 10 (a): The intrinsic muscles of the larynx, lateral view

Extrinsic muscles of larynx

1. Suprahyoid muscles:
    a. Stylohyoid.
    b. Digastric
    c. Mylohyoid
    d. Geniohyoid
2. Infrahyoid muscles:
    a. Sternohyoid
    b. Omohyoid
    c. Sternothyoid
    d. Thyrohyoid

- Nerve supply of larynx:
  - Motor supply- Vagus nerve via recurrent laryngeal nerve to all intrinsic muscles except cricothyroid (supplied by external laryngeal nerve)
  - Sensory supply- Mucosal membrane is supplied by internal laryngeal nerve upto the level of cords and below the vocal cord is supplied by recurrent laryngeal nerve.
- Arterial supply:
  - The larynx is supplied by the Superior and inferior laryngeal artery.
  - Cricothyroid artery also provides arterial supply to the larynx.
- Venous drainage:
  - Via superior and inferior laryngeal veins to superior and inferior thyroid veins respectively.
- Lymphatic drainage
  - The supraglottic part of the larynx is drained by lymph vessels into the upper deep cervical lymph nodes and the infraglottic part of larynx; lymph vessels reach pre and para tracheal lymph nodes and join the lower deep cervical lymph nodes

ULTRASONOGRAPHY(25,26,27,28,29):

Ultrasounds are acoustic waves characterized by a frequency above the threshold of human detection (above 20 000 Hz). In the field of medical imaging, frequencies ranging from 2 to 15 MHz are routinely used. US probes contain piezoelectric materials whose mechanical and electrical properties result in the production and transmission of sound waves, and their reception in the form of echoes from tissues.

According to the pattern of reflection of the received sound waves, which depends upon the different impedance of each tissue to ultrasound, the transducers recreate the shape and the internal structure of the explored organs. In the presence of different acoustic interfaces, the majority of echoes are derived from tissues shown as white and called hyperechoic. In the presence of few acoustic interfaces, echoes are formed much less; the structures appear black and are called hypoechoic. An inverse relationship exists between the US frequency and its ability to penetrate into tissues (e.g., low frequency and high penetration into tissues), and there is a direct relationship between frequency and potential image resolution.

When examining airways, superficial structures (2–3 cm below the skin) are visualized with 7.5 MHz linear probes, and deep structures with 5 MHz curved-array probes. Airways are mostly superficial structures, but their content of air prevents their deeper parts from being properly visualized. Similarly, the presence of air inside the filled cuff of an endotracheal tube makes its visualization impossible. Air is a weak conductor of US; at the tissue–air interface ultrasounds are reflected and artifacts created. For this reason, transducers with variable frequencies should be used, along with cross-beam imaging, in order to obtain images of good quality, or it may be necessary to adopt tricks to optimize the US reflection pattern, e.g., filling the cuff of an endotracheal tube with fluids (e.g., saline) or air bubbles, or visualizing the tube during its passage through the larynx.

Ultrasound waves in the frequency range of around 2 to 15 megahertz have a wide range of diagnostic and treatment purpose in the field of medicine. The ultrasonography works on the principle of Piezoelectric effect. This effect converts mechanical / kinetic energy into electrical energy by deformation of crystals. Piezoelectric effect can also be reversed i.e., by electrical energy the crystals can be oscillated to form ultrasound waves (mechanical energy).

The ultrasound transducer has the function of producing the ultrasound by the above said mechanism. This ultrasound produced travels through tissues and gets reflected back. The returned echo waves after reaching the transducer gets changed to electrical energy which is later processed and produce an image. The transducers work in a range of frequencies. Transducers with higher frequencies (5 – 7.5 MHz) are used in imaging superficial structures whereas the ones with lower frequencies (2.5 – 3.5 MHz) produce images of deeper structures.

It is on the surface that lies between tissues of varying density, the ultrasound gets reflected. If the difference in densities is higher, the sound waves that get reflected is also high and the opposite also holds true. Therefore, with very high difference of densities (bones, air, calculi) the sound will be completely reflected back. This produces the acoustic shadowing. If the tissues are homogenous in their densities, then echo-free images are seen (blood, urine, ascites).

Transducer:

This is the hand-held part of the ultrasound machine. It has the function of inter-converting the energies (electrical and mechanical) based on piezoelectric effect. They contain lead zirconate titanate crystals commonly.

It comprises 5 major components:

- Crystals: possessing piezoelectric property. Can be arranged in either linear or curvilinear manner.
- Electrodes: positive and ground. For electrical connection
- Damping block: to dampen stray sound waves.
- Matching layer: For proper transmission of sound waves to one or multiple tissues.
- Housing.

They produce the ultrasound waves in either linear (sequential) arrays or phased array.

Linear Transducer:

- The piezoelectric crystals – Linearly arranged
- Produce rectangular ultrasound beam
- Used for superficial imaging.
- Footprint – wide with frequency of 2.5 – 12MHz at the centre in 2D imaging probe and frequency 7.5 – 12 MHz at the centre in 3D imaging probe.

- Applications of linear probe in anaesthesia:
    - Airway assessment
    - Visualisation of superficial structures like Brachial plexus
    - Vascular access
    - Vascular examination
    - Ultrasonic velocity change imaging.

Figure 11: Ultrasound probes**;** (a) Linear array probe

Curvilinear Transducer:

- The Piezoelectric crystals – curvilinear arrangement.
- They produce convex ultrasound beam.
- Used to image deeper tissues.

- As depth of imaging increases, image resolution decreases.
- Foot print is wide with central frequency being, 2.5 – 7.5MHz for 2D imaging and 3.5 – 6.5MHz for 3D imaging.
- Applications of curvilinear probe in anaesthesia:
    - Deep nerve blocks
    - Abdominal examinations

Figure 11(b): Curved array probe

SONOANATOMY OF THE UPPER AIRWAYS

The hyoid bone is an important landmark for the sonoanatomy of the upper airways, which can be divided into two scanning planes called the suprahyoid and infrahyoid regions. The hyoid bone can be visualized in transverse, sagittal, and parasagittal scanning, as a superficial hyperechoic structure with a posterior acoustic shadow

Suprahyoid structures are studied using a curved, low-frequency probe in order to visualize deep structures in a wide field of view. The floor of the mouth is composed of muscles, mainly the mylohyoid, geniohyoid, and genioglossus muscles, going from the most superficial to deepest; they appear as hypoechoic curved stripes on a transverse view and as linear stripes on a sagittal view.

The tongue is attached to the deep muscles of the mouth floor and its dorsal border is characterized by a hyperechoic profile based on an air–mucosa (A–M) interface. The presence of the intrinsic muscles gives a striated appearance on US. Three-dimensional ultrasonography is helpful to study the tongue in detail.

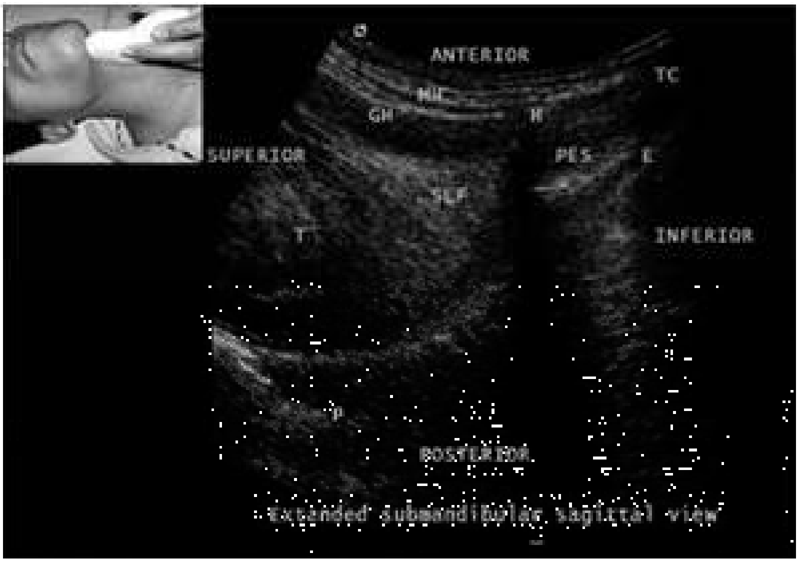


Figure 12: Submandibular sagittal view. E, epiglottis; GH, geniohyoid; H, hyoid; MH, mylohyoid; P, palate; PES, pre-epiglottic space; SLF, sublingual fossa; T, tongue; TC, thyroid cartilage. Note the A–M interface on the surface of the tongue.

The floor of the mouth and the tongue are easily visualized by placing the transducer submentally. If the transducer is placed in the coronal plane just posterior to the mentum and from there moved posteriorly until the hyoid bone is reached, one can perform a thorough evaluation of all the layers of the floor of the mouth, the muscles of the tongue, and any possible pathologic processes (Fig.13). The scanning image will be flanked by the acoustic shadow of the mandible on each side.

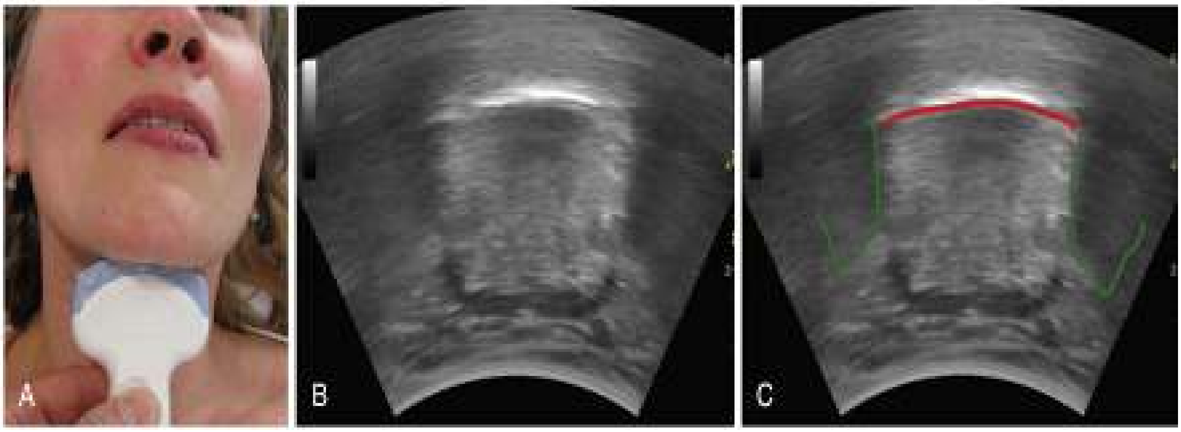


Figure 13: Transverse scan of the floor of the mouth and the tongue. (A) Placement of the transducer. (B) The resulting ultrasound image. (C) The dorsal surface of the tongue is indicated by a red line, and shadows arising from the mandible are outlined

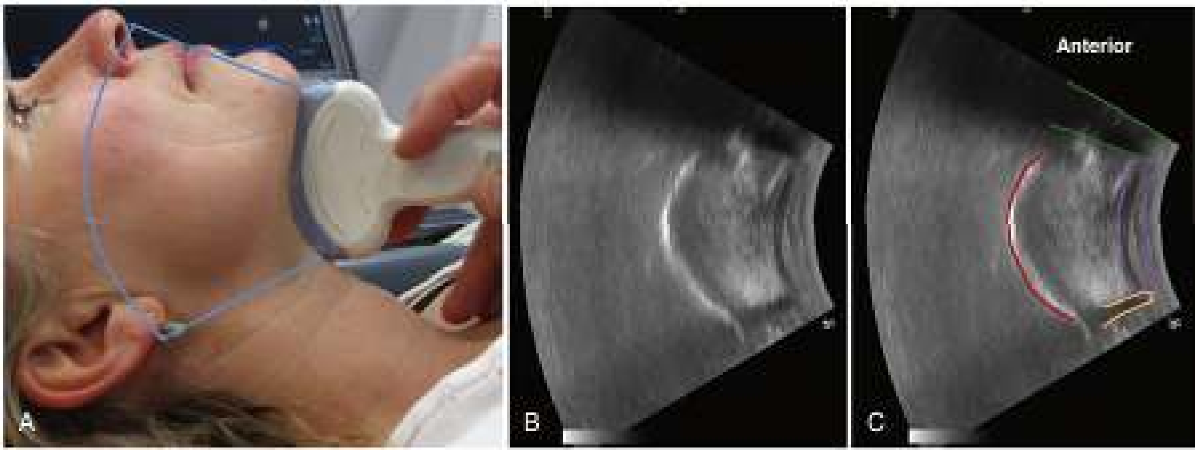


Figure 14: Longitudinal scan of the floor of the mouth and the tongue. (A) Placement of the curved low-frequency transducer. The area covered by the scan is outlined in light blue. (B) The resulting ultrasound image. (C) The shadow from the mentum of the mandible is outlined in green, the muscles in the floor of the mouth in purple, the shadow from the hyoid bone in yellow, and the dorsal surface of the tongue in red.

The palate can be visualized if the tongue is adherent to it; if not, it is not possible because of the presence of air. The presence of water in the mouth improves the visualization of the palate and could help to differentiate between the soft and hard palate.

The infrahyoid region can be studied using both low- and high-frequency probes. The thyrohyoid membrane provides a window for the visualization of the epiglottis, in both transverse and parasagittal views. Superior laryngeal nerves, passing through it, can be visualized as well.

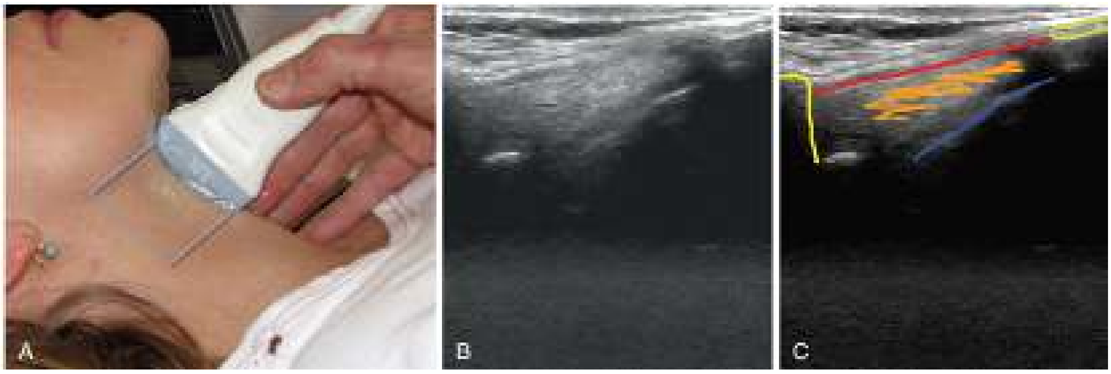


Figure 15: Midline sagittal scan from the hyoid bone to the proximal part of the thyroid cartilage. (A) The light blue outline shows the area covered by the scan. (B) The scanning image. (C) The shadow from the hyoid bone is marked in yellow, the thyrohyoid membrane in red, the posterior surface of part of the epiglottis in blue, the pre-epiglottic fat in orange, and the thyroid cartilage in green.

Figure 16: Cricothyroid membrane (CTM). (A) The linear high-frequency transducer is placed in the midsagittal plane. The scanning area is marked with light blue. (B) The scanning image. (C) The thyroid cartilage is marked in green, the cricoid

cartilage in dark blue, the tracheal rings in light blue, the CTM in red, the tissue-air border in orange, and the isthmus of the thyroid gland in brown.

The epiglottis appears as a curved, hypoechoic, and linear structure surrounded by a hyperechoic pre-epiglottic space anteriorly and a linear A–M interface posteriorly. The exposure of the tongue and swallowing improve the visualization of the epiglottis, as it moves away from the acoustic shadow of the hyoid bone.

The cartilages of the larynx and trachea generally appear hypoechoic; however, their US appearance may become hyperechoic due to calcification, variable in its extent over time. The thyroid cartilage is detectable either in the sagittal and parasagittal scan as a hypoechoic line with an A–M interface behind, or in the transverse scan as an inverted V with the false vocal cords in the middle.

Figure 17: Transverse US view of the larynx at the level of the vocal cords. Note the true vocal cords (hypoechoic) (arrow), the false ones (hyperechoic), strap muscles (M), and arytenoid (A) and thyroid (T) cartilages.

Vocal cords are best visualized through the window provided by the thyroid cartilage. If the thyroid cartilage is calcified, vocal cords can be visualized by combining two scans: one is performed cranial to the superior thyroid notch, and the other through the cricothyroid membrane, both in the midline and in each part of it, keeping the probe angled cranially at 30 degrees. The true vocal cords appear as two hypoechoic triangles, with the hyperechoic vocal ligaments medial and in the same plane; the false vocal cords appear hyperechoic and are superior to the true ones, and appear fixed during phonation

Tracheal rings appear hypoechoic and present an A–M interface and reverberation artifacts on the posterior surface. They have the shape of a “string of beads” in both sagittal and parasagittal views, and a U-shape in the transverse view. The esophagus should be identified posterior and lateral to the trachea, at the height of the suprasternal notch in a transverse view. The visualization can be improved by swallowing, due to the detection of peristalsis and by positioning the neck slightly flexed and turned 45 degrees, performing the exam on the opposite side.

	Suprahyoid region	**Infrahyoid region**
US probe	Low frequency: deep structures	High and low frequency: superficial and deep structures
Anatomic structures	Muscles of mouth floor, tongue, palate, oropharynx, hyoid bone	Epiglottis, cartilages of larynx and trachea, vocal cords, thyrohyoid and cricothyroid membranes, hyoid bone
Diameters measurable by US	Tongue thickness Distance to posterior surface of the tongue Thickness of submental region Hyomental distance Depth of epiglottis above hyoid Thickness of soft tissues at the level of hyoid bone Pre-epiglottic space	Thyrohyoid distance Depth of epiglottis below hyoid Depth of arytenoids from the skin Thickness of fat pad at the thyroid cartilage Thickness of fat pad at the vocal cords Thickness of fat pad at the thyrohyoid membrane Distance between epiglottis and vocal cords Subglottic diameter

Table 2: Correlation between sonoanatomy and US-based morphometric diameters

MATERIALS AND METHODS

STUDY DESIGN: A One Year Hospital Based Prospective Observational study

STUDY PERIOD: One year (January 2020 – December 2020)

PLACE: "Department of Anaesthesiology, KLE'S Dr. Prabhakar Kore Hospital and Medical Research Centre, KAHER, Belagavi".

SOURCE OF DATA: Adult patients between age group of 18-60 years, undergoing elective surgery under general anaesthesia with laryngoscopy and endotracheal intubation at KLE'S Dr. Prabhakar Kore Hospital and Medical Research Centre, Nehru Nagar, Belagavi -10.

SAMPLE SIZE: A total of 60 patients.

SAMPLING PROCEDURE: Sample size was calculated using the results of previous similar studies and substituting them in the formula as below:

$$n = \frac{(z_\alpha + z_\beta)^2 (s_1^2 + s_2^2)}{(\overline{X}_1 - \overline{X}_2)^2}$$

where z_α was linked with the level of significance and z_β was linked with the power of the test.

For 5% level of the significance z_α =1.96 and z_β =0.84 for 80% power of the test.

$\overline{X}_1$ was the mean of the first group (0.25) and $\overline{X}_2$ was the mean of the second group (0.35). s_1 is the standard deviation of the first group (0.11) and s_2 is the standard deviation of the second group (0.18).

With these values the sample size obtained is 35. To make the study more confirmative, the sample size was raised to 60.

Inclusion Criteria:

- ASA physical status I and II
- Age above 18 – 60 years of either gender
- Patients undergoing non-emergency surgeries under GA with laryngoscopy and endotracheal intubation.

Exclusion Criteria:

- Uncooperative patients.
- Patients having deviations in normal head and neck anatomy that might result in erroneous ultrasound airway assessment.
- Patients with inter incisor gap of <3 cm
- Patients who are disoriented and with alerted consciousness
- Patients requiring rapid sequence intubation.
- Patients having pathology of cervical spine.
- Patients undergoing fibre optic intubation.
- Edentulous patients or those with artificial dentures.

Ethical Clearance:

The approval by the institutional Ethical and Research Committee, Jawaharlal Nehru Medical College, Belagavi, was taken before starting the study.

Informed Consent:

All the patients who fulfilled the selection criteria were explained about the nature of the study and intervention being done. A written informed consent was obtained from all patients before enrolment in their vernacular language.

Method of Collection of Data:

After countenance by ethical committee and after getting informed consent, a prospective, observational study was done on patients of the age group of 18-60 years; both male and female, with the American Society of Anaesthesiologists status I/II and patients who underwent scheduled elective surgery and exacting general anaesthesia with direct laryngoscopy and endotracheal intubation.

The conventional airway assessments like mouth opening, assessment of modified Mallampatti scoring, measuring TMD and neck movements were recorded during the preanesthetic appraisal. The participants who met the inclusion criteria underwent ultrasonographic evaluation of airway by the incharge anaesthesiologists in the preop recovery.

On the day of surgery, intravenous route was acquired using appropriate iv cannula and iv fluids were started. In the preoperative holding area, the ultra-sonographic assessment of the patients was done with them lying in supine position together with dynamic maximal head-tilt/chin lift. The high-frequency linear probe (SonoSite Turbo) was positioned in the midline in the submandibular area. Keeping the probe in the same location, the linear disposition of the probe was rotated in the transverse planes from cephalad to caudal, until the epiglottis and posterior aspect of vocal folds with arytenoids are visualized concomitantly on screen.

Thenceforth, ensuing assessments were attained with the oblique&transverse USG images of the airway after freezing the screen:

a) **Pre-E**
b) **E-VC**

Figure 18: Linear probe to measure the Pre-E/E-VC

Furthermore, to discern the hyomental distances the curved low-frequency transducer was used and were assessed from upper limit of hyoid bone to the lower limit of mentum in the head neutral and extended positions, respectively. The **HMDR** was calculated.

With patient in sniffing position, the space between skin and anterior part of trachea at vocal cords level was measured as the anterior neck soft tissue thickness **(ANS-VC)**.

Figure 19: Ultrasound assessment of parameters A) distance from epiglottis to midpoint of vocal cords; B) pre-epiglottic space; C) anterior neck soft tissue thickness at the level of vocal cords.

Figure 20: Curviliner probe to measure HMDR

In the operation theatre, standard monitoring devices were affixed before induction of anaesthesia, inclusive of non-invasive blood pressure, heart rate, ECG leads and oxygen saturation probe.

Patients were premedicated with Inj. Glycopyrrolate 0.005mg/kg and Inj. Midazolam 0.05mg/kg and Inj. Fentanyl 2mcg/kg and pre-oxygenated with 100% oxygen for 3 mins. General anaesthesia was induced with Inj. Propofol 2mg/kg. Neuromuscular blockade was achieved with inj. Succinyl-choline 2 mg/kg.

Direct laryngoscopy was executed using Mac-blade of either 3 (for female) or 4(for males) size. Suitable sized ETT was introduced without any external laryngeal manoeuvring. Intubation was allocated as easy (CL Grade 1 and 2) or difficult (CL Grade 3 and 4). The number of attempts for intubation, need for other difficult intubation approaches or failure to secure the airway were also noted. After verifying bilateral equal air-entry, endo- tracheal tube was fixed with tapes at apt length and patients were mechanically ventilated.

Anaesthesia was maintained with oxygen:nitrous oxide (40:60), isoflurane and muscle relaxants (Inj. Vecuronium 0.08 mg/kg – 0.1 mg/kg). At the termination of the operation, patients were shifted to recovery after adequate reversal of neuromuscular blockade with Inj. Glycopyrrolate 0.01 mg/kg and Inj. Neostigmine 0.05 mg/kg and extubation after thorough suctioning.

STATISTICAL ANALYSIS:

The present study was of observational type, so the plan of analysis was as follows.

For the continuous quantitative variables, mean and standard deviation was calculated. For the purpose of comparison if the data was divided into two groups with respect to certain qualitative characteristic, the continuous variables were compared using suitable tools of statistics like student's unpaired t test. Discrete variables were represented by median. The categorical data was expressed in terms of rates, ratios and percentages. The association between the outcome, clinical and demographic characteristics were tested using Chi-square test.

Nonparametric tests were used for the discrete variables. Apart from the above, suitable tools like ANOVA, correlation, regression etc., were used according to the need.

Suitable graphs were used to depict the comparison.

For all the tests, the value of p less than 5% (0.05) was considered significant.

RESULTS

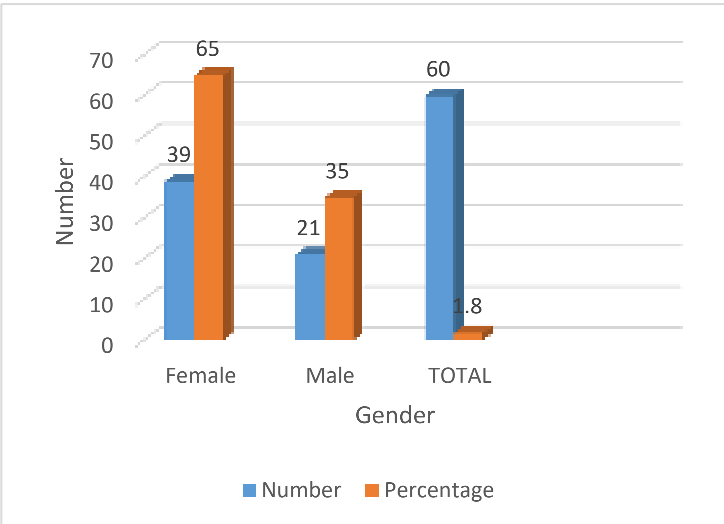
A total of 60 ASA I & II adult patients, between the age group of 18-60 years posted for elective surgery under general anaesthesia alongwith muscle relaxation and endotracheal intubation were incorporated in this study.

Various demographic data, ultrasound airway parameters and CL grading were noted down and corelated.

Data obtained was coded and entered into Microsoft excel spread sheet. The data was analysed using various tests like ANOVA for quantitative data, chi square test and Pearson's correlation and results obtained were tabulated as below

Table 3: Gender distribution

GENDER	NUMBER	PERCENTAGE
FEMALE	39	65.00
MALE	21	35.00
TOTAL	60	100.00

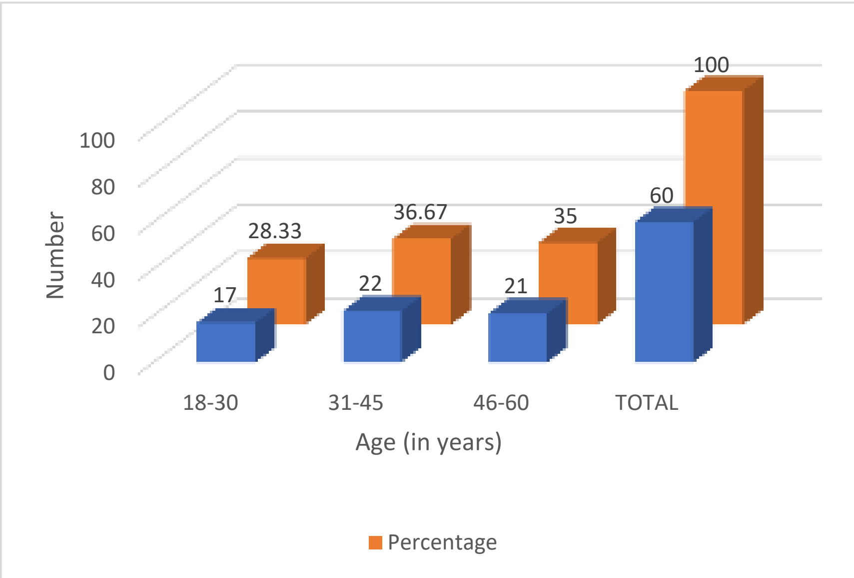


Graph 1: Gender distribution

65% of population in the sample are females and rest are males.

Table 4: Age distribution

AGE (in years)	Number	Percentage
18-30	17	28.33%
31-45	22	36.67%
46-60	21	35%
TOTAL	60	100%



Graph 2: Age distribution

Out of the 60 patients, distribution of age groups was comparable. Mean age was found to be 40.12 years with standard deviation 13.50

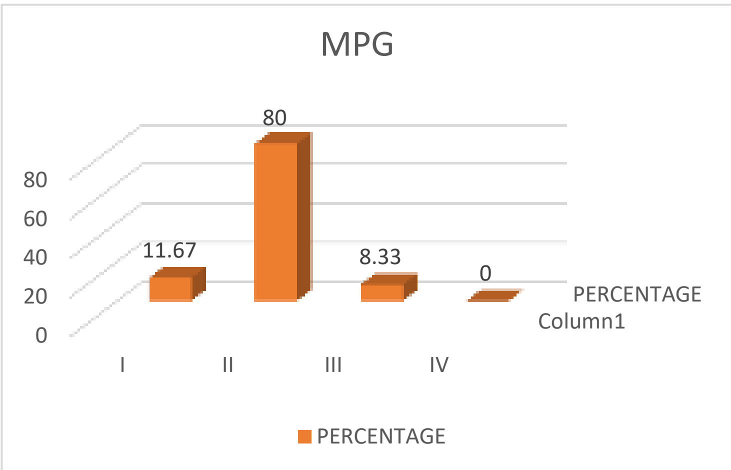
Table 5: ASA distribution

ASA	NUMBER	PERCENTAGE
I	44	73.33
II	16	26.67
TOTAL	60	100.00

73% of population in the sample belonged to ASA physical status I

Table 6: MPG distribution

MPG	NUMBER	PERCENTAGE
I	07	11.67
II	48	80.00
III	05	08.33
IV	00	00.00
TOTAL	60	100.00

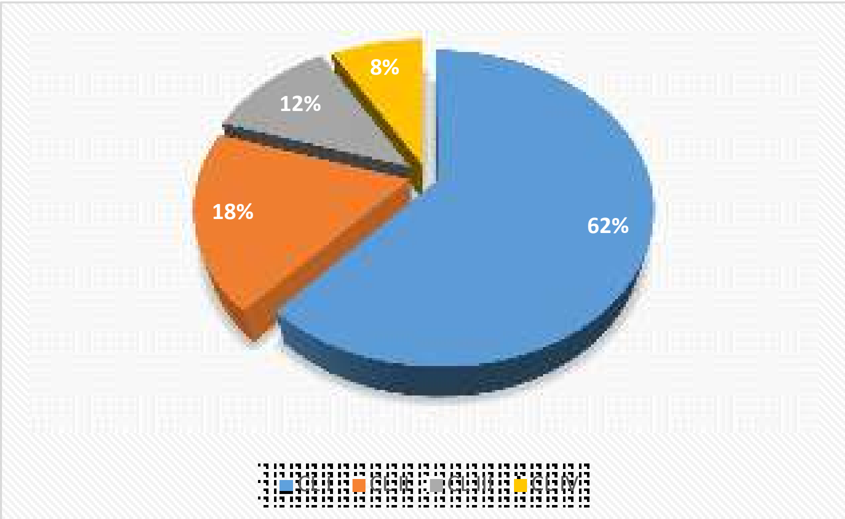


Graph 3: Patient Distribution according to MPG

Out of 60 patients, 80% belonged to MPG II

Table 7: CL Grade distribution

CL GRADE	NUMBER	PERCENTAGE
I	37	61.67
II	11	18.33
III	7	11.67
IV	5	8.33
TOTAL	60	100.00



Graph 4: Patient distribution in relation to CL grading

61.67% of population in the sample belonged to CL grade I

Table 8. Analysis of ASA grading and CL grade

	ASA		
CL GRADE	**I**	**II**	**TOTAL**
I	30	7	37
II	8	3	11
III	4	3	7
IV	2	3	5
TOTAL	**44**	**16**	**60**

The p value using chi-square test is 0.1780 (NS)

There is no association between the CL grades and the levels of ASA.

Table 9: Distribution of MPG in CL grades

	MPG			
CL GRADE	**I**	**II**	**III**	**TOTAL**
I	2	30	5	37
II	2	9	0	11
III	1	6	0	7
IV	2	3	0	5
TOTAL	**7**	48	5	60

The p value using chi-square test is 0.2023 which was not significant.

There is no association between the CL grades and the levels of MPG.

Table 10: Statistical analysis of demographic data & USG parameters of airway
.

	MEAN	S.D.	MINIMUM	MAXIMUM
AGE	40.12	13.50	18	60
BMI	24.34	3.58	16.5	32.5
Pre-E/E-VC	1.14	0.51	0.29	3.1
HDMR	0.96	0.11	0.77	1.22
ANS-VC (cm)	0.51	0.14	0.28	0.98

As per the analysis, the mean age of our sample population was 40.12 years with standard deviation 13.50 and the mean BMI was 24.34kg/m^2.

The mean values of Pre-E/E-VC ratio was 1.14 with standard deviation of 0.51; for HMDR it was 0.96 with standard deviation of 0.11 and for ANS-VC it was 0.51 with standard deviation of 0.14.

ANALYSIS WITH RESPECT TO CL GRADES

In the following table p value is calculated using one way analysis of variance (ANOVA)

NS - Not Significant S - Significant

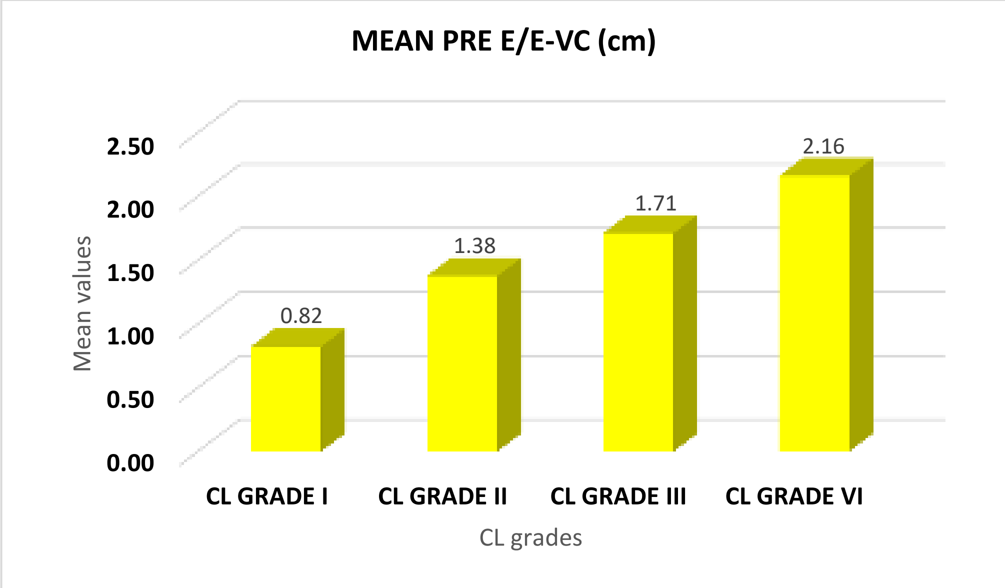
VS – Very Significant HS - Highly Significant

Table 11: Analysis of various parameters with respect to CL grade

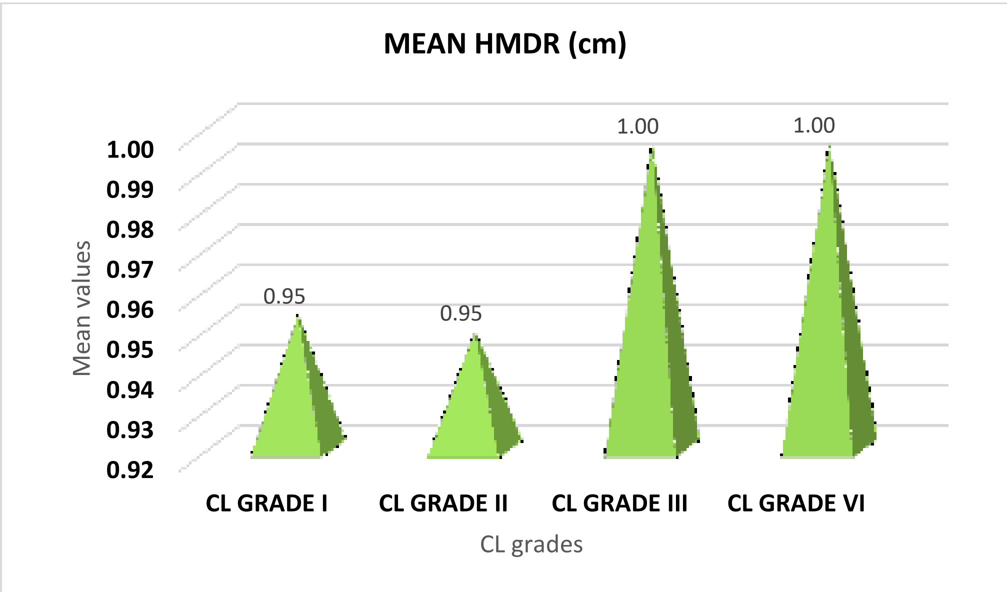
	I				II			
	MEAN	**S.D.**	**MINIMUM**	**MAXIMUM**	**MEAN**	**S.D.**	**MINIMUM**	**MAXIMUM**
BMI (kg/m2)	24.72	3.89	16.5	32.5	22.56	2.52	19.5	27.5
Pre-E/E-VC	0.82	0.25	0.29	1.23	1.38	0.12	1.23	1.54
HMDR	0.95	0.10	0.77	1.22	0.95	0.10	0.8	1.09
ANC-VC (cm)	0.50	0.12	0.29	0.74	0.52	0.17	0.28	0.98

	III				IV			
	MEAN	**S.D.**	**MINIMUM**	**MAXIMUM**	**MEAN**	**S.D.**	**MINIMUM**	**MAXIMUM**
BMI (kg/m2)	26.51	2.54	21.5	29.1	22.39	2.22	19.53	25.2
Pre-E/E-VC	1.71	0.12	1.55	1.87	2.16	0.53	1.91	3.1
HMDR	1.00	0.12	0.86	1.16	1.00	0.14	0.83	1.14
ANC-VC (cm)	0.56	0.20	0.4	0.9	0.55	0.19	0.34	0.71

Using ANOVA, the mean of four CL grades are compared for homogeneity of means in the groups.



Graph 5: Mean Pre-E/E-VC



Graph 6: Mean HMDR (cm)

Table 12: Inference of the analysis

	p VALUE	**INFERENCE**
BMI (kg/m2)	0.0620	NS
PreE/E-VC	0.0000	HS
HMDR	0.6684	NS
ANC-VC (cm)	0.6550	NS

Pearson's correlation coefficients between CL grades and the other parameters

p values are calculated using student t distribution

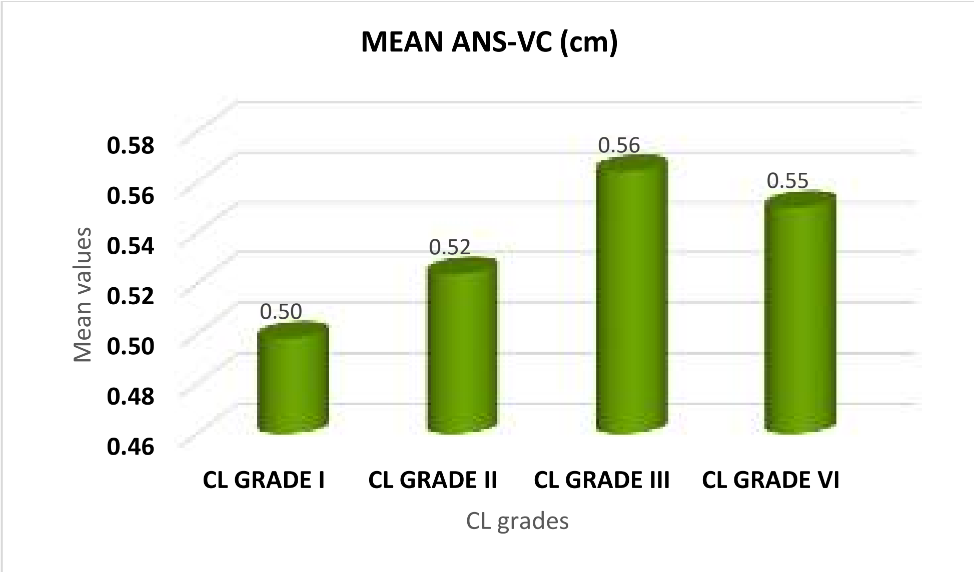
Table 13: Inference of the analysis

	r VALUE	**p VALUE**	**INFERENCE**
Pre-E/E-VC	0.8712	<0.0001	HS
HMDR	0.1416	0.2805	NS
ANS-VC (cm)	0.1574	0.2298	NS

With respect to the CL grades, Pre-E/E-VC has highest correlation coefficient with correlation coefficient of 0.8712 and p value of <0.0001.

Whereas, the HMDR and ANS-VC showed no linear correlation.

Hence, among the ultrasound parameters, the Pre-E/E-VC was highly convincing in comparison with Cormack Lehane grading.

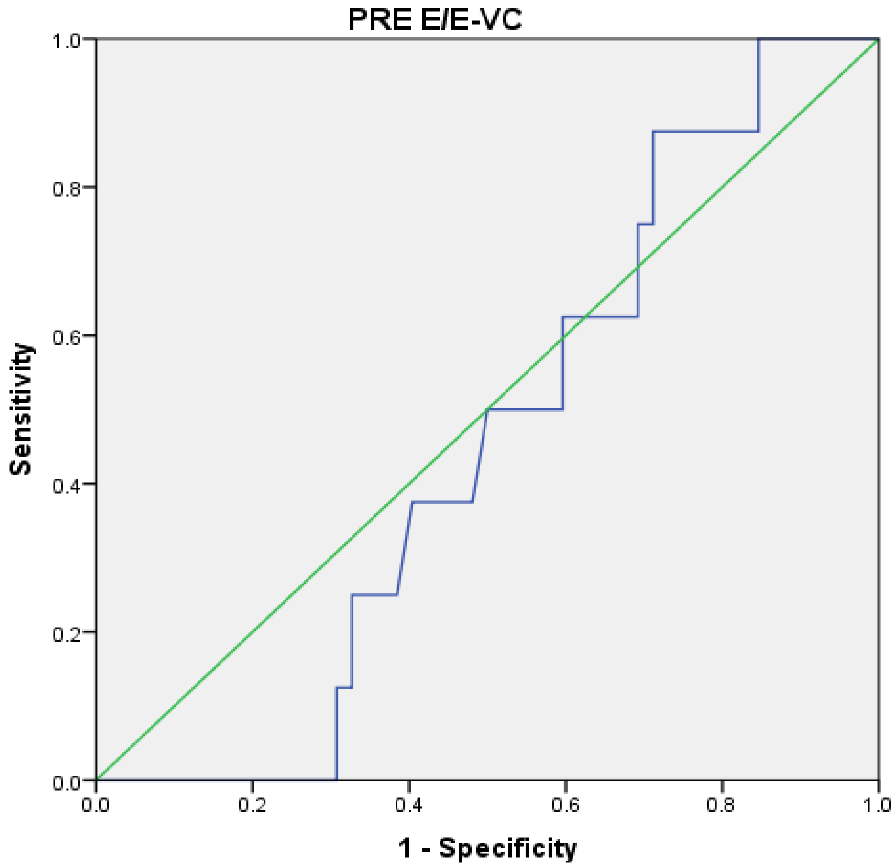


Graph 7: Mean ANS-VC

Sensitivity analysis for difficult intubation

Table 14: For PRE-E/E-VC > 1.24:

SENSITIVITY	91.67%
SPECIFICITY	41.67%
POSITIVE PREDICTIVE VALUE	86.27%
NEGATIVE PREDICTIVE VALUE	55.56%
DIAGNOSTIC ACCURACY	81.67%



Graph 8: Relative operating characteristics curve for Pre-E/E-VC

Area under the curve is 0.4542

According to the sensitivity analysis, the ratio of Pre-E/E-VC was found to be highly significant and had a sensitivity of 91.67% and diagnostic accuracy of 81.67%.

DISCUSSION

Airway assessment, care and its management is a vital skill for anaesthesiologists. Maintaining a patent airway requires the ability of the person's lungs to deliver to the nearby tissues with oxygen to prevent hypoxia and related adverse effects. Failure in maintaining the same has been identified as a serious patient safety care.

As the consequences of unexpected difficult airway might be life-threatening, a procedure for extensive pre-operative airway examination has become a necessary pre-requisite.

Vijayalakshmi Patil proposed that evaluating anatomical factors in the neck and head have a role in the presence of difficult airway in the 1980s, and the approach was born. Around the same time, Seshagiri Rao Mallampatti2 MD proposed a hypothesis based on the structures seen inside the oropharynx when the patient's mouth is open wide and tongue protrudes out to forecast difficult airway build-up.

Since then, several other clinical markers of difficult airway have been investigated, including the inter-incisor gap, sternomental distances, neck mobility, and so on. Radiographic markers such as an X-ray neck lateral view to examine the distance from the C1 spine to the occiput, the length of the mandible, and the depth of the mandibular space followed this trend. Several advanced predictors, such as the Flow Volume Loop, Acoustic Response measurement, flexible bronchoscope, and airway assessment utilising ultrasound, have been developed in recent years.

The research and techniques involved in anaesthesia and related procedures have gained visibility in recent years, particularly with the help of ultrasonography. It is a safe, non-intrusive, and real-time imaging aid whose utility is being evaluated by anaesthesiologists in numerous sectors in the present period.

In this study the usefulness of ultrasonograph in identifying a difficult airway scenario was examined. Main adversity faced was the difficulty in imaging , anatomical airway structures. The reason for this is because these structures were only lightly set and filled with air, resulting in a high acoustic impedance and poor image quality.

The viability of employing an ultrasonograph for airway assessment was investigated by Prasad et al. They compared airway measures taken by ultrasonography and computed tomography in the supra-hyoid and infra-hyoid regions. They came to the conclusion that the measurements taken in the United States were comparable to those obtained from a CT scan. However, the Infra-hyoid region was revealed to be more significant than the Supra-hyoid region.[30]

We evaluated the usefulness of ultrasonography in predicting difficult airway by measuring the ratio Pre-E/E-VC, HMDR, and ANS-VC and their association to the CL Grade for this study, which was conducted in an Indian population.

We enrolled a total of 60 ASA 1 and 2 patients aged 18-60 years, posted for elective surgeries under general anaesthesia and endotracheal intubation

Among the patients enrolled, there were 39 females accounting for 65% of the total population and 21 male patients accounting for 35% of the same.

The mean BMI of the patients was 24.34±3.58 kg/m^2 while the mean age was 40.12±13.50 yrs.

In our study 73.33% of patients were of ASA grade I and 26.67% were of grade II.

In the study, 11.67% of patients were of MPG I, 80% had MPG II and 8.33% were of MPG III category.

When observed for the ratio of Pre epiglottic space and the distance from the epiglottis to the midpoint between the vocal cords (Pre-E/E-VC), it was found to have a p value of <0.0001 which was highly significant and sensitivity of 91.67% as was observed in a similar study by Koundal etal, where the cut-off for Pre-E/E-VC was ≥1.785 with sensitivity of 82.8% and specificity of 83.8% which was comparable.[17]

In a similar study by Gupta etal depicted that assessment of CL grade can be sufficiently done with the help of ratio of Pre-E/E-VC with 67-68% sensitivity and strong positive correlation with regression coefficient of 0.495.[8]

In another study by Rana et al., the Pre-E/E-VC ratio was found to be 1.33 0.335 and 1.62 0.264 for CL Grade I&II, respectively, and 1.87 0.243, 2.22 0.29 for CL Grade III&IV[15], whereas in our study, the values were 0.82 0.25, 1.38 0.12, 1.71 0.12, and 2.16 0.53 for CL Grade I,II,III&IV, respectively. For predicting difficult airway, the cut-off values for this ratio were 3.1, with a sensitivity of 91.67 percent and a diagnostic accuracy of 81.67 percent, according to our findings.[15]

In 2016, Reddy et al. found that the mean for Pre-E/E-VC was 1.09 0.38, 1.28 0.37 for CL Grade 1 and 2, and 1.29 0.44 for CL Grade 3. However, they did not come across any CL grade 4 patients during their research.[33]

Visualization of the glottis as assessed by CL grading during laryngoscopy depends on several factors, including the extension of the head at the atlanto-occipital and atlanto-axial joints.

Huh *et al.,* stated that the values of HMDR can be a reliable indicator for difficult intubation. In their study HMDR alone had the highest predictive value for difficult laryngoscopy with cut-off point of 1.2 at which this measure had a sensitivity of 88%. However, in our study the value for HMDR did not vary much for the

Cormack Lehane gradings with it sensitivity being only 62.51%. the p value obtained made it not so significant for diagnosing difficult airway.[32]

In another study, Wojtczak et al found that the "mean hyomental distance in the neutral position did not differ significantly between the two groups: 51.3 ±5.3 mm (difficult intubation) versus 57.5 ±4.3 mm (easy intubation), though the difference in the mean hyomental distance in the head-extended position, 52.6 ±5.8 mm (difficult intubation) versus 65.5 ±4.1 mm (easy intubation)[7], but in our study we observed that the mean hyomental distance ratio in CL I and II was 0.95±0.10 whereas it was 1.00±0.12 and 1.00±0.14 in CL III and IV respectively. It did not differ significantly in our study.

In the study conducted by Rana *et al* in 2018, the range of HMDR is 1.085–1.21 and 1.02–1.15 in the easy and difficult laryngoscopy, respectively (P = 0.00). The difference in the range of values can be due to the different patient profiles and strata. US measurement of HMDR has moderate predictive value in predicting easy and difficult laryngoscopy. However, it was not helpful in predicting CL grade 1 or 2, as the cutoff value was more than 1.085 for both gradings. These observations were similar to what we observed in this study where the range of HMDR in CL grades I and II were between 0.77-1.22 and 0.80-1.09 respectively and 0.86-1.16 and 0.83-1.14 in grades III and IV respectively. It had diagnostic accuracy of only 61% demonstrating that ultrasonographic measurement of HMDR is not as significant.[15]

We also studied ANS-VC and found that this parameter had low diagnostic accuracy as compare to the other parameters. The mean values of ANS-VC were 0.50±0.12 and 0.52±0.17 for the CL grades I and II respectively and 0.56±0.20 and 0.55±0.19 for grades III and IV respectively. There was not much difference in the range of this parameter observed in our study population.

In a study by Komatsu *et al*, patients with difficult laryngoscopy had thinner neck soft tissue thickness at the level of vocal cords (20.4±3.0 vs 22.3±3.8mm; P=0.049). Despite the fact that the difference was minor (1.9mm), it was unlikely to be clinically significant. As a result, there appeared to be no correlation between anterior soft tissue thickness and CL grade. Similarly in our study the anterior neck soft tissue thickness at the level of vocal cords did not vary much in all the Cormack Lehane groups and was not a good predictor of difficult laryngoscopy and intubation.[34]

In a similar study conducted in a Middle Eastern population, physicians discovered that the presence of pre-tracheal soft tissue in both easy and difficult laryngoscopic groups was unrelated. They studied that patients with difficult laryngoscopy had a larger neck circumference [50 (3.8) cm] than patients with easy laryngoscopy [43.5 (2.2) cm]; P < 0.001). The difficult laryngoscopy patients also had much more soft tissue in zone 1 [(28 (2.7) mm] (where zone 1 is the distance from the skin to the anterior aspect of the trachea at the level of vocal cords) than did patients with easy laryngoscopy [17.5 (1.8) mm, P < 0.001]. According to their study zone 1 soft tissue appears to be the best predictor of a difficult laryngoscopy.[31]

In a study by Reddy et al., they found that the ANS-VC is a good tool for assessing difficult airway and that a depth of greater than 0.23cm is a good predictor of difficult airway.[33]

Wu *et al.,* studied that in Chinese population they found that the amount of soft tissue in the neck was higher in the difficult laryngoscopy group, i.e. CL grades III and IV, and there was a significant correlation. Furthermore, the anterior neck soft tissue ranges for individuals who had a difficult laryngoscopy were mutually exclusive with those who had an easy laryngoscopy, demonstrating that they are independent predictors of difficult laryngoscopy..[10]

LIMITATIONS:

Sample size in our study was small with a majority of female subjects and hence extrapolation of this study to general population may not lead to appropriate inferences.

Also, the participants with expected difficult airway were excluded from our study and their addition would've enhanced the outcome. This would've validated the use of ultrasonography in routine assessment of the airway and supported our hypothesis

Future research is needed to determine the exact value of these sonographically determined variables that correlate with a difficult laryngoscopy.

CONCLUSION

The study, which was undertaken for evaluating the usefulness of ultrasonogram to predict difficult airway pre-operatively, deciphered that,

1) US is a reliable instrument to anticipate difficult-airway in the pre-operative area by measuring the ratio of pre-epiglottic depth to epiglottis to midpoint of vocal cords, HMDR and ANS thickness at the level of vocal cords.
2) Among the ultrasound parameters, Pre-E/E-VC ratio was highly significant in association to CL grading.
3) A cutoff value of 1.55 for the ratio of Pre-E/E-VC entirely outlined the difficult (CL 3&4) and easy intubation (CL 1&2).
4) There was no noteworthy association between the clinical assessment and CL grading.
5) Among the demographic variables, there was not much significance when compared with difficult intubation.

Hence, point-of-care ultrasound should be included more in the pre-operative evaluation of a patient to predict with accuracy, the presence of difficult airway and intubation.

SUMMARY

Our present study was aimed to know the efficacy of the various ultrasound airway assessment measures to predict difficult airway like ratio of Pre-E/E-VC, the HMDR and ANS-VC and to associate the obtained parameters with the CL grade to predict difficult laryngoscopy and intubation.

The current study was carried out to compare the utility of US in assessing the airway to know potential difficulties that may arise during intubation. Adult 60 patients of ASA I and II, of either gender between the age group of 18-60 years, who were posted for elective surgery requiring general anaesthesia with direct laryngoscopy followed by endo-tracheal intubation, were involved.

In this study, the analysis with respect to Cormack Lehane grade showed the ratio of Pre-E/E-VC was more significant than the other ultrasound parameters in the pre operative time to assess difficult airway with a p value of <0.0001.

To summarise our study, results suggest that it is feasible to integrate ultrasound into an airway assessment and the same could be applied for evaluating the airway prior to surgery as an easy and inexpensive modality. In our study, the highest sensitivity was shown by Pre-E/E-VC ratio.

BIBLIOGRAPHY

1. Peterson GN, Domino KB, Caplan RA, Posner KL, Lee LA, Cheney FW, et al. Management of the difficult airway: A closed claims analysis. Anesthesiology 2005; 103:33-9.
2. Sharma, S., Mehta, N., & Charak, D.S. (2015). Comparative evaluation of airway assessment tests and their correlation with laryngoscopy. Indian Journal of Clinical Anaesthesia, 2015;2,19-26.
3. Arne J, Descoins P, Fusciardi J, Ingrand P, Ferrier B, Boudigues D et al. Preoperative assessment for difficult intubation in general and ENT surgery: predictive value of a clinical multivariate risk index. Br J Anaesth 1998;80:140-6
4. Osman A, Sum KM. Role of upper airway ultrasound in airway management. J Intensive Care. 2016 Aug 15;4:52. https://dx.doi.org/10.1186%2Fs40560-016-0174-z.
5. Kristensen M.S. (2011), Ultrasonography and the airway. Acta Anaesthesiol Scand, 55: 1155-1173. https://doi.org/10.1111/j.1399-6576.2011.02518.x
6. Adhikari S, Zeger W, Schmier C, Crum T, Craven A, Frrokaj I, Pang H, Shostrom V. Pilot study to determine the utility of point-of-care ultrasound in the assessment of difficult laryngoscopy. Acad Emerg Med. 2011 Jul;18(7):754-8. doi: 10.1111/j.1553-2712.2011.01099.x. Epub 2011 Jun 27. PMID: 21707828
7. Wojtczak JA. Submandibular sonography: assessment of hyomental distances and ratio, tongue size, and floor of the mouth musculature using portable sonography. J Ultrasound Med. 2012 Apr;31(4):523-8. doi: 10.7863/jum.2012.31.4.523.
8. Gupta D, Srirajakalidindi A, Ittiara B, Apple L, Toshniwal G, Haber H. Ultrasonographic modification of Cormack Lehane classification for pre-anesthetic airway assessment. Middle East J Anaesthesiol. 2012 Oct;21(6):835-42.

9. Hui CM, Tsui BC. Sublingual ultrasound as an assessment method for predicting difficult intubation: a pilot study. Anaesthesia. 2014 Apr;69(4):314-9. doi: 10.1111/anae.12598.

10. Wu J, Dong J, Ding Y, Zheng J. Role of anterior neck soft tissue quantifications by ultrasound in predicting difficult laryngoscopy. Medical Science Monitor : International Medical Journal of Experimental and Clinical Research. 2014 Nov;20:2343-2350. DOI: 10.12659/msm.891037.

11. Sharma S, Mehta N, D.s.charak, comparative evaluation of airway assessment tests and their correlation with laryngoscopy. Indian J Clin Anaesth 2015;2(1):19-26

12. Kalezić N, Lakićević M, Miličić B, Stojanović M, Sabljak V, Marković D. Hyomental distance in the different head positions and hyomental distance ratio in predicting difficult intubation. Bosn J Basic Med Sci. 2016 Aug 2;16(3):232-6. doi: 10.17305/bjbms.2016.1217.

13. Parameswari A, Govind M, Vakamudi M. Correlation between preoperative ultrasonographic airway assessment and laryngoscopic view in adult patients: A prospective study. J Anaesthesiol Clin Pharmacol 2017;33:353-8. doi 10.4103/joacp.JOACP_166_17

14. Petrisor C, Szabo R, Constantinescu C, Prie A, Hagau N. Ultrasound-based assessment of hyomental distances in neutral, ramped, and maximum hyperextended positions, and derived ratios, for the prediction of difficult airway in the obese population: a pilot diagnostic accuracy study. Anaesthesiol Intensive Ther. 2018;50(2):110-116. doi: 10.5603/AIT.2018.0017.

15. Rana S, Verma V, Bhandari S, Sharma S, Koundal V, Chaudhary SK. Point-of-care ultrasound in the airway assessment: A correlation of ultrasonography-guided

parameters to the Cormack–Lehane Classification. Saudi J Anaesth 2018;12:292-6.

16. Falcetta, S., Cavallo S., Gabbanelli V., Pelaia P., Sorbello M., Zdravkovic I., Donati A. Evaluation of two neck ultrasound measurements as predictors of difficult direct laryngoscopy. European Journal of Anaesthesiology.2018;35(8):605-612. doi: 10.1097/EJA.0000000000000832
17. Koundal V, Rana S, Thakur R, Chauhan V, Ekke S, Kumar M. The usefulness of point of care ultrasound (POCUS) in preanaesthetic airway assessment. Indian J Anaesth. 2019 Dec;63(12):1022-1028. doi: 10.4103/ija.IJA_492_19. Epub 2019 Dec 11. PMID: 31879427; PMCID: PMC6921326.
18. Yadav NK, Rudingwa P, Mishra SK, Pannerselvam S. Ultrasound measurement of anterior neck soft tissue and tongue thickness to predict difficult laryngoscopy - An observational analytical study. Indian J Anaesth. 2019 Aug;63(8):629-634. doi: 10.4103/ija.IJA_270_19.
19. J. Kanoujiya, A. Sancheti, S. Swami, Prediction of difficult laryngoscopy by ultrasound guided valuation of anterior neck soft tissue thickness, IJAR 7 (2) 2019 Feb;242e255.
20. Hagberg CA. Benumof and Hagberg's Airway Management: Third Edition. Elsevier Inc., 2012. 1141 p. https://doi.org/10.1016/B978-1-4377-2764-7.00057-9Mete, A., & Akbudak, İ. H. (2018). Functional Anatomy and Physiology of Airway. Tracheal Intubation. doi:10.5772/intechopen.77037
21. Williams PL, Warwick R, Dyson M, Bannister LH. Gray’s anatomy. 37th Ed. New york: Churchill Livingstone; 1989.
22. Netter F, Hansen J. Atlas of human anatomy. 3rd Ed. Teterboro, N J: Icon Learning Systems;2003.

23. Ellis H, Feldman S. Anatomy for Anaesthetists. 5th Ed., Oxford: Blackwell Scientific Publications Ltd; 1988.

24. Mete, A., & Akbudak, İ. H. (2018). *Functional Anatomy and Physiology of Airway. Tracheal Intubation.* doi:10.5772/intechopen.77037

25. Kundra P, Mishre SK, Ramesh A. Ultrasound of the airway. Indian J Anaesth 2011:55:456-62.

26. Gupta PK, Gupta K, Dwivedi AD, Jain Manish. Potential role of ultrasound in anaesthesia and intensive care. Anesth Essays Res 2011;5:11-9.

27. Loveday E. The larynx. In : Ahuja AT, Evans RM, editors. Practical Head and Neck Ultrasound. 1st ed. London: Greenwich medical media limited; 2000. P. 105-17.

28. In: Iro H, Bozzato A, Zenk J, editors. Atlas of Head and Neck Ultrasound. New York: Thieme medical publishers; 2013. 142

29. Wong K.T., Ahuja A.T. Benign Thyroid Conditions. In: Sofferman R., Ahuja A.(eds) Ultrasound of the Thyroid and Parathyroid Glands. Springer, New York, NY.2012 https://doi.org/10.1007/978-1-4614-0974-8_5

30. Prasad A., Singh M., & Chan V. Ultrasound imaging of the airway. Canadian Journal of Anesthesia/Journal canadien d'anesthésie, 2009;56(11):868-870.

31. Ezri T, Gewürtz G, Sessler DI, Medalion B, Szmuk P, Hagberg C, Susmallian S. Prediction of difficult laryngoscopy in obese patients by ultrasound quantification of anterior neck soft tissue. Anaesthesia. 2003 Nov;58(11):1111-4. doi: 10.1046/j.1365-2044.2003.03412.x.

32. Huh J, Shin HY, Kim SH, Yoon TK, Kim DK. Diagnostic predictor of difficult laryngoscopy: the hyomental distance ratio. Anesth Analg. 2009 Feb;108(2):544-8. doi: 10.1213/ane.0b013e31818fc347. PMID: 19151285.

33. Reddy PB, Punetha P, Chalam KS. Ultrasonography - A viable tool for airway assessment. Indian J Anaesth. 2016 Nov;60(11):807-813. doi: 10.4103/0019-5049.193660. PMID: 27942053; PMCID: PMC5125183.

34. Komatsu R, Sengupta P, Wadhwa A, Akça O, Sessler DI, Ezri T, Lenhardt R. Ultrasound quantification of anterior soft tissue thickness fails to predict difficult laryngoscopy in obese patients. Anaesth Intensive Care. 2007 Feb;35(1):32-7. doi: 10.1177/0310057X0703500104. PMID: 17323663.

ANNEXURE I. ETHICAL CLEARANCE.

K.L.E. ACADEMY OF HIGHER EDUCATION AND RESEARCH
(Deemed – to-be-University)
Accredited 'A' Grade by NAAC (2nd Cycle)   Placed in Category 'A' by MHRD (GoI)

JAWAHARLAL NEHRU MEDICAL COLLEGE,
NEHRU NAGAR, BELAGAVI-590010 (KARNATAKA-INDIA)

Website: http//www.jnmc.edu
E-Mail : dome@jnmc.edu

Phone: (+91-(0)831 Office : 2472550
Principal: 2471701
Fax No. +91 (0)831 – 2470759

Ref: MDC/DOME/ 176   **Date: 24/12/2019**

To,
REG NO. BA0119001
PG student in Anaesthesiology,
J.N.Medical College,
BELAGAVI.

Sub: Institutional Ethical Clearance for the study.

With reference to the above, we wish to inform you that your proposed research project titled **"CORRELATION OF ULTRASOUND GUIDED AIRWAY PARAMETERS TO THE CORMACK-LEHANE GRADING – A ONE YEAR HOSPITAL BASED PROSPECTIVE OBSERVATIONAL STUDY"**, is ethical and justifiable. The proposed research project has been cleared by the JNMC Institutional Ethics Committee on Human Subjects Research.

(Dr. Anita Dalal)
Member Secretary
JNMC Institutional Ethics Committee
on Human Subjects Research,
J.N.Medical College, Belagavi.

(Dr. Roopa M Bellad)
Chairman,
JNMC Institutional Ethics Committee
on Human Subjects Research,
J.N.Medical College, Belagavi.

43

ANNEXURE II

INFORMED CONSENT

CONSENT FOR PARTICIPATION IN RESEARCH STUDY

Mr/Mrs/Miss. ______________________________ we are requesting you to enrol yourself in study titled **"CORRELATION OF ULTRASOUND GUIDED AIRWAY PARAMETERS TO THE CORMACK-LEHANE GRADING - A ONE YEAR HOSPITAL BASED PROSPECTIVE OBSERVATIONAL STUDY"** conducted by **REG NO. BA0119001,** Post Graduate in M.D. Anaesthesiology under the guidance of Dr. _____________ M.D., Professor, in Department of Anaesthesiology, J.N. Medical College, Belagavi under KAHER, Belagavi.

Respected Sir/Madam We request you to participate in our study as you are eligible for participating in the study. During the study you will be asked some questions regarding your present complaint and you are supposed to answer to the best of your knowledge.

Your participation in this research is voluntary. Your decision whether or not to participate in the study will not affect your relationship with J.N.Medical College. If you decide to participate you are free to withdraw at any time.

Purpose of the study: The purpose of research is to assess the uitility of ultrasound in predicting difficult intubation in various cases undergoing general anaesthesia and to correlate its finding with Cormack Lehane classification during direct laryngoscopy.

Procedure Involved: If you agree to enroll in my study, I will ask you present, past and family history. Then you will be clinically examined in detail. Ultrasonographic examination will be done before undergoing the surgery and the findings will be noted. You will then be taken up for proposed surgery and routine anaesthesia will be given. While doing direct laryngoscopy Cormack-Lehane grading will be noted and tracheal intubation will be performed.

Risks: There is almost no risk involved in ultrasonographic examination.

Benefits: Ultrasonographic measurement of parameters (like Pre-E/E-VC) has high potential to predict difficult intubation. It has high sensitivity when compared to other physical parameters.

Voluntary Participation/Withdrawal: Taking part in the study is voluntary. You may choose not to enroll yourself in this study. Your decision will not change present or future health care services offered to you or your ward at K.L.E. S Hospital & MRC.

Alternatives: Even if you decline the participation in the study, you will get the routine line of management.

Privacy and Confidentiality: The only people to know that you are a research subject is you and the members of the research team. No information provided by you during the research will be disclosed to other without your written permission except:

1. In emergency to protect your rights and welfare.
2. If required by law.

Authorization to Publish Results: When the results of the research are published or discussed, in a conference, no information will be displayed that would disclose your identity. Any information that is obtained in connection with this study and that can be identified with your identity will remain confidential.

Financial Incentives for participation: No financial incentives are being offered to enrolled patients. It is purely being done with the idea of research and all the cost of the study will be borne by the investigator.

Compensation: In the event of injury related to the study, treatment will be made available through KLES Hospital and MRC, Belagavi. There is no compensation or payment for such medical treatment by law. If you get injured you may contact **REG NO. BA0119001**, Post Graduate at Department of Anaesthesiology, KLES Hospital and MRC.

Questions: In case you have any questions related to the study, in future or in case of study related injury or illness, you can contact **REG NO. BA0119001,** Post Graduate, Department of Anaesthesiology, KLES Hospital and MRC, Belagavi. Dr. ____________ M.D., Professor, Department of Anaesthesiology, KLES Hospital and MRC. If you have any queries about your rights as a study subject, you may call Dr. Harsha Hegde, Chairperson, JNMC, IEC & SCIENTIST, ICMR, National Institute of Traditional Medicine, Belagavi-10.

INFORMED CONSENT FOR PARTICIPATION IN RESEARCH TRIAL

"CORRELATION OF ULTRASOUND GUIDED AIRWAY PARAMETERS TO THE CORMACK-LEHANE GRADING - A ONE YEAR HOSPITAL BASED PROSPECTIVE OBSERVATIONAL STUDY"

I, Mr/Ms/Mrs ________________________________ voluntarily agree for the participation of as a subject of study. By signing this consent form I am not giving up any of my legal rights, I may withdraw from the study anytime. I am signing the consent form after having read or been read for me in vernacular language, including the risks and the benefits and having all my questions answered.

Subject Name   Guardian Name

Subject signature/Left thumb print   Guardian signature/Left thumb print

Date: _____________

Witness Name: ____________________________ Signature: _______________

Investigators Name: _______________________ Signature: _______________

Date: _______________   Place: _______________

ANNEXURE III

PROFORMA

NAME: **AGE:** **SEX:**
ASA STATUS: **IP NO.:** **DATE:**

PREANAESTHETIC EVALUATION:

Chief Complaints:

Past History:

Family History:

General Physical Examination:

Weight: Temperature: Pallor:

Height: Cyanosis: Pedal Oedema:

Clubbing:

BMI: Pulse: BP: RR:

Systemic examination:

CVS: CNS:

RS: PA:

Airway Assessment:

Mouth Opening:

Teeth:

Jaw Movements:

Mallampati Grading:

CLASS	STRUCTURES VISIBLE	PATIENT'S CLASS
I	Soft palate, fauces, uvula, pillars	
II	Soft palate, fauces, uvula	
III	Soft palate, base of uvula	
IV	Soft palate not visible	

Neck Movement

Neck movement	Yes	No
Inability to extend and flex neck >90’		

Thyromental Distance

DISTANCE	LARYNGOSCOPY, INTUBATION	PATIENT’S VALUE
>6.5cm	No problem with laryngoscopy and intubation	
6 – 6.5cm	Without other concomitant anatomical problems, laryngoscopy and intubation are difficult but possible	
<6cm	Laryngoscopy may be impossible	

Sternomental Distance

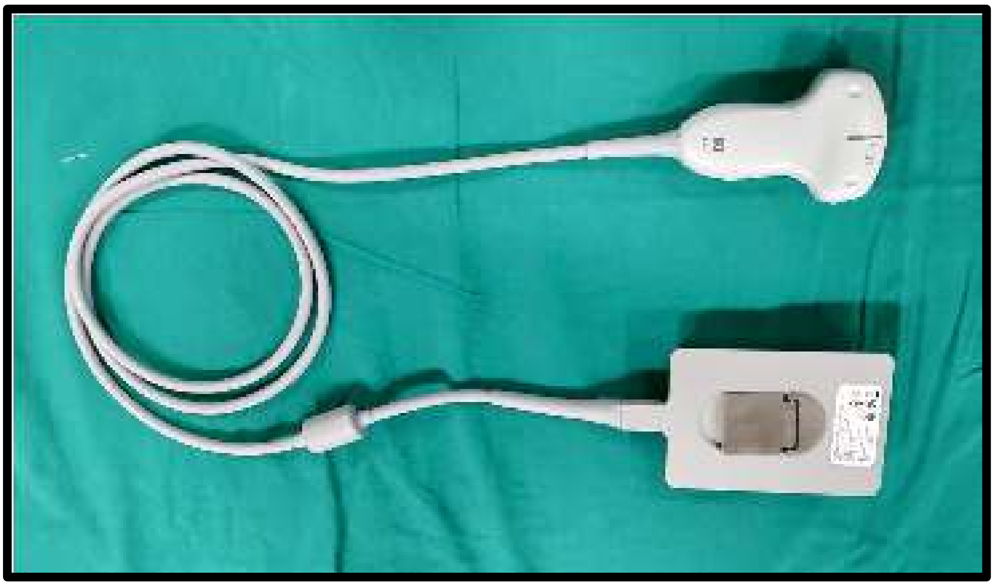
Modified *Cormack-Lehane* Classification

ULTRASOUND FINDINGS

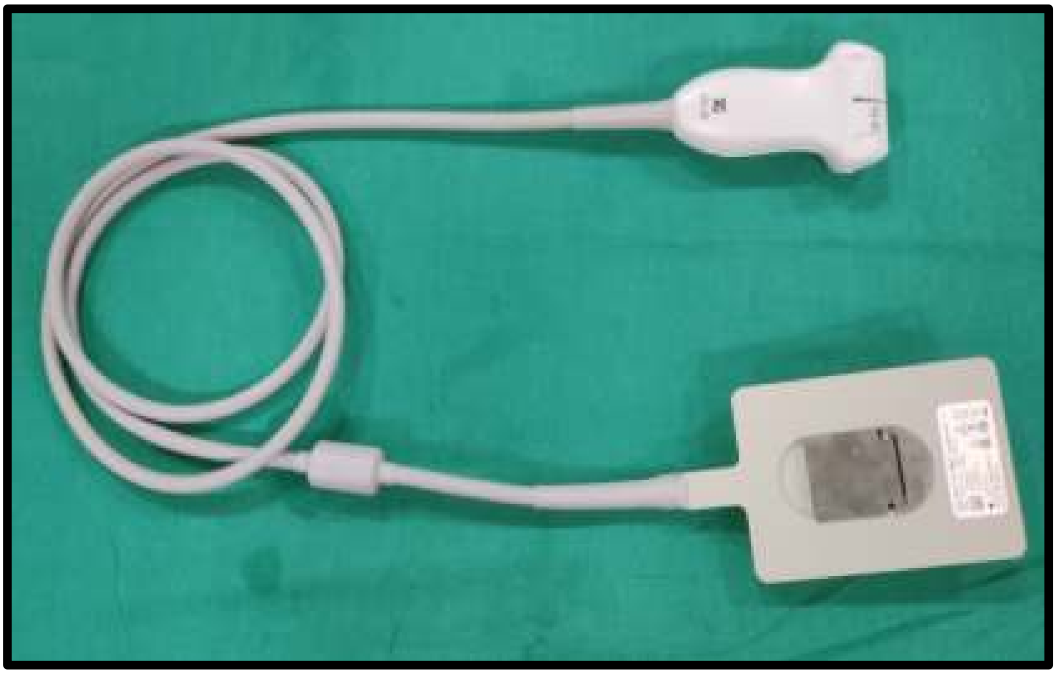
PARAMETERS	FINDINGS
Depth of pre-epiglottic space	
Distance between the epiglottis and the midway between the vocal cord	
The ratio between the pre epiglottic space and the distance between the epiglottis and the midpoint between the vocal cord	
Hyomental distance ratio (HMDR)	
Anterior neck soft tissue thickness at the level of vocal cords (ANS-VC)	

ANNEXURE IV - PHOTOGRAPHS

Photograph 1: SonoSite Ultrasound Machine



Photoograph 2: SonoSite US: Curvilinear probe



Photograph 3: SonoSIte US: Linear probe

Photograph 4: US image: A) distance from epiglottis to midpoint of vocal cords; B) pre-epiglottic space; C) anterior neck soft tissue thickness at the level of vocal cords.

Photograph 5: US image: Hyomental distance in head extended position

Photograph 6: US image: Hyomental distance in head neutral position

ANNEXURE V- KEY TO MASTERCHART

ANS-VC	-	Anterior Neck Soft tissue thickness at the level of Vocal cords
ASA	-	American Society of Anaesthesiologists
BMI	-	Body Mass Index
CL	-	Cormack Lehane
cm	-	centimetre
HMDR	-	Hyomental Distance Ratio
kg/m^2	-	kilograms per meter square
MPG	-	Modified Mallampatti Grading
Pre-E/E-VC	-	Ratio of pre-epiglottic space to distance from epiglottis to mid-point of vocal cords
SMD	-	Sternomental Distance
TMD	-	Thyromental Distance
yrs	-	years

ANNEXURE VI- MASTERCHART

Sl no	IP No	Age in yrs	Sex	ASA	BMI (kg/m2)	MPG	Pre-E/E-VC	HMDR	ANC-VC (cm)	TMD (cm)	SMD (cm)	CL Grade
1	995794	19	Male	I	20.2	II	1.54	1.05	0.55	7	15	II
2	995296	32	Female	I	20.8	II	0.55	0.99	0.29	6.8	14	II
3	1013123	20	Male	I	21.8	II	1.15	0.88	0.43	6.8	13	III
4	1014387	40	Female	I	24.9	II	0.7	1.07	0.53	8	15	II
5	1014502	26	Female	I	20.2	II	0.46	1.12	0.74	7.2	14.6	II
6	1014533	60	Female	II	29.61	II	0.29	1.09	0.56	6.8	16	II
7	1014229	60	Male	I	24.91	II	0.53	0.91	0.46	7.4	13.8	III
8	1015201	54	Female	II	29.38	II	0.86	0.93	0.72	8	14	II
9	1014291	60	Male	II	26.2	II	0.43	0.92	0.5	7	15	II
10	1015506	30	Male	I	20.8	II	1.2	1.06	0.45	6	13	III
11	1015426	52	Female	II	19.53	II	1.93	1.14	0.71	6	12.5	III
12	1015146	23	Female	I	20.8	II	1.2	0.77	0.48	8	15	II
13	1015894	34	Female	I	21.5	I	1.55	1.16	0.4	7.6	14.2	I
14	1016301	37	Female	I	26.4	II	0.88	0.92	0.44	8	15	II
15	1015981	31	Male	I	21.3	II	1.01	0.94	0.5	7	13	III
16	1015874	34	Male	II	22.5	II	1.23	1.07	0.57	8	17	II
17	1017028	48	Female	I	24.8	II	0.9	0.88	0.67	7.5	14	I
18	1016525	18	Female	I	23.3	II	1.02	0.95	0.59	7.8	15.2	I
19	1017362	59	Female	I	28.8	II	1.87	0.94	0.4	10	14	II
20	1017462	39	Female	I	20.2	II	1.5	0.92	0.49	9	15	II
21	1017541	37	Female	I	26.7	II	1.83	0.86	0.8	8	14.8	II
22	1018286	20	Female	I	25.2	I	1.91	0.87	0.68	8.5	15	I
23	1019679	57	Female	I	29.1	II	1.55	1.12	0.9	9	14.2	III
24	1019690	60	Female	II	22	II	3.1	1.09	0.68	9	15	III
25	1019483	34	Female	I	32.5	II	0.98	0.9	0.57	8.1	14.3	I
26	1020515	45	Male	II	30.1	II	0.47	1.1	0.54	8	14	II
27	1020283	35	Female	I	21.3	I	1.93	0.83	0.34	8.2	14	II
28	1020612	25	Male	I	25.7	II	1.38	0.88	0.52	8	14.6	II
29	1020872	35	Male	I	22.8	II	0.66	0.86	0.5	7.4	15	II
30	1021296	25	Male	I	20.8	II	0.68	1.1	0.44	7.8	14.6	II
31	1021987	19	Male	I	23.9	II	1.47	1.02	0.43	8.4	14.4	II
32	1021823	30	Male	I	24.1	II	1.25	1.09	0.45	7.4	14	II
33	1021578	50	Male	I	20.3	II	0.73	1.08	0.44	8.2	14.3	II
34	1015459	44	Female	I	30.4	III	0.93	0.88	0.68	7.4	13	II
35	1026403	47	Male	I	19.5	I	1.4	0.88	0.28	7.8	13.8	I
36	1026658	38	Female	I	22	II	1.27	0.8	0.44	8	12.5	I
37	1026967	29	Male	I	16.5	II	0.63	0.95	0.35	9	14.6	II
38	1026876	60	Female	I	29.4	II	0.78	0.92	0.38	7.4	13	II
39	1027312	58	Female	II	27.5	II	1.74	0.96	0.55	7	14	I
40	1028874	30	Female	I	20.6	I	1.51	0.98	0.98	9	16	I

41	1029072	38	Female	I	25.7	II	1.74	1.07	0.45	10	15	II
42	1029102	32	Female	I	29.1	II	0.6	0.81	0.62	7.2	13.8	III
43	1029126	46	Female	I	27.5	II	1.34	0.83	0.45	8.2	15	II
44	1029923	60	Male	I	20.8	III	0.72	0.89	0.34	9	15	III
45	1029945	39	Male	I	21.5	II	0.77	0.9	0.65	7	13	IV
46	1029693	60	Male	II	26.6	III	0.8	0.9	0.6	7	12.5	IV
47	1029894	39	Female	II	25.4	II	1.12	0.91	0.4	8	13	III
48	1030788	22	Female	I	26.2	II	0.95	0.86	0.31	7	14	I
49	1031285	53	Male	II	26.1	II	1.09	0.78	0.46	8	14.2	II
50	1031571	57	Female	II	20.57	II	0.46	1.22	0.5	7.5	10.5	III
51	1031806	43	Female	II	24	III	1.23	1.09	0.6	8	13	II
52	1032695	30	Female	I	23.4	I	0.71	0.95	0.41	8	15	I
53	1032761	44	Female	I	27.9	II	0.71	0.82	0.41	8	13.5	II
54	1034002	60	Female	I	23.9	II	1.93	1.05	0.34	8	15	II
55	1034687	20	Female	I	22	II	1.25	0.92	0.6	8	14	II
56	1035347	44	Female	II	32	II	1.04	1.07	0.63	10	15	II
57	1035788	20	Female	I	21.1	I	0.92	0.96	0.34	7	14.5	I
58	1036817	52	Female	II	26.3	II	1.7	0.86	0.45	7	14	II
59	1036183	41	Female	I	24.9	II	1.16	0.93	0.4	6.5	13.5	III
60	1036718	53	Male	II	27.1	III	1.12	0.96	0.5	7.2	14.3	III