COMPARISON OF UPPER AIRWAY ULTRASONOGRAPHY WITH END TIDAL CAPNOGRAPHY FOR CONFIRMATION OF ENDOTRACHEAL TUBE PLACEMENT IN PATIENTS REQUIRING GENERAL ANESTHESIA

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ABBREVIATIONS

ETT – Endotracheal tube

ETCO2 – End-tidal capnography

USG – Ultrasonography

A – Amplitude mode

B – Brightness mode

M – Motion mode

CO2 – Carbon dioxide

Paco2 – Partial pressure of carbon dioxide

Petco2 – Patient end tidal carbon dioxide

ASA – American society of anaesthesiologists

CBC – Complete blood cell count

RBS – Random blood sugar

ECG – Electrocardiogram

HIV – Human immunovirus

HbsAg – Hepatitis B antigen

IV – Intravenous

P – ‘p’ value

GA – General anaesthesia

BMI – Body mass index

SD – Standard deviation

ABSTRACT

BACKGROUND & AIMS

ETCO2 has been the recommended method for confirmation of endotracheal intubation but it has its own disadvantages such as inaccuracy and unreliability in different pathophysiological conditions. Hence our study aimed to compare upper airway USG and ETCO2 for the confirmation of endotracheal tube location in patients undergoing general anaesthesia since upper airway USG has an advantage of being quicker and reliable than ETCO2.

METHODS

In this prospective randomized clinical trial, 150 patients with ASA I and II requiring endotracheal intubation for surgeries under general anaesthesia, were enrolled and randomized into either of the two groups Group U– upper airway USG and Group E-ETCO2. Patient was intubated under general anaesthesia and endotracheal tube location confirmation was done by upper airway USG in U group by placing a linear transducer on the anterior part of the neck over the suprasternal notch and looking for two hyper echoic parallel lines if it is tracheal intubation and reverberation effect and distended oesophagus in case of oesophageal intubation. In E group confirmation of ETT location was done by ETCO2 more than or equal to 4mm hg after more than or equal to 5 breaths and detection of characteristic CO2 waveform. The objective was to compare the time taken for confirmation of ETT location and the correct identification of oesophageal and tracheal intubation by USG and ETCO2.

RESULTS

On comparison of both the groups, upper airway had faster average confirmation time of 16.41 seconds when compared to ETCO2 which took an average confirmation time of 23.56 seconds. Upper airway USG also was able to identify oesophageal intubation with 100% specificity.

CONCLUSION

Upper airway USG can be a reliable method and can be employed as a standard method for confirmation of ETT location in patients undergoing elective surgeries under general anaesthesia when compared to ETCO2.

KEYWORDS

ETCO2- End-tidal capnography, USG - Ultrasonography

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INTRODUCTION

Endotracheal intubation for airway protection with an Endotracheal Tube (ETT) is a key competency in emergency, critical care, and anaesthesia. [1] The most trustworthy technique for securing and preserving a patient's airway is tracheal intubation. [2]

It can be disastrous if an endotracheal tube cannot be properly confirmed to have been placed in a patient who is pharmacologically paralyzed (as in an operating room). [1] There may be a limited view of the airway anatomy during the endotracheal tube attempt, and the tube may slide into the oesophagus. Patient morbidity and mortality have been linked to challenging laryngoscopies and unsuccessful intubations under general anaesthesia. [3]

The goal of doing an airway evaluation is to identify challenging airways in advance for optimal patient preparation, appropriate equipment and technique selection, and the participation of specialists skilled in managing challenging airways.

Hence confirmation of successful ET tube placement is very important because the incidence of intubation into the oesophagus is approximately 6% in emergency situations and 1.75% in elective settings which can be disastrous. 69% of the death was related to airway management. Though the confirmation is by direct visualization of the endotracheal tube passing through the vocal cord, it is not always feasible, especially in cases of difficult laryngoscopy. [4][5]

There are numerous techniques for tracheal placement verification [1], including:

- Auscultation of bilateral lung
- Endotracheal tube misting
- Capnography which can be qualitative (colorimetric carbon dioxide detector) and quantitative (continuous waveform)
- Xray confirmation of endotracheal tube placement
- Endotracheal tube location confirmed using Fibreoptic bronchoscope
- Upper airway ultrasonography

One of the supreme ways to quickly determine the location of an ET tube has been the use of capnography. [3] Due to a lack of resources, capnography is not generally available in developing nations like India. Hopefully, in the future, better monitoring standards will be implemented, requiring the use of capnography during anaesthesia in addition to sedation and all surgical procedures under anaesthesia.

The basis for capnography is the employment of Infrared spectrometry (IR)-based monitors, which are now the most affordable and well-liked in clinical settings. But it has its own limitations such as atmospheric pressure, conditions that cause compromised pulmonary blood flow, such as severe pulmonary embolism and cardiac arrest and humidity.

Ultrasonography (USG) is a tool that is readily available. The advantages of ultrasonography are that it is light, portable, non-invasive, has reproducible images,is widely available, painless, reasonably priced, is easily repeatable, and has a solid safety record. [6]

There are numerous clinical uses for USG [1], including

- Confirming the correct positioning of the supraglottic device and the endotracheal tube
- Determining the proper depth of the same
- Determining the airway's size
- Invasive methods like needle cricothyroidotomy and percutaneous tracheostomy recognise subglottic region stenosis
- Predicting whether an intubation will be simple or difficult
- Identifying post-extubation stridor
- Prediction of the pediatric ET tube's size

- Determining the appropriate size of the double lumen tubes

Regrettably, ETCO2 is not widely available and cannot be present everywhere as it is in tiny centers. As a result, we propose that USG (ultrasonography) be used as a crucial technique for confirming the location of the endotracheal tube.

Numerous studies using upper airway USG for ET tube location confirmation have positive outcomes, particularly in patients in sterile operating rooms. Therefore, Ultrasonography is another method that may be trustworthy for verifying ETT position. [4]

This study's objective was to determine whether USG can also be a dependable method for verifying endotracheal tube placement in individuals undergoing elective procedures under general anaesthesia.

AIM & OBJECTIVES

AIM:

- To compare upper airway ultrasonography (USG) with end tidal capnography ($ETCO_2$) for confirmation of endotracheal tube (ETT) placement in patients requiring general anaesthesia.

OBJECTIVES:

- To compare the time taken for upper airway USG versus $ETCO_2$ for confirmation of endotracheal tube placement in patients requiring general anaesthesia.

- To compare the number of correct identifications of endotracheal and oesophageal intubation by USG versus $ETCO_2$.

REVIEW OF LITERATURE

Taku Takeda et al., [2] **(2002)** in a study to assess three methods to verify – $ETCO_2$, esophageal detector device, and clinical methods (auscultation) to verify the tracheal tube placement. They came to the conclusion that while clinical approaches are superior during cardiac arrest and CPR, $ETCO_2$ is the most reliable technique for confirming tracheal intubation in patients who are posted for elective procedures.

Chun et al., [7] **(2004)** assessed the portable hand-held US machine to ensure the proper ETT insertion. During all stages of airway management, they bilaterally documented the visceral parietal pleural interface (VPPI) on the chest wall of the patients. They came to the conclusion that thoracic sonography would prove to be a useful tool for validating ETT insertion, particularly in extreme circumstances like aerospace medical transport where other modalities like capnography might not be available and auscultation might not be practical.

Galicinao et al., [8] **(2007)** conducted research to determine the effectiveness of USG in confirming ETT placement in pediatric patients. It demonstrated that sniffing is the optimal posture for high-quality images, with linear transducers providing better images but being constrained by their size in comparison to curvilinear ones and having greater timeliness of ultrasound as compared to chest radiograph. Additionally, they demonstrated how USG may be used with accuracy when $ETCO_2$ detector data are inaccurate or unclear.

Ma G Davis et al., [9] **(2007)** undertook a cadaveric study where a low-frequency curvilinear probe was placed over the cricothyroid region in the longitudinal plane to calculate the specificity and sensitivity of the USG to confirm the placement of the ET tube. They came to the conclusion that the dynamic transcricothyroid ultrasound is a reliable method of ET tube confirmation following intubation after comparing the dynamic and static images of the ultrasound.

Pfeiffer et al., [1] **(2011)** conducted a study to compare the duration of bilateral lung USG with auscultation and capnography for verifying endotracheal intubation. They came to the conclusion that USG is just as quick as auscultation alone and quicker than the capnography standard method of auscultation.

Chou HC et al., [10] **(2011)** conducted a study in 112 patients who underwent intubation in emergency conditions such as cardiorespiratory arrest, respiratory failure, and severe trauma and was intended to evaluate the diagnostic accuracy and turnaround time for TRUE confirmation (Tracheal Rapid Ultrasound Examination). When intubating a patient in an emergency, a low-frequency ultrasonography probe was positioned slightly above the suprasternal notch to confirm the location of the ET tube. End-tidal carbon dioxide, the reference method used to confirm the position of the ET tube, showed a sensitivity of 98.9 percent, a specificity of 94.1 percent, and an average time of 9 seconds. The aforementioned approaches had greater concordance, and it was discovered that TRUE could be used to quickly determine the location of an ET tube in an emergency intubation.

Adi et al., [6] **(2013)** demonstrated a strong degree of agreement between the two modalities in their study comparing the practicality of bedside upper airway USG to confirm ETT site after intubation in contrast to capnography in patients of various ages, ethnic groups, and intubation indications. They emphasized the value of USG in excluding esophageal intubation as well. They demonstrated that upper airway USG can accurately determine if a tube is in the trachea or the esophagus while simultaneously observing the upper airway. The study highlights how crucial it is for emergency physicians to receive proper training in airway USG so they can perform it as a point-of-care procedure on patients who arrive in an emergency.

Kristensen et al., [11] **(2014)** used an ultrasonogram to image the airway in real-time, from the mouth to the alveoli, and they found a direct correlation between this imaging and airway management. A linear frequency probe was used for imaging, and it was positioned transversely at the front of the neck, right above the suprasternal notch.

Saeed Abbasi et al., [12] **(2015)** A study was done on the methods for employing ultrasound throughout the dynamic and static stages of intubation and how to use it as a trustworthy instrument to confirm tracheal intubation in emergencies. A high-frequency linear probe was positioned in the transverse plane above the cricothyroid membrane in the dynamic phase of the investigation by a single researcher, and above the suprasternal notch in the static phase. They came to the conclusion that ultrasound was highly sensitive, specific, and had a good predictive value for both positive and negative outcomes when used to confirm the installation of an ET tube.

Vimal Koshi et al., [13] **(2017)** compared USG with conventional clinical techniques and quantitative waveform capnography in a study, and they evaluated the results such as the sensitivity and specificity of USG against the other techniques to confirm endotracheal intubation. The amount of time it took for each approach to confirm the tube placement was the secondary outcome that was evaluated. According to the study, quantitative waveform capnography and other clinical techniques, as well as USG, validated the tube placement with similar sensitivity and specificity, but USG produced results much more quickly.

Priyanka Bansal et al., [14] **(2018)** evaluated upper airway ultrasonography, quantitative waveform capnography, and auscultation on adult patients scheduled for elective procedures in prospective observational research. To rule out esophageal intubation, the probe was positioned horizontally from the cricothyroid membrane up to the suprasternal notch, and it was then given a little 30° tilt to the left. They came to the conclusion that upper airway USG can take the place of end-tidal carbon dioxide ($EtCO_2$) monitoring as the preferred method for confirming proper endotracheal intubation.

Chintamani Abishek et al., [3] **(2020)** compared upper airway USG and capnography in a trial to quickly validate the placement of an ET tube during general anaesthesia. The study found that upper airway USG and capnography may both be utilised as the main techniques for confirming the placement of an ETT.

ANATOMY OF UPPER AIRWAY [15] [16] []17]

In normal respiration, the upper airway is crucial. Its anatomy and functions of it, affect how much air is inspired and exhaled. The upper airway is made up of the following parts: the mouth, nasal cavity, palate, uvula, pharynx, larynx, and trachea.

The normal airway serves a number of purposes while a person is awake and in good health, including filtration of the surrounding air, air conditioning, humidification, and air transportation to and from the lungs for gaseous exchange between pulmonary capillaries and alveoli.

Due to the suppression of respiratory functions during the induction and maintenance of general anaesthesia, the airway is not in an active condition. The patient should be ventilated by a bag and mask, laryngeal mask airway, or endotracheal tube, according to the anesthesiologist.

The anesthesiologist should be well-versed in the anatomy of the airways, how they are used, and the different airway assessment techniques. This will help the anesthesiologist predict the factors that will make mask ventilation and laryngoscopy challenging, allowing them to create an airway management strategy.

UPPER AIRWAY

NOSE

The nasal bones, upper and lower lateral cartilages, the cartilaginous portion of the nasal septum, and skin combine to form the external portion of the nose. The flexible portion of the nasal septum and the columella divide the pair of nostrils. The two nasal bones together create the skeletal framework of the upper part of the nose. The vomer makes up the inferior and the ethmoid's perpendicular plate makes up the superior portions of the posterior septum's bones. The bottom and anterior part of the nose is supported by cartilage.

Blood supply: The maxillary artery, superior labial artery, posterior ethmoidal artery, and anterior ethmoidal artery all provide arterial supply. The facial, ophthalmic, and sphenopalatine veins are involved in venous drainage.

Nerve supply: Olfactory nerve and trigeminal nerve.

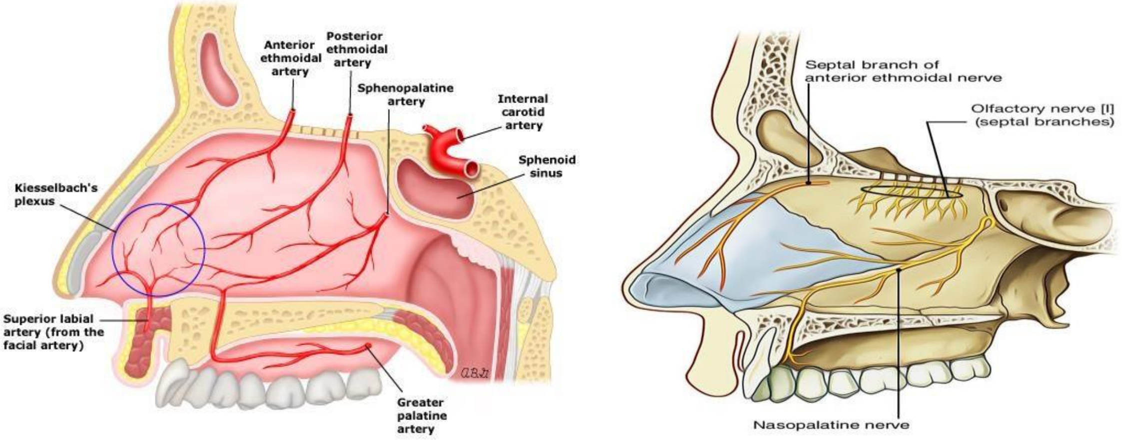


Figure 1: Blood supply and Nerve supply of Nose

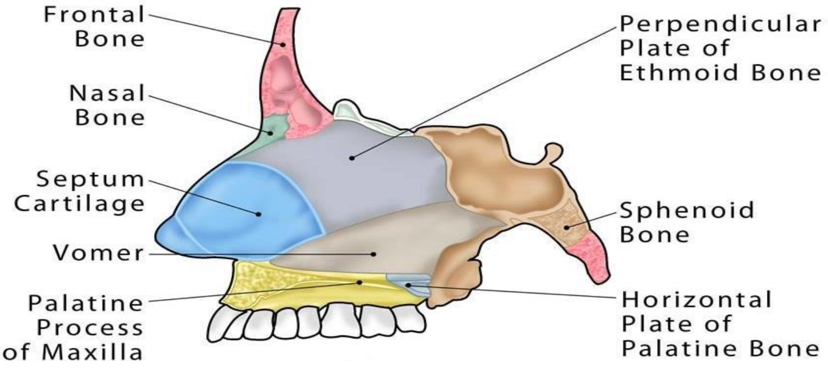


Figure 2: Bones forming the nasal cavity

MOUTH

An interior, massive oral cavity proper and an outer, small vestibule make up the mouth. The lips, cheek, and teeth and gums on the inside define the vestibule of the mouth, which is a small area. The tongue, the sublingual area, the teeth, the gums, and the alveolar arches of the jaw form the anterolateral boundaries of the oral cavity. The roof is defined by the hard and soft palates.

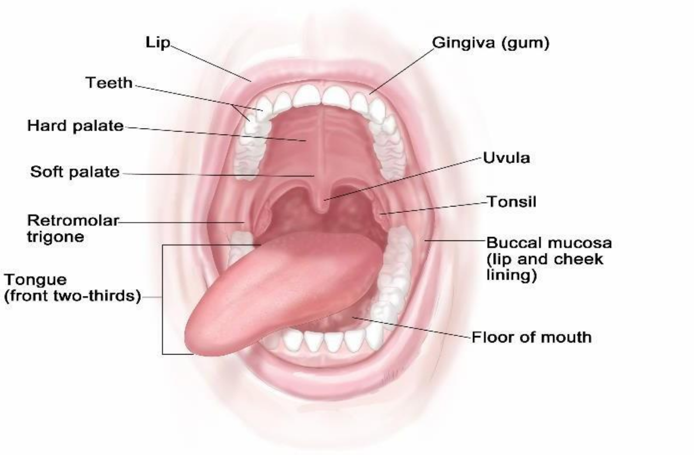


Figure 3: Parts of the mouth

HARD PALATE AND SOFT PALATE

The nasal and oral cavities are separated by the hard palate. The palatine processes of the maxillae make up its anterior two-thirds, and the horizontal plates of the palatine bone make up its posterior one-third. The Greater Palatine branch of the Maxillary artery supplies it.

The soft palate is a flexible muscle fold that hangs from the hard palate's posterior border. The oropharynx and nasopharynx are divided by soft palate. The Uvula is a conical projection that emerges from the center. The mucous membrane folds stretch laterally and downward from either side of the base of the uvula. The palatoglossal arch refers to the anterior fold, and the Palatopharyngeal Arch refers to the posterior fold.

Muscles of the soft palate includes levator veli palatini, tensor veli palatini, palatoglossus, palatopharyngeus and uvula.

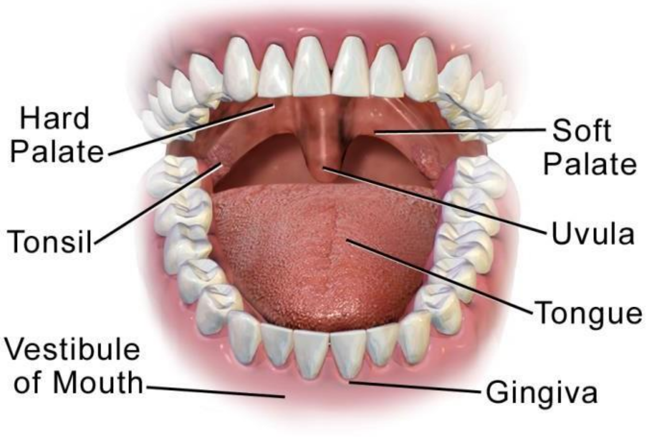


Figure 4: Hard palate and soft palate

PHARYNX

Behind the mouth, larynx, and nose is a broad, muscular tube called the pharynx. The Nasopharynx, Oropharynx, and Laryngopharynx are its three distinct sections.

Area behind the nose is called the nasopharynx. It reaches the soft palate from the skull's base. It connects to the oropharynx below and the nose anteriorly.

Behind the mouth cavity lies the oropharynx. It reaches the upper surface of the epiglottis from the soft palate. It communicates below with the laryngopharynx, above with the nasopharynx, and anteriorly with the oral cavity. The palatine tonsils are within.

Behind the larynx is the laryngopharynx. It reaches from the lower edge of the cricoid cartilage to the upper edge of the epiglottis. It connects to the oesophagus inferiorly, the larynx anteriorly, and the oropharynx above. On either side of the laryngeal inlet is a Pyriform fossa on the laryngopharyngeal lateral wall.

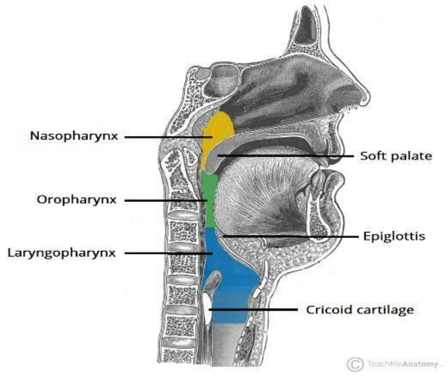


Figure 5: Pharynx

LARYNX

The organ of phonation is the larynx. The location of the larynx is in the front midline of the neck, running from the root of the tongue to the trachea. It is located in front of cervical vertebrae C3–C6.

The oral axis, pharyngeal axis, and laryngeal axis, which typically lie in perpendicular planes to one another, must be oriented such that they come to be in the same plane in order to observe the glottic aperture during direct laryngoscopy.

The laryngeal and pharyngeal axes are aligned by elevating the head by about 10 cm, placing a pillow under the occiput, and leaving the shoulders on the table. The sniffing position is when the neck is flexed and the atlanto-occipital joint is extended, creating virtually a straight line from the incisor teeth to the glottis opening.

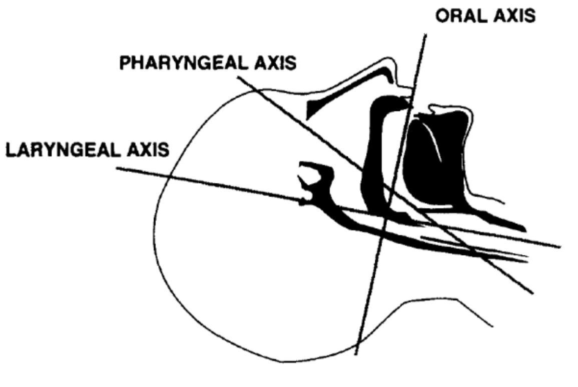


Figure 6: Positioning for intubation

The structures seen as the laryngoscopic blade is inserted into the oral cavity include the base of the tongue, vallecula, the front surface of the epiglottis, and finally, the laryngeal opening. A thin tissue fold can be seen extending posteriorly from the epiglottis is the aryepiglottic fold.

Cuneiform and corniculate cartilage can be found on their posterior end. As the patient is paralyzed with a muscle relaxant before the laryngoscopy, pale paired structures that are abducted are seen as the rima glottidis, the opening between vocal cords. Through this opening, the tracheal rings can be seen.

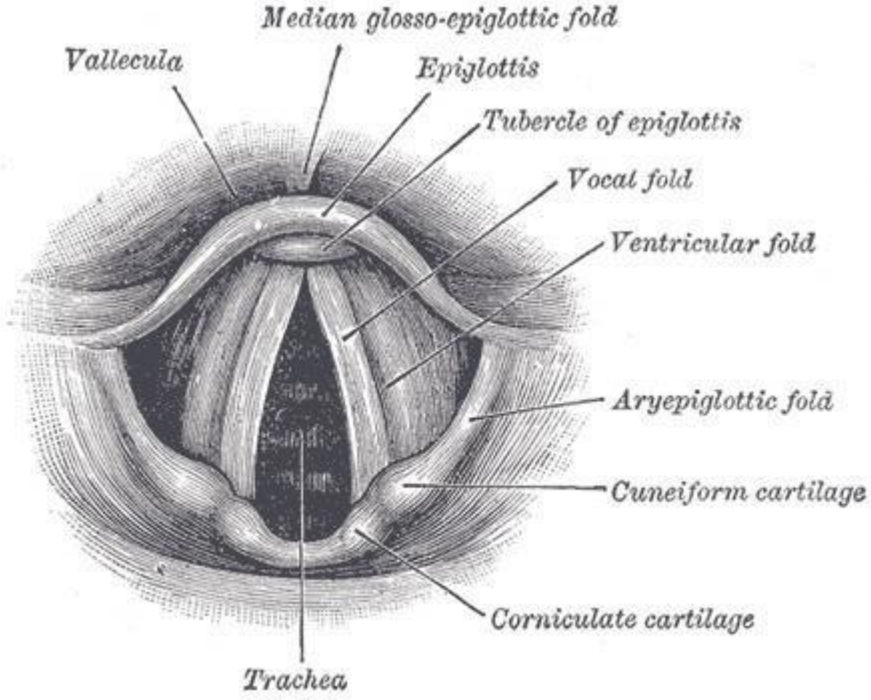


Figure 7: Laryngoscopic view of glottis

CARTILAGES OF THE LARYNX:

It contains 3 paired and 3 unpaired cartilages.

Unpaired cartilages are thyroid cartilage, cricoid cartilage and epiglottis.

Paired cartilages are arytenoids, corniculate and cuneiform cartilages.

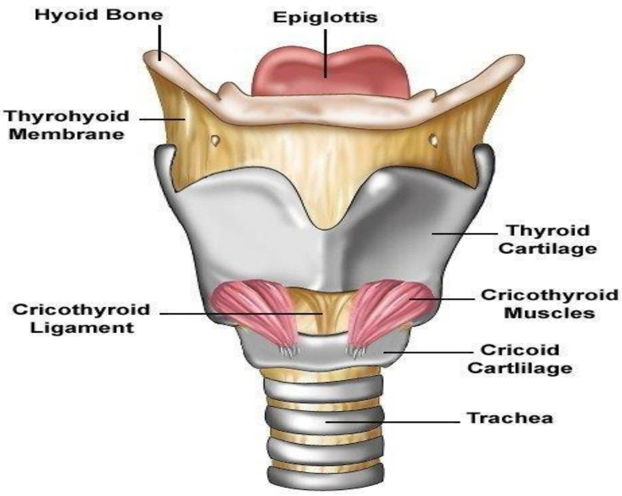


Figure 8: Anterior view of cartilages of the larynx

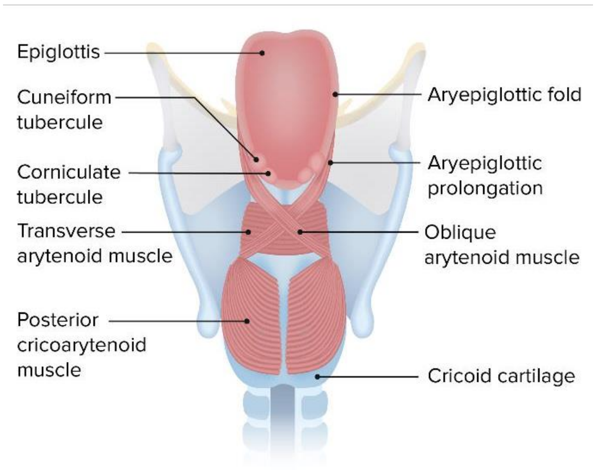


Figure 9: Posterior view of cartilages of the larynx

THYROID CARTILAGE

In cross-section, the cartilage has a V shape. It is made up of the left and right laminae. The laryngeal prominence is created by the fusion of the lower portions of the anterior margins of the right and left laminae. The thyroid notch divides the upper portion of the anterior boundaries. Superior and inferior cornua comprise this structure. The sternohyoid, thyropharyngeus and thyrohyoid are joined to the oblique line. Along the back border are the palatopharyngeus, salpingopharyngeus, and stylopharyngeus. The Median thyroepiglottic ligament, thyroepiglottic muscle, Vestibular fold, Vocal fold, Thyroarytenoid, and Vocalis muscle are all related to the inner aspect.

CRICOID CARTILAGE

This cartilage has a ring-like form. The larynx is encircled beneath the thyroid cartilage. It is the source of the lateral cricoarytenoid muscle and the cricothyroid muscle.

EPIGLOTTIS

It is a cartilage in the form of a leaf is positioned in the front wall of the upper section of the larynx. Its top end, which extends upward behind the tongue and the hyoid bone, is broad and free. Between the two laminae of the thyroid cartilage is joined the lower end designated by the thyroepiglottic ligament. The Hyoepiglottic ligament and the median glossoepiglottic fold attach its anterior surface to the hyoid bone and the tongue, respectively.

ARYTRENOID CARTILAGE

These two tiny cartilages have the shape of a pyramid. They are located on the Cricoid cartilage's upper edge. Its base and apex are articulated by cricoid lamina and corniculate cartilage, respectively. The vocal processes, which provide attachment to the vocal fold and the vocalis muscle, are lengthened anteriorly. It creates the muscular processes on either side of the posterior cricoarytenoid. Above the vocal cords is where the vestibular fold is attached.

CORNICULATE CARTILAGES

Two small conical nodules which articulates with the arytenoid cartilages. They lie in the posterior parts of Aryepiglottic folds.

CUNEIFORM CARTILAGES

On the aryepiglottic folds, just ventral to the corniculate cartilage, are these two little rod-shaped pieces of cartilage.

LARYNGEAL LIGAMENTS AND MEMBRANE

The extrinsic ligaments and membrane are the Thyrohyoid membrane, Hyoepiglottic ligament, Cricotracheal ligament.

The fibroelastic membrane of the larynx is a large sheet of fibroelastic tissue that includes the intrinsic ligaments. On either side, the laryngeal sinus interrupts it. The Quadrate membrane and Conus elasticus are the names of the portions of the sinus membrane that are above and below the sinus, respectively. From the arytenoid cartilage to the epiglottis, the quadrate membrane is present. It has an upper border that creates the Aryepiglottic fold and a free lower border that creates the vestibular fold. From the cricoid cartilage's arch, the Conus elasticus, also known as the Cricovocal membrane, extends upward and medially. The Cricothyroid ligament is a term used to describe the thick anterior portion. The vocal fold is created by the free upper border.

LARYNGEAL CAVITY

The laryngeal cavity stretches from the inlet to the lower edge of the cricoid cartilage. The Interarytenoid fold of the mucous membrane, the Epiglottis, and the Aryepiglottic folds on either side define the inlet's boundaries. There are two mucous membrane folds in the laryngeal cavity, one on each side. The vestibular fold is their upper fold, and the lower fold is the vocal fold. The Rima vestibuli and Rima glottidis are the spaces between the vocal folds and the right and left vestibular fold, respectively. The larynx's chamber is divided into three sections by the vocal fold and vestibule. The Vestibule of the Larynx is the term for the area above the vestibular fold. The larynx's sinus or ventricle is the region between the vestibular and vocal folds. The Infraglottis is the term for the area below the vocal fold. Between the vestibular and vocal folds is a little fusiform fissure known as the Sinus of Morgagni or ventricle of the larynx. The saccule of the larynx is a diverticulum that extends upward from the anterior portion of the structure. The larynx's "oil can" is often referred to as the saccule because it houses the mucus glands that lubricate the vocal folds.

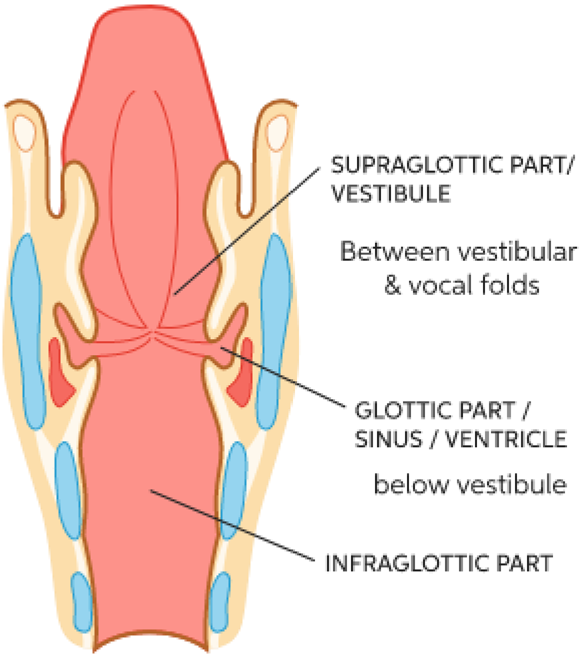
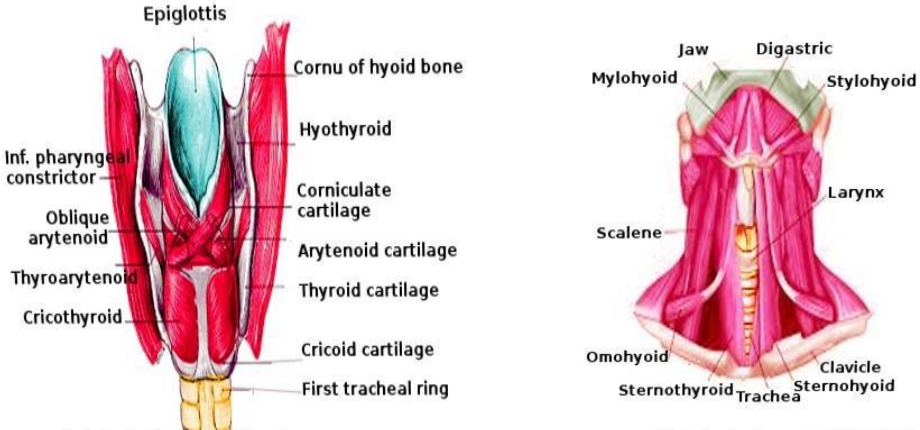


Figure 10: Laryngeal cavity

MUSCLES OF THE LARYNX

There are two muscle groups in the larynx – The extrinsic group and the intrinsic group.

The extrinsic muscles of the larynx include Sternothyroid, Thyrohyoid, Stylopharyngeus and Palatopharyngeus. The larynx's intrinsic muscles perform opening, closing, and cord tensor functions. The Intrinsic muscles include Cricothyroid muscle, Posterior cricoarytenoid muscle, Lateral cricoarytenoid muscle, Thyroarytenoid muscle. Vocalis muscle, aryepiglottic, cricothyroid and inter arytenoid muscles.



Intrinsic Larynx Muscles

Extrinsic Larynx Muscles

Figure 11: Muscles of the Larynx

THE MALLAMPATI CLASSIFICATION [18]

This is the test that is used the most frequently to identify challenging airway management. It shows how much room is available in the oral cavity for the laryngoscope and endotracheal tube. The patient is asked to open their lips as wide as they can and stick out their tongues without phonating during the exam.

In order to simulate the sniffing position for laryngoscopy and intubation, one needs to make sure the patient is seated with the head kept forward. The eye of the observer should be level with the patient's open mouth. Now we can assess how well we can see the uvula, soft palate, hard palate, and facial pillars.

EXTENDED MALLAMPATI SCORE

In Extended Mallampati scoring, the patient sits with their head fully extended as opposed to the neutral position used in standard Mallampati grading. The specificity and predictive value of the Mallampati airway evaluation are improved by this grading with craniocervical extension.

Intubation may be more challenging the more the tongue blocks the vision of the pharyngeal structures.

MALLAMPATI SCORING:

CLASS 1: The palatal arch, the bilateral faucial pillars along with the base of pillars are visualized.

CLASS 2: The upper part of the faucial pillars and most the uvula are visible.

CLASS 3: Only the soft palate and the hard palate are seen.

CLASS 4: Only the hard palate is visualized.

Figure 12: The Mallampati Classification

CORMACK AND LEHANE LARYNGOSCOPIC GRADES [18]

The best view of the larynx is used to gauge how effective direct laryngoscopy is. The scale that Cormack and Lehane describe is the one that is most frequent. There are 4 grades:

Grade 1: Full view of the glottis.

Grade 2A: Partial view of the glottis.

Grade 2B: Only arytenoids are visible.

Grade 3: Only epiglottis is seen.

Grade 4: No airway structure is visible.

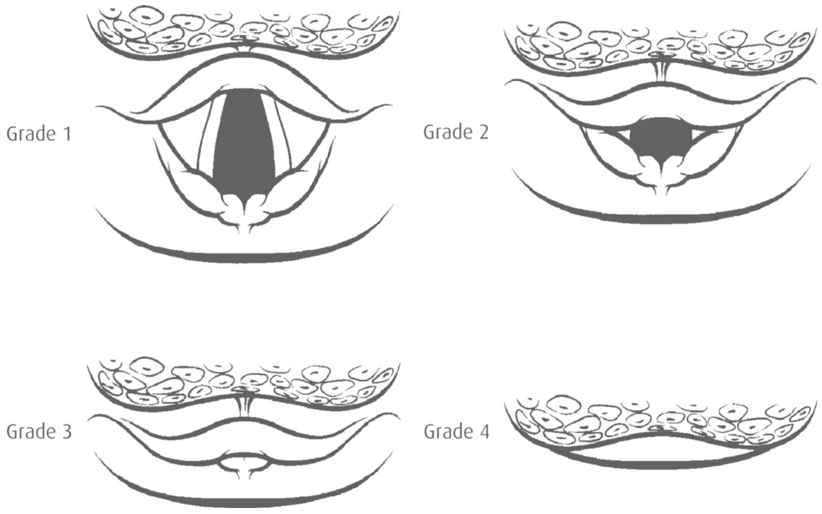


Figure 13: Cormack & Lehane Laryngoscopic grades

INDICATIONS FOR TRACHEAL INTUBATION [18]

SURGICAL AND ANAESTHETIC INDICATIONS:

- The need for neuromuscular blocking medications during surgery.
- Shared airway access with the surgeon during ear, nose, and throat operations.
- Patient positioning that limits or prevents quick tracheal intubation, such as the lateral and prone positions.
- Predicting a challenging airway.
- Risk factors for aspirating blood or stomach contents include face injuries, infection in the upper gastrointestinal system, and bleeding into the respiratory tract.
- Gas exchange-impairing surgery.

CRITICAL ILLNESS:

- Inability to keep the airway open, as in a coma.
- Respiratory impairment (hypoxia, hypercapnia) that is resistant to non-invasive treatment.
- Preventing hypercapnia, and raising intracranial pressure.

THE ULTRASOUND MACHINE [19]

PRINCIPLE OF ULTRASOUND:

Sound waves are used in ultrasound to create images of the objects they travel through. In tissues, the sound waves manifest as alternating pressure waveforms. While the high-pressure wave is referred to as compression, the low-pressure wave is known as rarefaction. The range of Human hearing is 20-20000HZ. The ultrasound machine transmits waves at a frequency of above 20000HZ.

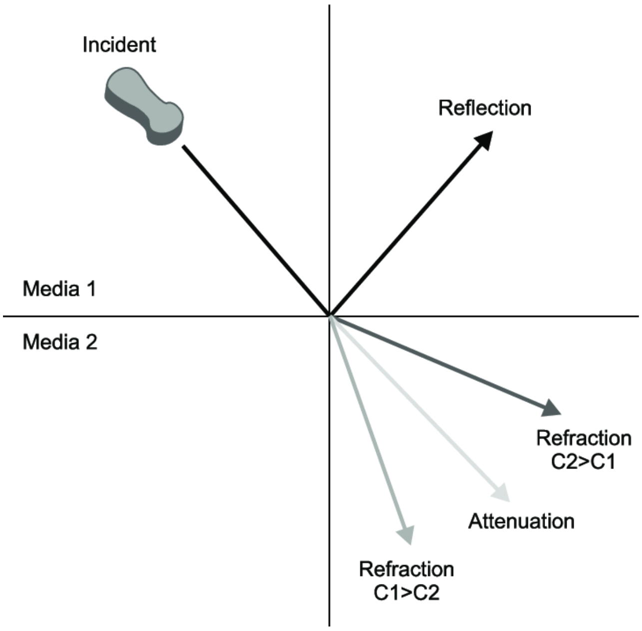


Figure 14: Reflection & Refraction of the ultrasound waves

GENERATION OF THE ULTRASOUND WAVE:

When an electric field is applied to a collection of piezoelectric crystals situated on the transducer surface, an ultrasonic wave is produced. Crystals are mechanically distorted by electrical stimulation, which generates vibration and the generation of sound waves. The converse piezoelectric effect is the transformation of electrical energy into mechanical energy.

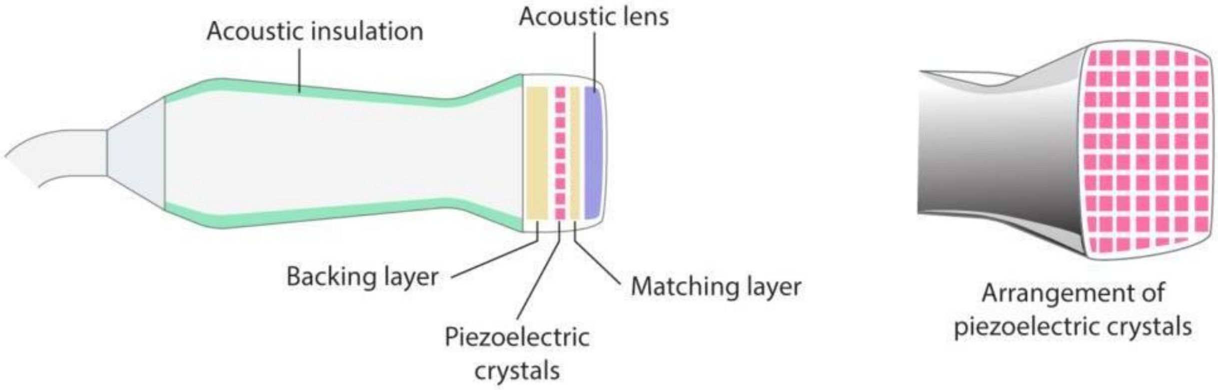


Figure 15: The ultrasound transducer & the arrangement of piezoelectric crystals

The ultrasonic transducer sends out sound waves and then waits for the sound waves to come back before sending out the next wave. The sound waves that were delivered from the transducer are reflected after passing through the bodily tissues. The transducer probe receives these reflected waves as they come back to it. Then, this is changed back into electrical energy. It is known as the piezoelectric effect.

The machine computer transforms this electrical energy into displayed visuals. The following occurs as the sound waves move through the body tissues: Rarefaction, reflection, and Diffraction, or the bending of waves when they encounter a material of a different density Scattering, oppositional acoustic impudence to sound waves.

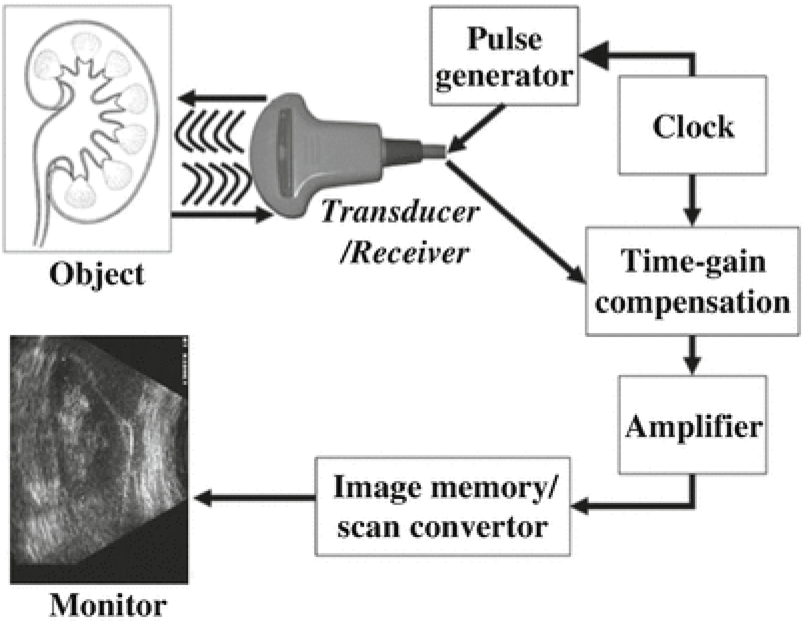


Figure 16: Production of an image by the Ultrasound

The three modalities of ultrasonography are A (Amplitude) mode, B (Brightness) mode and M (Motion) mode.

For the creation, presentation, and preservation of an ultrasound image, an ultrasound scanner has to have the following 5 main parts:

1. A pulser that powers crystals with high-amplitude voltage.

2. A transducer that transforms mechanical (ultrasound) energy from electrical energy and the other way around.

3. The receiver finds and amplifies flimsy signals.

4. The display that shows ultrasound signals in a number of different settings.

5. Memory, which houses images and video displays.

SELECTING A TRANSDUCER PROBE

There are three main properties based on which the transducer is selected.

They are

1. Frequency
2. Array configuration
3. Foot print - It is the diameter of the probe

The transducers are divided into the following categories based on frequency:

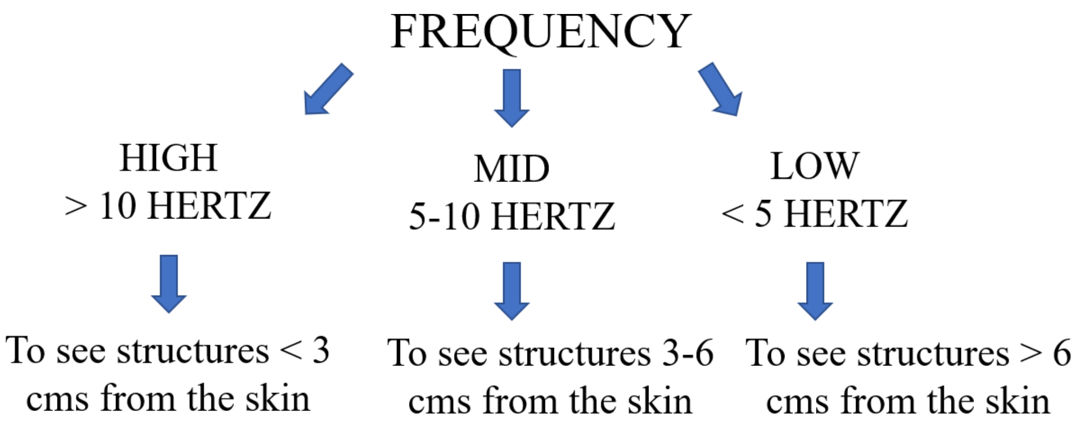


Figure 17: Classification of the ultrasound transducer based on Frequency

Following is a classification of transducers based on array configuration:

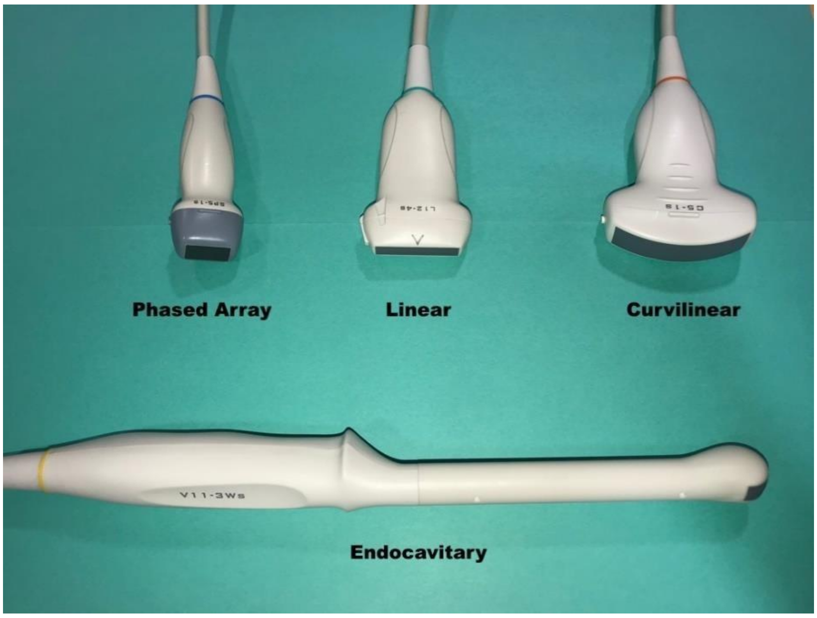


Figure 18: Classification of the ultrasound transducer based on array

ENHANCEMENT AND ATTENUATION

Deeper structures appear brighter than expected given their initial depth. This is due to the fact that more sound waves than anticipated have reached the structure due to the structure's surroundings absorbing more sound waves. Enhancement is the name of this phenomenon. Attenuation is the reverse effect, when surface features seem dark because fewer sound waves can reach them as a result of greater impedance.

CONTROLS IN THE MACHINE

- GAIN: Amplifying echoes that are returning.
- TIME GAIN: Various depths of brightness adjustment.
- FREEZE: Freezing of monitor of the structures visualised.
- DEPTH: Zoom in briefly or out for a broad perspective.
- FOCAL ZONE: This is where the resolution is at its best.

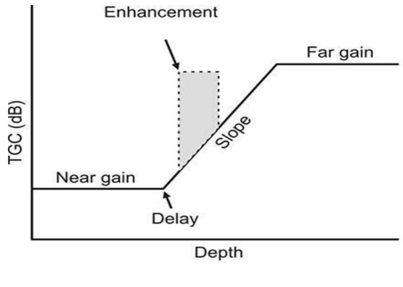


Figure 19: Time Gain compensation curve

ULTRASOUND ANATOMY OF THE AIRWAY [19] [20]

According to Kristensen et al., (2014) [11] the curved low-frequency transducer is best for obtaining sagittal and parasagittal views of structures in the submandibular and supraglottic regions due to its wider field of view and the linear high-frequency transducer is best for imaging superficial airway structures (within 2-3 cm from the skin).

The upper airway structures show as follows on an ultrasonogram: An air-mucosa (A-M) interface is any point where the mucosa lining the upper airway tract and the air inside it meet. Air artifacts like comet tails and reverberation artifacts could be seen in an air-filled area deep to an A-M interface, round hypoechoic in the parasagittal plane, arch-shaped in the transverse plane, vivid A-M interface and reverberation effects from intraluminal air distinguish the posterior surface of its anterior wall.

The tracheal rings are hypoechoic, just like other cartilaginous structures. They appear as a "string of beads" in the parasagittal and sagittal views, and as an inverted U with a linear hyperechoic A-M interface with reverberation artifact posteriorly in the transverse image. On the transverse view, the suprasternal notch level allows for the visualization of the thyroid's two lobes and isthmus. The thyroid gland has a homogeneously hyperechoic appearance and seems coarsely specked.

SONOANATOMY OF THE UPPER AIRWAY [21] [22]

EPIGLOTTIS

Epiglottis is visualized as a curvilinear hypoechoic structure. It is readily visualized when the probe is placed transversely and parasagittally. It is difficult to visualize the epiglottis in the sagittal view because of theacoustic shadowing of the hyoid bone. The pre-epiglottic space is the space that is seen as hyper echoic structure anterior to the epiglottis. Posterior to the epiglottis lies the Air-Mucosal interface, seen as a linear hyperechoic structure. It is better visualized by asking the patient to protrude the tongue.

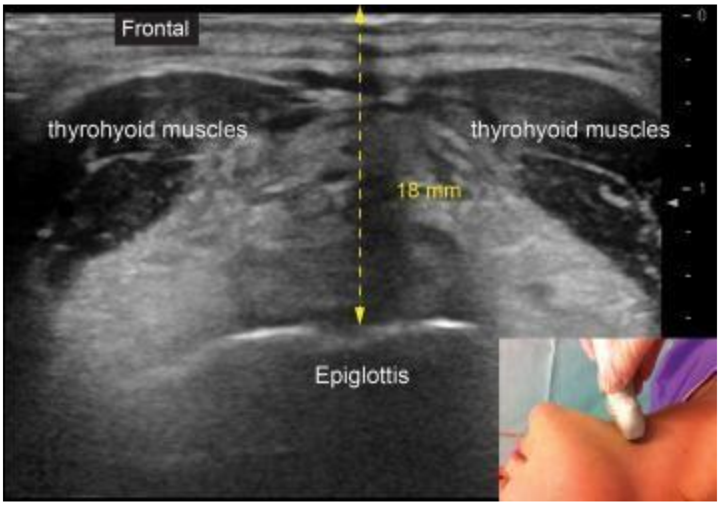


Figure 20: Transverse view of epiglottis in Ultrasound

TONGUE AND FLOOR OF THE MOUTH

Low-frequency curvilinear probes are used to visualize the tongue and the mouth's floor. The air-mucosal interface causes the dorsum of the tongue to seem hyper-echoic. The intrinsic muscles appear uniformly striated on an ultrasonogram. From the jaw to the hyoid bone, linear hypoechoic bands can be seen in the submandibular view.

HYOID BONE

It is considered to be an inverted U-shaped linear hyperechoic structure. It possesses a posterior acoustic shadowing as other bones do. The hyoid bone is visualized via the transverse and sagittal views.

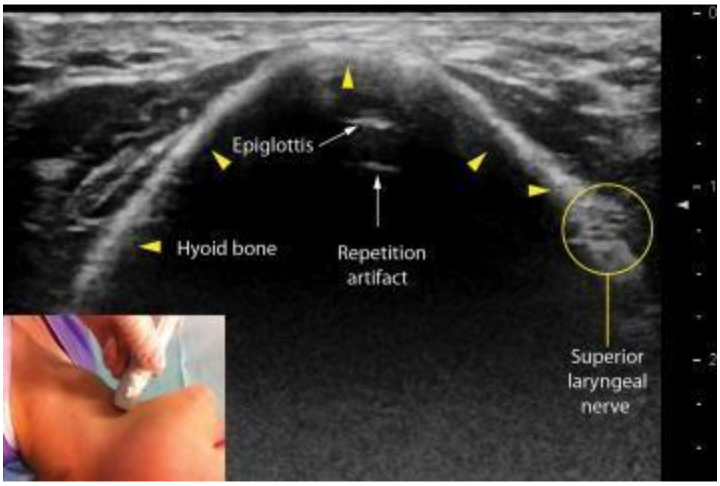


Figure 21: Transverse view of hyoid bone in Ultrasound

VOCAL CORDS

The vocal cords may be seen clearly using a transverse probe placed on the thyroid cartilage. To see the vocal cords as they truly are, the probe is shifted slightly caudal. A hyper-echoic rim surrounds the true vocal cords. The arytenoid cartilages are the little patches of echogenicity deep and lateral to the vocal cords. The hyperechoic vocal ligaments medially enclose the vocal cords in the shape of an isosceles triangle. To locate the false cords, the probe is cephalad-tilted just a little. The patient is asked to say aa/ee to help with visualization. While the false cords appear static, the true cords move in the direction of the midline.

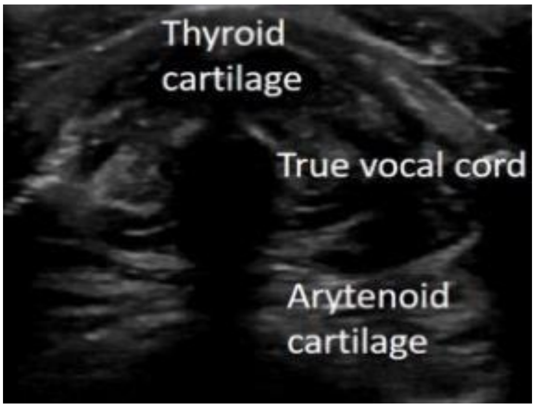


Figure 22: Transverse view of vocal cords in Ultrasound

CRICOID CARTILAGE AND CRICOTHYROID MEMBRANE

The cricoid cartilage is perceived as a semicircular, hypoechoic structure. The Air-Mucosal Interface is observed as a linear hyper-echoic line with reverberation artifact beneath the cricoid cartilage. Following the initial layer of skin and subcutaneous tissue, the hypoechoic thyroid and cricoid cartilages are seen in the longitudinal scan, which runs from anterior to posterior. Between the thyroid cartilage and the cricoid cartilage is the cricothyroid membrane. The tracheal rings are seen in numerous hypo-echoic pictures, giving the appearance of a string of black pearls. connecting the hypoechoic thyroid and cricoid cartilages with a hyperechoic ribbon. The tracheal rings appear as an inverted U in the transverse image, with a hyperechoic linear air-mucosal interface and a reverberation artifact posteriorly.

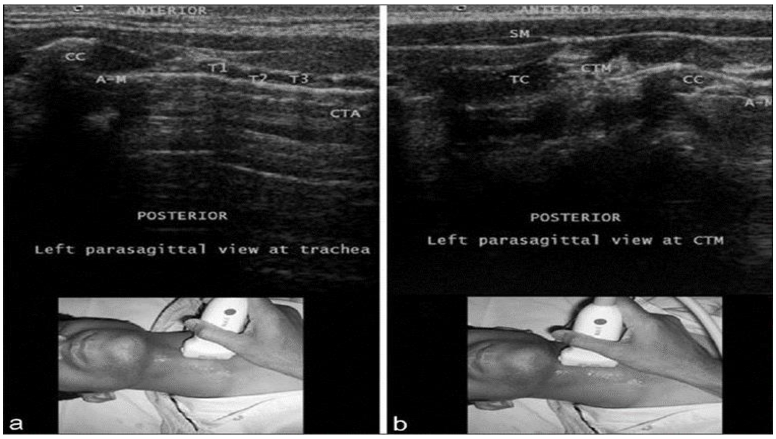


Figure 23: (a) Left parasagittal view at trachea (b) Cricothyroid membrane

CC=Cricoid cartilage, T1–T3=Tracheal cartilages, A–M=Air-mucosal interface, CTA = Comet tail artefact

THYROID GLAND

The probe is often positioned transversely along the front surface of the neck, right above the suprasternal notch, to image the thyroid gland. The thyroid glands lobes and isthmus are visible anteriorly and laterally to the trachea. The thyroid gland shows a hyperechoic homogenous structure. Additionally visible nearby structures include the internal carotid artery, internal jugular vein, oesophagus, and vertebral bodies. Throat and surrounding the suprasternal notch, the air mucosa contact, and the appearance of a comet tail are structures.

OESOPHAGUS

When the probe is inserted transversely in the anterior surface of the neck just above the suprasternal notch, this is seen posterolateral to the trachea on the left side. Usually, the oesophagus looks like a stratified structure. The oesophagus moves during swallowing, which makes it clear to visualize.

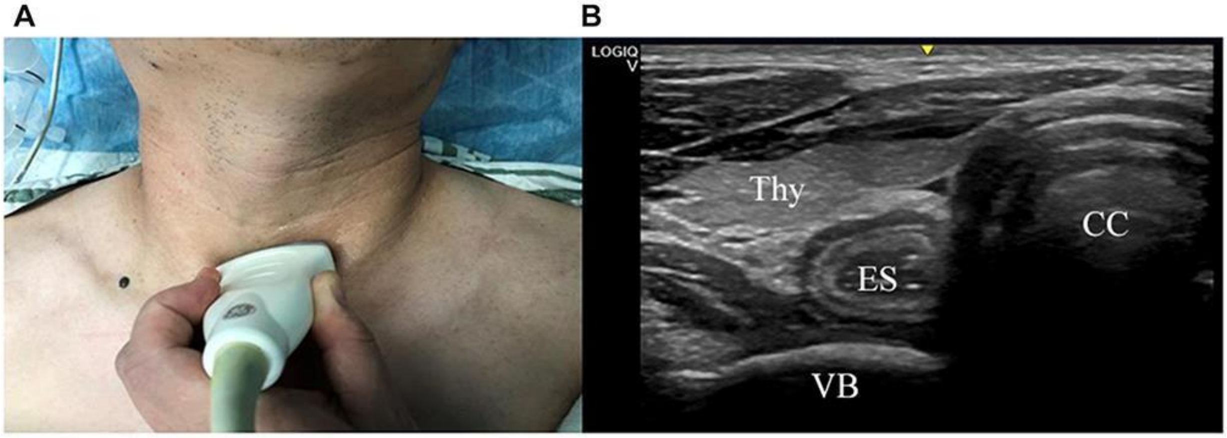


Figure 24: USG view of the thyroid gland (Thy), Esophagus (ES)

END-TIDAL CAPNOGRAPHY

TERMINOLOGY [23]

The measurement of carbon dioxide in a gas mixture is known as capnometry, and a capnometer is a tool used to carry out the measurement and provide numerical data. A capnograph is a device that creates the waveform, and capnography is the recording of carbon dioxide content vs time. The waveform itself is called a capnogram.

INTRODUCTION

Capnography has several beneficial clinical uses, and the American Society of Anesthesiologists recognized it as the standard of care for all delivered general anaesthetics in 1998 [24].

CO2 removal from the lungs (pulmonary processes) is indirectly indicated by the measurement of CO2 in expelled gases. It denotes the direct delivery of CO2 to the lungs and the generation of CO2 at the tissue level (metabolic process) (circulatory process). Exhaled CO2 monitoring helps ensure the integrity and patency of the airway for patients on mechanical ventilation, whether they are in operating rooms (OR) or intensive care units (ICU), which improves patient safety. It is currently the preferred procedure in anaesthesia for confirming the correct placement of the endotracheal tube.

TECHNOLOGY [25,26]

Infrared and chemical colorimetric analysis are two techniques for measuring CO2 levels. The CO2 level can be shown continuously or as the peak value, and it can be presented as partial pressure or volume percent. Because CO2 is a polyatomic gas, it absorbs light at a certain wavelength in the far infrared spectrum, and this absorption is proportional to the concentration of CO2 in the analysis chambers. This is why infrared technology is used to measure CO2. The measured CO2 is shown as partial pressure or volume percent (mmHg).

There are two different forms of capnographs: (I) side stream and (II) main stream, depending on where the IR sensor is located.

MAINSTREAM

The breathing circuit and endotracheal tube are separated by a CO2 sensor, but no gas is taken out of the circuit, increasing mechanical dead space. Due to their weight, early sensors may have kinked or disconnected the circuit. Modern sensors are compact and light.

Although it displays waveforms in real-time, non-intubated patients find it challenging to use. This kind is modified to allow attachment to an oxygen mask or to simulate a side stream by aspirating a sample through a sampling line to a mainstream sensor plugged into the side of the display unit.

SIDESTREAM

Gas is continuously inhaled from the circuit into the unit housing the CO2 sensor through a 6-foot sampling tube. The CO2 sensor is located exterior to the breathing circuit. It has very little dead space, and a compact adapter. The sampling line may clog. Due to the passage of gases from the patient's airway to the sensor-containing unit, the waveform is presented for (1-4) seconds. It can be easily modified for patients who aren't intubated.

TIME CAPNOGRAM

The graphical representation of CO2 levels in the most typical application of time is in clinical contexts, where it creates a time capnogram.

Time capnograms can be recorded at two different sweep speeds: a slow speed (0.7 mm/s) that results in a trend capnogram, or an overall change in CO2, or a fast speed (7 mm/s) that results in a distinctive waveform with specific information about each breath. An inhalation segment and an exhalation segment make up a typical high-speed time capnogram. Phases I, II, III, and occasionally Phase IV make up the expiratory segment. Phase IV represents the ultimate rise in CO2 caused by the emptying of alveoli with long time constants and higher CO2 concentration.

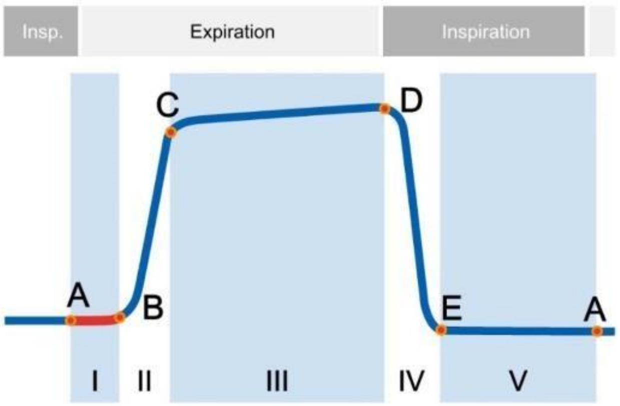


Figure 25: Time capnogram

Phase I

- Denotes the initial phase of expiration.
- Gases from the anatomical and apparatus dead space evaporating.
- The concentration of CO2 does not increase.

Phase II

- represents the expiration stage.
- A mixture of dead space gas and alveolar gas.
- A significant increase in CO2 levels**.**

Phase III

- Alveolar plateau phase.
- Symbolises the evolution of CO2 from alveoli.

Pet CO2

- Alveolar plateau phase maximum concentration is 5 mmHg which is lower than arterial CO2.

ANGLES

- Alpha angle: 100 to 110 - Between phase 2 and 3. It represents ventilation perfusion status of lung.
- Beta angle: 90 - Between phase III and phase 0, Increases during rebreathing.

VOLUME CAPNOGRAM

In volume capnogram, the CO2 concentration is plotted against the expired volume and it has similar characteristics. The slope of the phase III is a better reflection of the V/Q status of the lung compared totime capnogram. This is because in a time capnogram, most of the exhalation is predominantly completed in the proximal one – third of the phase III and the remaining portion of the plateau represents expiratory pause with continuous CO2 sampling from the airways.

A volume capnogram can be divided into various components of tidal volume so that the capnogram analysis offers a mode estimating physiological dead space.

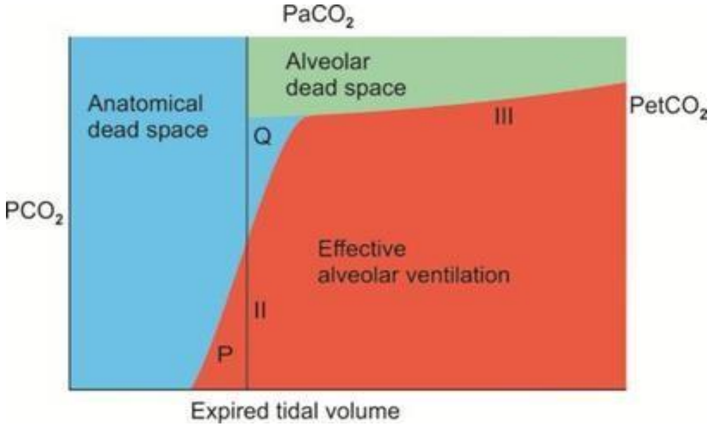


Figure 26: Volume capnogram

CAUSES OF INCREASE OF PARTIAL PRESSURE OF END-TIDAL CARBON DIOXIDE:

- Causes of the increase in CO2 production are Malignant hyperthermia, Thyroid storm or hyperthyroidism, Malignant neuroleptic syndrome, Sepsis. Causes of increased metabolic rate like fever, shivering, laparoscopic surgeries.
- Causes of decrease in CO2 elimination are Hypoventilation, Rebreathing, Exhaustion of CO2 absorber.
- Causes of technical failure such as Improper calibration, Measuring system Malfunction or contamination.

CAUSES OF DECREASE OF PARTIAL PRESSURE END-TIDAL CARBON DIOXIDE:

- Because of the causes of decrease in CO2 production such as hypothermia, hypothyroidism or decreased metabolic rate conditions like general anaesthesia.
- Because of the increase in CO2 elimination such as hyperventilation.
- Due to reduction in CO2 alveolar delivery such as decreased cardiac output states or hypo perfusion, pulmonary embolism, pulmonary edema,
- Because of technical failure such as a leak in the sampling tube or blockage, breathing system disconnection.

SPECIFIC SITUATIONS:

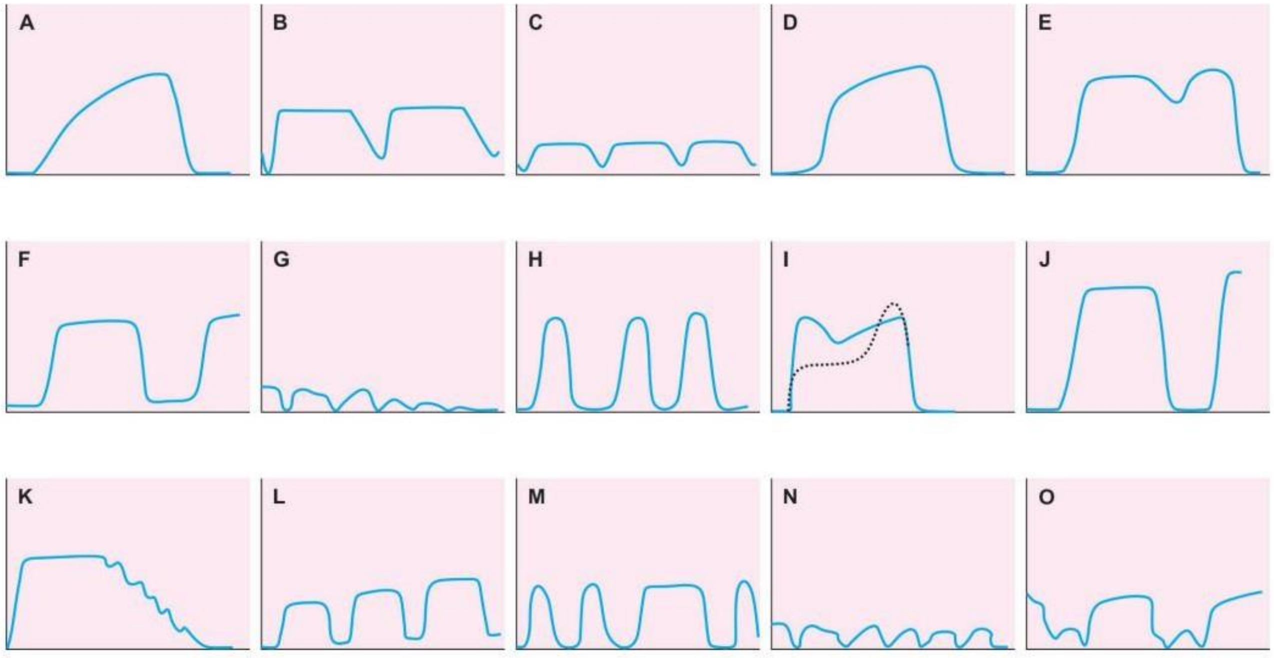


Figure 27: Capnogram in specific situations

A. Prolonged phase II and phase III in the case of bronchospasm or airway blockage.

B. Elevated baseline and oblique down stroke of the inspiratory down stroke are symptoms of an expiratory valve dysfunction. An issue with the inspiratory valve causing rebreathing of exhaled gases from the inspiratory limb during inhaling.

C. Capnograms of pregnant patients under general anaesthesia showed normal phase II but an elevated slope of phase III.

D. Curare Cleft: The patient is breathing through some muscle paralysis.

E. Abdominal and chest movements during surgery.

F. Baseline is increased due to CO2 rebreathing.

G. Oesophageal intubation

H. Phase III of the spontaneously breathing capnogram.

I. Dual capnogram in a recipient of a single lung transplant

a. The transplanted normal lung provides the first peak of phase III.

b. The second peak is from a lung with a native illness.

c. A leak at the monitor's side stream sensor portion.

d. Airborne dilution of expired PCO2.

J. Malignant hyperthermia: A gradual increase in CO2 with a zero baseline suggests increased CO2 production and soda lime absorption of CO2.

K. The ripple effect: Expiratory pause demonstrating fluctuations in the heart rate. This occurs as a result of the heartbeat moving the expired gases at the sensor.

L. An abrupt increase in baseline and the partial pressure of end-tidal carbon dioxide (PETCO2) as a result of secretions or water vapor contaminating the sensor.

M. While the patient is breathing naturally, intermittent mechanical ventilation (IMV) breathes for them. To evaluate spontaneous breathing throughout the weaning process, a comparison of the height of spontaneous breaths to mechanical breaths is important.

N. Cardiopulmonary resuscitation: Positive waveforms on the capnogram during each compression, indicating that the heart is effectively being compressed.

O. Rebreathing during inspiration is visible on the capnogram. In rebreathing circuits like the Mapleson D or Bain circuit, this is typical.

MATERIALS AND METHODS

SOURCE OF DATA:

This study was done in the Department of Anaesthesiology, Shri. B.M. Patil Medical College, Hospital and Research center, BLDE University, Vijayapura.

METHOD OF COLLECTION OF DATA:

Study Design: A prospective randomized comparative study

Study Period: One and half year from December 2020 to August 2022

STUDY POPULATION:

This study was done on in-patients undergoing various elective surgical procedures (ASA I and II) under general anaesthesia.

INCLUSION CRITERIA:

a. Patients with age >20 years and <60 years
b. Patients posted for elective surgeries under general anaesthesia (ASA I and II)
c. Both male and female patients
d. Only 1st attempt intubation is included

EXCLUSION CRITERIA:

a. Inability to consent for the procedure
b. Patients posted for neck surgeries under general anaesthesia
c. Obese patients with BMI more than equal or more than 30.0
d. Patients with abnormal neck anatomy, patients with poor pulmonary compliance
h. Pregnant females

METHODOLOGY:

Pre anaesthetic evaluation includes the following:

HISTORY:

- History of underlying medical illness, surgical history, anaesthetic exposure and hospitalization history were elicited.

PHYSICAL EXAMINATION:

- General condition of the patient
- Vital signs -heart rate, blood pressure, respiratory rate
- Height and weight
- Examination of respiratory system, cardio vascular system, central nervous system and the vertebral system
- Airway assessment by Mallampati grading

INVESTIGATIONS/INTERVENTIONS:

- Routine investigations which includes CBC, RBS, ECG, Chest X ray, HIV, HbsAg, Urine routine were done.

PROCEDURE:

- Procedure was explained to the patient and patient attenders.
- Written informed consent was taken prior to procedure.
- Patients were kept nil by mouth for 6 hrs before surgery according to the ASA guidelines.
- After shifting the patient to preoperative room, patient’s vitals were noted.
- Patients were divided into two groups: Group U and Group E by envelope

picking method.

The technique of Verification of ETT:

Patients were taken to the operation theatre, standard monitoring devices including pulse oximeter, sphygmomanometer cuff, ECG leads were connected and baseline values were recorded.

IV line was secured with 18G/20G cannula and patient was premedicated with Inj. Ondansetron 0.4mg/kg IV, Inj. glycopyrrolate 0.2mg/kg IV and Inj. Midazolam 1mg/kg IV. Pre oxygenation was done with 100% oxygen for 3 minutes.

General anaesthesia was induced with Inj. Propofol 2mg/kg IV and muscle relaxation was achieved by Inj. atracurium 0.8mg/kg IV to facilitate the ET tube insertion.

In group U patients, the USG probe was kept linear in midline of neck after the non-depolarising muscle relaxant given. After 3 minutes, ET tube was inserted by fellow resident anaesthesiologist using direct laryngoscopy and by visualization of vocal cords.

After insertion of ET tube, under the supervision of senior residents trained in Ultrasonography, the USG liner probe (SONOSITE M – Turbo machine in B mode) was transversely placed on the neck anteriorly superior to the sternal notch and Transverse and longitudinal images of the trachea were seen before moving the probe to the left to look at the oesophagus to see whether it was empty or distended from ETT.

ETT placement was confirmed in the case of tracheal intubation, where two hyper echoic parallel lines in both horizontal and vertical views were seen.

In oesophageal intubation reverberation artifact in trachea and two hyperechoic lines in oesophagus/distended oesophagus with empty trachea was seen. The time taken and correct tracheal/oesophageal intubation was noted.

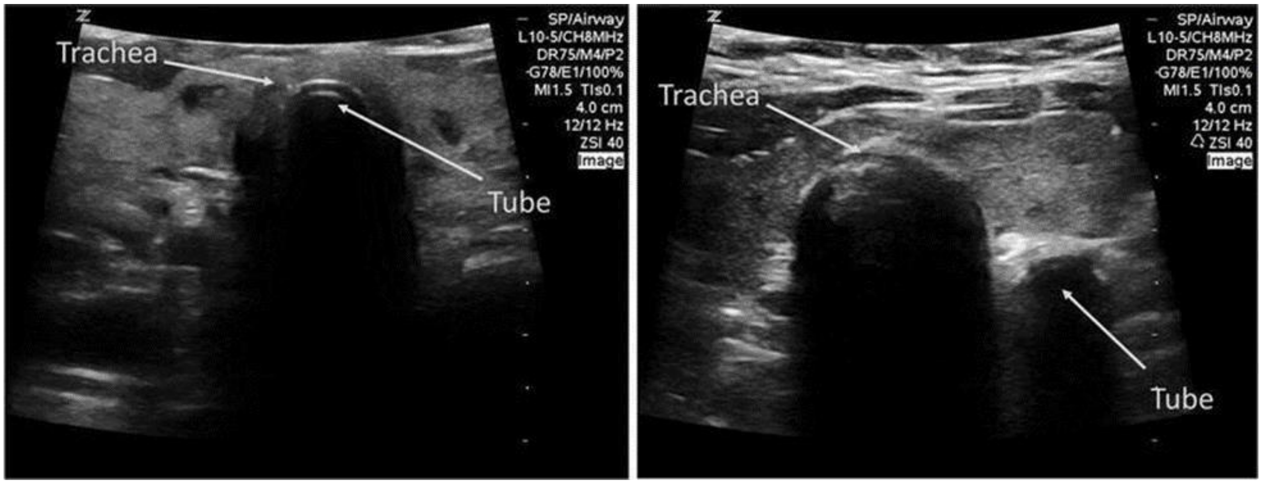


Figure 28: Upper airway USG showing Tracheal and Oesophageal intubation

In group E patients, ETCO2 were connected to ETT soon after intubation, and the correct placement was identified by ETCO2 detection – exhaled CO2 more than or equal to 4mm hg after more than or equal to 5 breaths and detection of characteristic CO2 waveform.

Soon after the confirmation, the findings and time taken for each was noted. ETT cuff was inflated with air. Patient was auscultated for B/L equal air entry and ETT was fixed appropriately. The ETT was connected to the ventilator circuit and age, weight adjusted ventilator settings were set in the ventilator.

Intraoperatively the patient was monitored with standard monitoring devices.

Post extubation, the patient was shifted to PACU (Post Anesthesia Recovery Unit) monitored for post operative complications such as fall in saturation, hyper/hypotension, etc., with pulse oximeter, ECG, Sphygmomanometer cuff and managed accordingly.

SAMPLE SIZE CALCULATION

The anticipated Mean±SD of time taken for confirmation of ETT in USG 16.4±7.3 and in ETCO2 18.6±4.4 resp. the required minimum sample size is 75 per group (i.e., a total sample size of 150 assuming equal group sizes) to achieve a power of 80% and a level of significance of 5% (two sided), for detecting a true difference in means between two groups.

$$N = 2\left[\frac{(Z_a + z_\beta) * S^{2}}{d}\right]$$

Z_a Level of significance = 95%

Z_β--power of the study = 90%

D = clinically significant difference between two parameters.

SD = Standard deviation.

STATISTICAL ANALYSIS:

Using the statistical software for the social sciences, the data were analyzed statistically after being entered into a Microsoft Excel sheet (Version 20).

Mean, SD, counts, percentages, and graphs were used to display the results.

Independent t-tests were used to compare normally distributed continuous variables between two groups. Mann Whitney U test was employed for variables that weren't normally distributed. Using the Chi-square categorical variables between the two groups were compared.

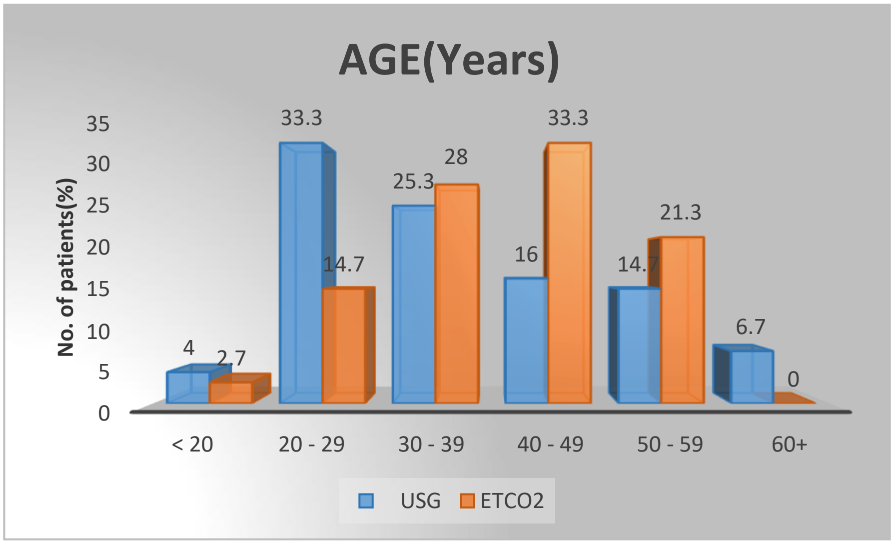
p<0.05 were considered statistically significant. All statistical tests were performed two tailed.

RESULTS

Table 1: Comparison of age between USG and ETCO2

Age (Years)	USG		ETCO2		Independent t test	P value
	No. of patients	Percentage	No. of patients	Percentage		
< 20	3	4.0	2	2.7	2.0	0.06
20 - 29	25	33.3	11	14.7		
30 - 39	19	25.3	21	28.0		
40 - 49	12	16.0	25	33.3		
50 - 59	11	14.7	16	21.3		
60+	5	6.7	0	0		
Total	75	100.0	75	100.0		
Mean±SD	36.16	12.73	40.08	10.954		
Statistically insignificant as P value is more than 0.05.						

The sample's age distribution in the two groups is comparable. There is no statistical distinction between the USG and the ETCO2 group.

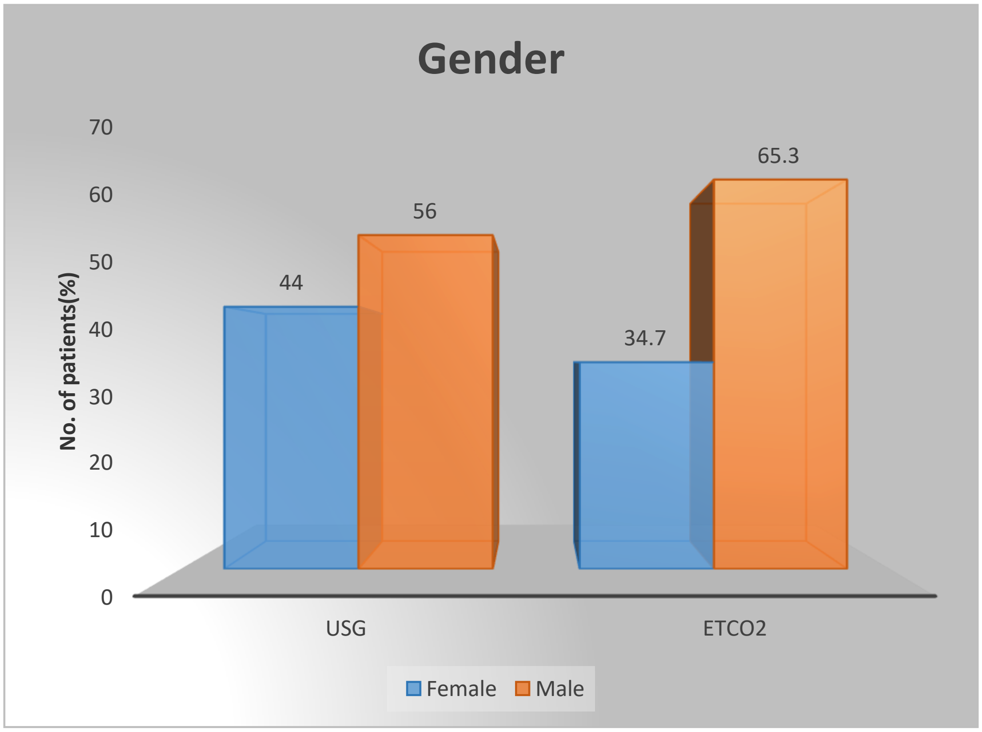


Graph 1: Age distribution in both the groups

Table 2: Comparison of gender between USG and ETCO2

Gender	USG		ETCO2		Chi Square Test	P value
	No. of patients	Percentage	No. of patients	Percentage		
Female	33	44.0	26	34.7	1.369	0.2420
Male	42	56.0	49	65.3		
Total	75	100.0	75	100.0		
Statistically insignificant as P value is more than 0.05.						

The male and female patients among both the groups were comparable. There is no statistical difference between the both the USG and ETCO2 group.

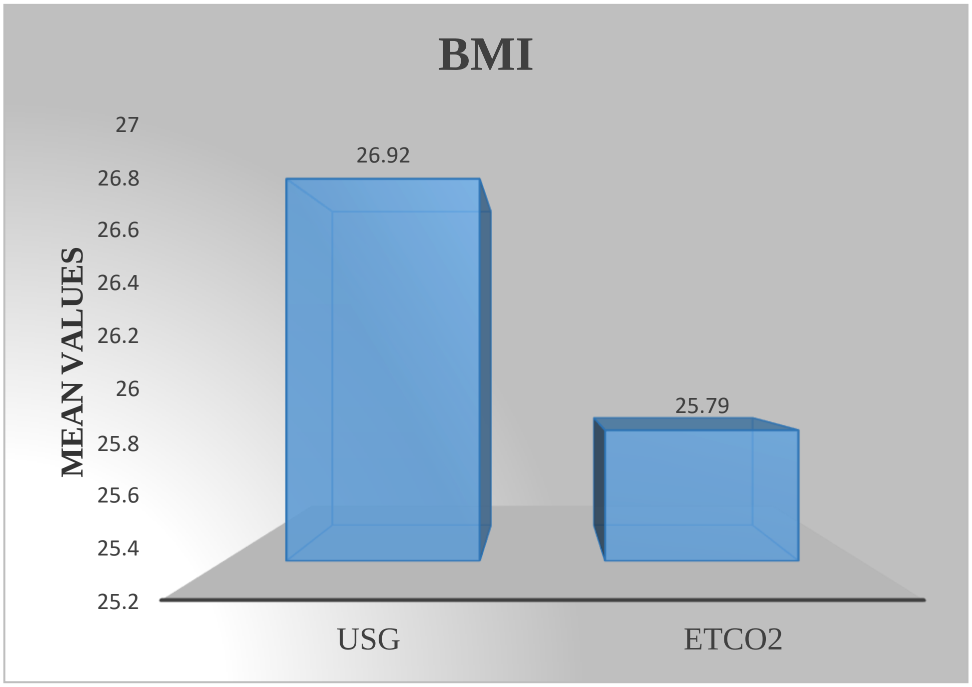


Graph 2: Gender wise distribution in both the groups

Table 3: Comparison of BMI between the USG and ETCO2 groups

Comparison of	USG		ETCO2		Mann-Whitney U test	P value
	Mean	Std. Deviation	Mean	Std. Deviation		
BMI	26.92	12.390	25.79	4.262	2741.000	0.787
Statistically insignificant as P value is more than 0.05.						

The BMI among both the groups were comparable. There is no statistical difference between the both the USG and ETCO2 group.

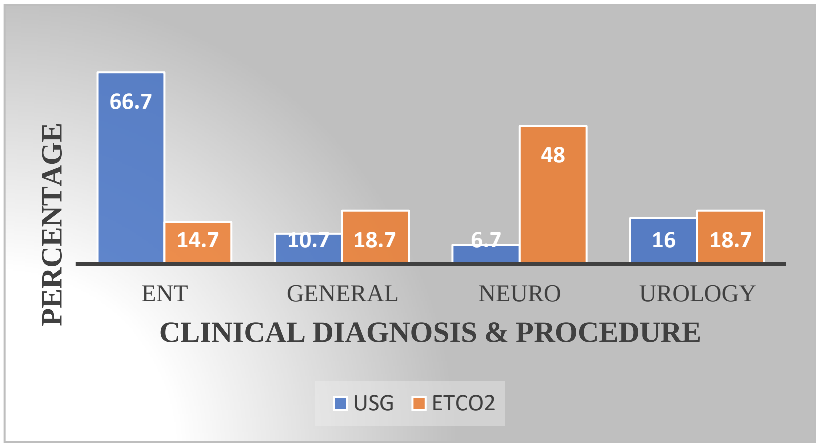


Graph 3: Comparison of BMI among both the groups

Table 4: Comparison of clinical diagnosis & surgical procedure between USG and ETCO2 groups

CLINICAL DIAGNOSIS	USG		ETCO2		Chi square test	P value
	No. of patients	Percentage	No. of patients	Percentage		
ENT	50	66.7	11	14.7	50.164	<0.0001
GENERAL SURGERY	8	10.7	14	18.7		
NEURO	5	6.7	36	48		
UROLOGY	12	16.0	14	18.7		
Total	75	100.0	75	100.0		
Statistically significant as P value is less than 0.05.						

The clinical diagnosis and procedure among the both groups, in which in the first group of USG the percentage of ENT, General surgery, Neurosurgery, Urology were 66.7%, 10.7%, 6.7%, 16.% respectively and in the ETCO2 group, the percentage of ENT, General surgery, Neurosurgery, Urology were 14.7%, 18.7%, 48%, 18.7% respectively.

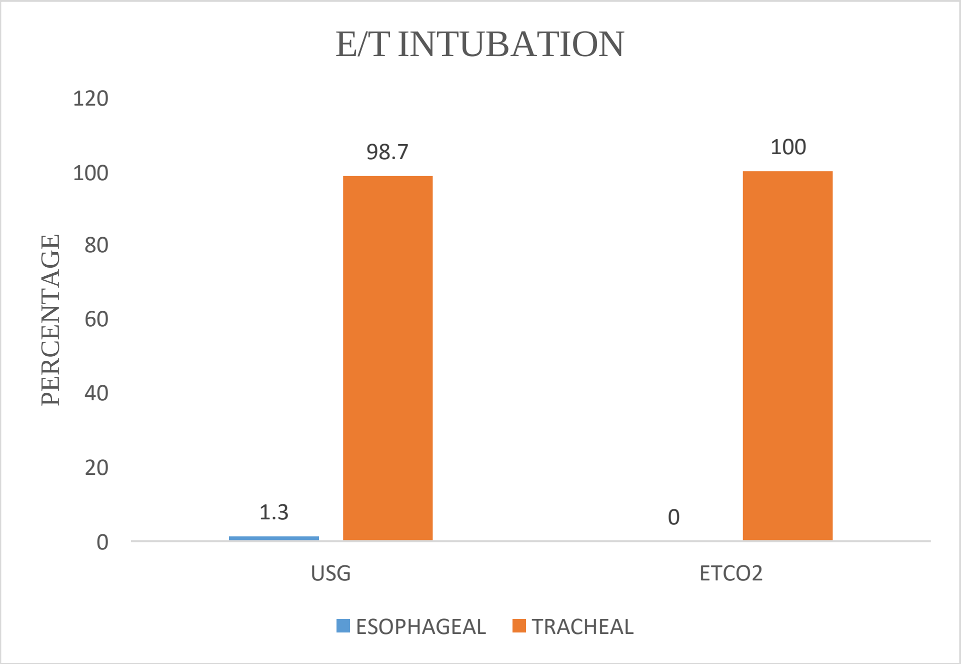


Graph 4: Comparison of clinical diagnosis & surgical procedure between USG and ETCO2 groups

Table 5: Comparison of Endotracheal (T) / Oesopgheal intubation (E) between USG and ETCO2 groups

E/T INTUBATION	USG		ETCO2		Chi square test	P value
	No. of intubations	Percentage	No. of intubations	Percentage		
Esophageal	1	1.3	0	0	1.007	0.3157
Tracheal	74	98.7	75	100.0		
Total	75	100.0	75	100.0		
Statistically insignificant as P value is more than 0.05.						

The Upper airway USG was able to diagnose the esophageal intubation in real time. The results are comparable. The statistical difference is insignificant as P value is more than 0.05.

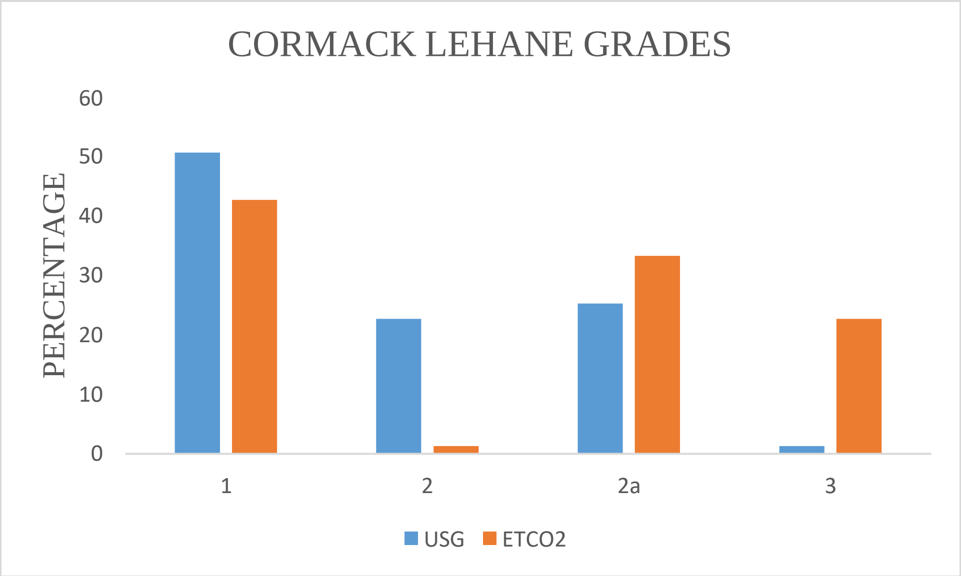


Graph 5: Comparison of Endotracheal (T) / Oesophageal (E) intubation among both the groups

Table 6: Comparison of Cormack Lehane between USG and ETCO2 groups

CORMACK LEHANE GRADES	USG		ETCO2		Chi square test	P value
	No. of intubations	Percentage	No. of intubations	Percentage		
1.	38	50.7	32	42.7	29.777	<0.0001
2.	17	22.7	1	1.3		
2a	19	25.3	25	33.3		
3.	1	1.3	17	22.7		
Total	75	100.0	75	100.0		
Statistically significant as P value is less than 0.05.						

The Cormack Lehane grades between the USG and ETCO2 groups is statistically significant.

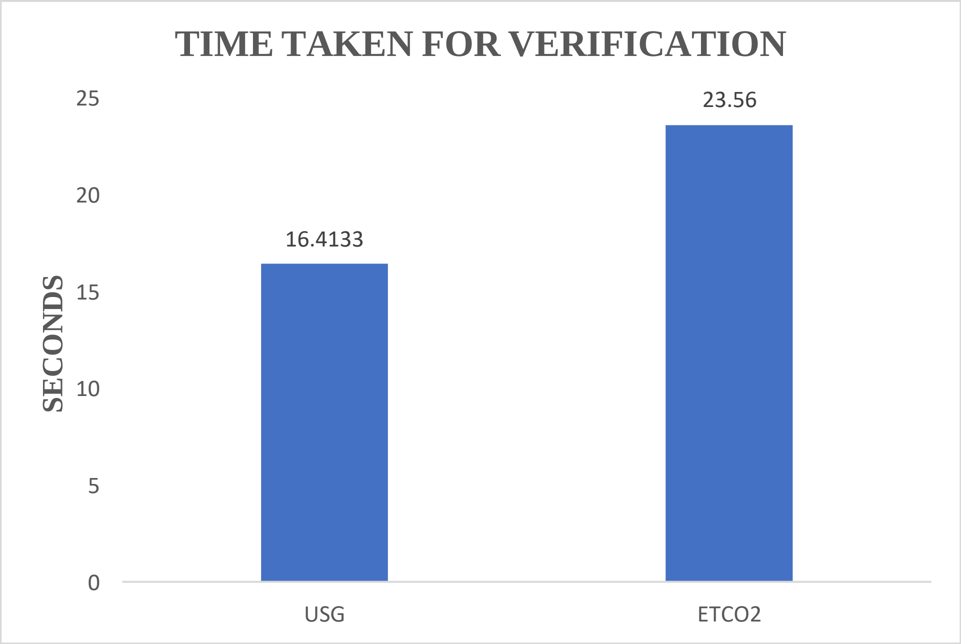


Graph 6: Comparison of Cormack Lehane grades among both the groups

Table 7: Comparison of Time taken for verification between USG and ETCO2 groups

VARIABLE	NUMBER OF PATIENTS	AVERAGE TIME TAKEN FOR VERIFICATION (SECS)	Mann Whitney Test	P value
USG	75	16.4133	0.000	0.000
ETCO2	75	23.5600		
Statistically significant as P value is less than 0.05.				

The time taken for the Upper airway USG and ETCO2 were 16.4133 seconds and 23.56 seconds. This is statistically significant as USG has shown to be taking less time for the identification of ETT than ETCO2.



Graph 7: Time taken for verification of ETT by USG and ETCO2 groups

DISCUSSION

Tracheal intubation has two basic objectives: putting the tube in the trachea and positioning it at the right depth inside the trachea. Tracheal intubation can be verified with absolute certainty by seeing the tube pass between the cords during direct laryngoscopy and by seeing the tracheal rings and carina with a fiberscope after intubation. There are various methods to verify tracheal and oesophageal intubation in elective and emergency settings.

End-tidal carbon dioxide and upper airway USG distinguish between tracheal and esophageal intubation early in the intubated patient. A chest scan in a critical care situation can quickly find misplaced tracheal tubes. [27]

This prospective study was carried out to find out whether the upper airway USG can be superior to end tidal carbon dioxide in verification of endotracheal intubation. The patients in this study ranged widely in terms of their age, weight, and types of operations. With no waveform visible on capnography, upper airway USG was able to diagnose the oesophageal intubation. Therefore, it was discovered that upper airway USG was 100% specific for identifying oesophageal intubation.

The sniffing posture, according to the study by Galcinao et al., [28] and

Shibasaki et al.,[29] allowed for the best picture collection. Similar to other studies, ours found that the sniffing posture was ideal for both intubation and ultrasonography of the upper airway.

According to Kristensen et al., [11] imaging superficial airway structures is best done with a linear high-frequency transducer. By positioning the ultrasonic probe transversely on the neck at the level of the suprasternal notch during intubation, USG can be utilized to directly observe whether the tube enters the trachea or the oesophagus, verifying intubation without the need for ventilation or circulation. Even in our study, a linear high-frequency probe was positioned transversely at the level of the suprasternal notch to observe the endotracheal intubation.

In Priyanka Bansal et al., [14] study, the probe was positioned horizontally from the cricothyroid membrane up to the suprasternal notch where as the transducer probe was solely positioned at the level of the suprasternal notch in our study. Placing the transducer probe over the cricothyroid membrane offers more specificity. Our analysis showed the same sensitivity and specificity as the tracheal rapid ultrasound examination (TRUE) study by Chou HC et al [10] and Masoumi B et al.,[30], in which they placed a convex transducer probe transversely above the suprasternal notch.

The operational characteristics value for prediction of tracheal ETT insertion were found to be satisfied with both dynamic and static ultrasonography in the study by Saeed Abbasi et al [12] on direct ultrasound methods. Dynamic and static ultrasonography was used to do the ultrasonography. We did ultrasonography during and after intubation in our trial as well and found that both methods were satisfactory.

In our study, upper airway USG discovered one esophageal intubation, which was confirmed by waveform capnography to be positive. In one investigation by Sustic et al., [31] it was discovered that two of the false negative patients had subcutaneous emphysema as a result of pneumothorax, which made it challenging to identify two hyper echoic lines. The false negative subjects were discovered to be overweight or obese with more subcutaneous fat in the neck region in a study by Kundra P et al., and Singh M et al.,[32] [33]. It is challenging to identify the hyper echoic comet tail shape and posterior shadowing in the transverse view, and as a result, the ETT placement was missed in a study by Ezri et al., [34]

In a study of paediatric patients, Galcinao et al., [28] compared bedside ultrasonography with a colorimetric end-tidal carbon dioxide monitor and chest radiographs and came to the conclusion that ultrasound is timelier than chest radiographs.

Upper airway USG and capnography have a rapid mean time of 12 seconds and 9 seconds, respectively, according to a study by Abhishek C et al [3]. In the study by Vimal Koshi Thomas et al.,[13] endotracheal tube placement was identified more quickly by ultrasound than by end-tidal capnography and other standard clinical techniques. Our study found that upper airway USG identified the installation of the ET tube faster than capnography, with quick mean times of 16 seconds and 23 seconds, respectively.

There are numerous ways to verify the location of the endotracheal tube after intubation. Before securing the endotracheal tube, preliminary confirmation procedures include quantitative waveform capnography measurement, auscultation of breath sounds, bilateral chest rise, presence of condensed vapor in the tube, and direct observation of the tube passing through the glottis. [35,36]

The direct method of confirmation known as capnography measures the amount of carbon dioxide in the exhaled air. Our research shows that upper airway ultrasound can be used as a direct technique of real-time viewing of upper airway features to determine where an endotracheal tube is inserted.

In conditions with the low pulmonary flow, such as cardiac arrest or severe shock, bronchoconstriction, or other circumstances, such as hypothermia, when ETCO2 may be inaccurate and the validity of quantitative capnography is questioned, but the upper airway USG images are unaffected. [37]

USG is painless, portable, reasonably priced, and radiation-free, and its safety has been established. Hence Ultrasound has become more often used in the management of the upper airways, particularly in emergency situations and outlying clinics where capnography is not always easily available. Therefore, in such circumstances and in an emergency, ultrasonography can be utilized to verify the insertion of an ETT. Upper airway USG has been demonstrated to be faster and more accurate than auscultation in confirming endotracheal tube placement in overweight and obese patients.

There are many complications which are associated with endotracheal intubation such as severe hypoxemia, severe hypotension, etc., [39] The dreaded complication during endotracheal intubation which is oesophageal intubation which has a role in perioperative morbidity was discovered in our study by USG.

There are a few limitations in our study such as performing upper airway USG is user dependent and it requires in-depth knowledge about the sono-anatomy of the upper airway for effective visualization. Another limitation is that airway difficulty in obese patients and their correlation with the upper airway USG pre-operatively and perioperatively were not emphasized upon.

Both methods were safer, quicker, and more efficient than alternative methods like chest radiography. The advantage of upper airway USG is it is quicker and more reliable than ETCO2. This study, therefore, shows that upper airway USG could be utilized as the initial verification of endotracheal tube insertion.

CONCLUSION

Compared to ETCO2, upper airway USG has better reliability, portability, faster confirmation times and reproduction of images is possible. ETCO2, on the other hand, is not available in all the centres and it is not as accurate because of its variation based on the various pathophysiologic conditions of the body. Upper airway USG has the potential to replace other non-invasive airway assessment methods as the primary method in the future for the confirmation of ET tube under General anaesthesia.

SUMMARY

This randomized comparative study titled “**COMPARISON OF UPPER AIRWAY ULTRASONOGRAPHY WITH END TIDAL CAPNOGRAPHY FOR CONFIRMATION OF ENDOTRACHEAL TUBE PLACEMENT IN PATIENTS REQUIRING GENERAL ANAESTHESIA’’** was carried out from December 2020 to August 2022 in the department of anaesthesiology at Shri BM Patil medical college and hospital, BLDE University, Vijayapura.

This study was designed to compare the upper airway ultrasonography with ETCO2 for the confirmation of ETT placement in the trachea in patients undergoing elective surgeries under general anaesthesia.

The objectives of this study were to compare the time taken and the number of correct tracheal/oesophageal intubation identified by both upper airway USG and ETCO2.

The study population of 150 patients were selected between the age of more than 20 years and less than 60 years under ASA I and II. They were randomised by envelope picking method into U – USG group and E – ETCO2 group.

Group U – Upper airway USG was performed for the confirmation of ETT placement

Group E – ETCO2 was used for the confirmation of ETT placement

The time taken and correct tracheal/oesophageal intubation identified by each USG and ETCO2 group was noted.

The results were USG upper airway had a faster average confirmation time of 16.41 seconds when compared to ETCO2 which took an average confirmation time of 23.56 seconds. Upper airway USG also was able to identify oesophageal intubation with 100% specificity.

Thus, Upper airway USG can be used as a standard method for confirmation of ETT placement in patients undergoing general anaesthesia.

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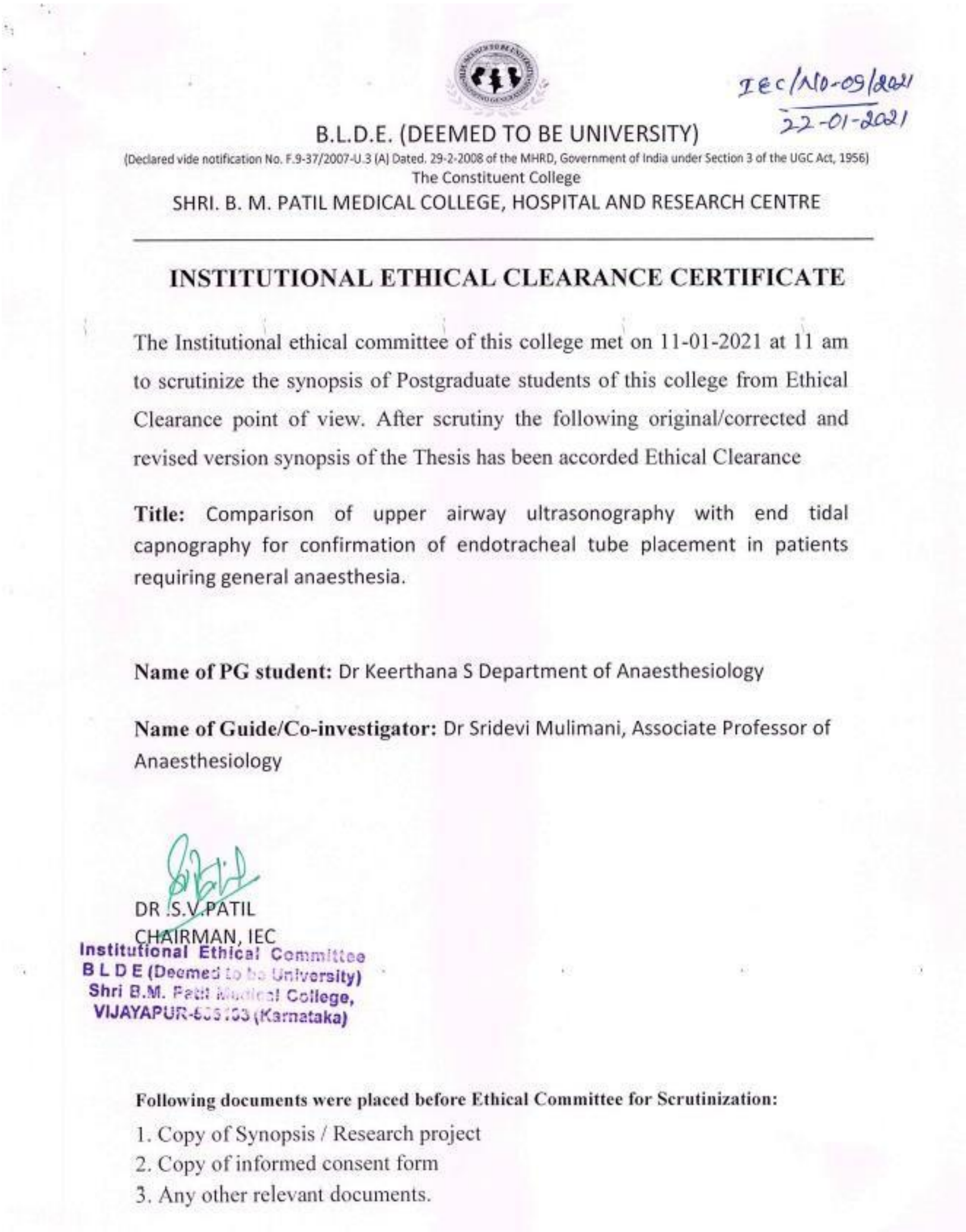
ANNEXURE-I

ETHICAL CLEARANCE CERTIFICATE



IEC/No-09/2021
22-01-2021

B.L.D.E. (DEEMED TO BE UNIVERSITY)
(Declared vide notification No. F.9-37/2007-U.3 (A) Dated. 29-2-2008 of the MHRD, Government of India under Section 3 of the UGC Act, 1956)
The Constituent College
SHRI. B. M. PATIL MEDICAL COLLEGE, HOSPITAL AND RESEARCH CENTRE

INSTITUTIONAL ETHICAL CLEARANCE CERTIFICATE

The Institutional ethical committee of this college met on 11-01-2021 at 11 am to scrutinize the synopsis of Postgraduate students of this college from Ethical Clearance point of view. After scrutiny the following original/corrected and revised version synopsis of the Thesis has been accorded Ethical Clearance

Title: Comparison of upper airway ultrasonography with end tidal capnography for confirmation of endotracheal tube placement in patients requiring general anaesthesia.

Name of PG student: Dr Keerthana S Department of Anaesthesiology

Name of Guide/Co-investigator: Dr Sridevi Mulimani, Associate Professor of Anaesthesiology

DR .S.V.PATIL
CHAIRMAN, IEC

Institutional Ethical Committee
B L D E (Deemed to be University)
Shri B.M. Patil Medical College,
VIJAYAPUR-586103 (Karnataka)

Following documents were placed before Ethical Committee for Scrutinization:

1. Copy of Synopsis / Research project
2. Copy of informed consent form
3. Any other relevant documents.

ANNEXURE –II

SAMPLE INFORMED CONSENT FORM:

B.L.D.E.U.'s SHRI B.M. PATIL MEDICAL COLLEGE HOSPITAL AND
RESEARCH CENTER, VIJAYAPURA - 586103, KARNATAKA

TITLE OF THE PROJECT:

TO COMPARE UPPER AIRWAY ULTRASONOGRAPHY WITH END-TIDAL CAPNOGRAPHY FOR CONFIRMATION OF ENDOTRACHEAL TUBE PLACEMENT IN PATIENTS REQUIRING GENERAL ANAESTHESIA.

PRINCIPAL INVESTIGATOR: Dr. KEERTHANA S
Department of Anaesthesiology
BLDE University's Shri B M Patil Medical College
& Research Center, Solapur Road Vijayapura-03
E mail: keerthisivaji.s@gmail.com

PG GUIDE: Dr. Sridevi Mulimani
M.D.
ANAESTHESIOLOGY
Professor
Dept of Anaesthesiology
BLDE University's Shri B M Patil Medical
College & Research Center, Vijayapura

PURPOSE OF RESEARCH:

I have been informed that this study is to compare upper airway ultrasonography with end tidal capnography for confirmation of endotracheal tube placement in patients requiring general anaesthesia.

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

PROCEDURE:

I understand that I will be participating in the study to compare upper airway ultrasonography with end tidal capnography for confirmation of endotracheal tube placement in patients requiring general anaesthesia.

RISKS AND DISCOMFORTS:

I understand that my ward may experience some discomfort during the procedure and I understand that necessary measures will be taken to reduce them.

BENEFITS:

I understand that my ward participating in this study will help in comparing upper airway ultrasonography with end tidal capnography for confirmation of endotracheal tube placement in patients requiring general anaesthesia.

CONFIDENTIALITY:

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

REQUEST FOR MORE INFORMATION:

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

If during this study or later I wish to discuss my participation in or concerns regarding this study with a person not directly involved, I am aware that the social worker of the hospital is available to talk with me. And that a copy of this consent form will be given to me for keep for careful reading.

REFUSAL OR WITHDRAWAL OF PARTICIPATION:

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

I also understand Dr. KEERTHANA.S will terminate my participation in this study at any time after she has explained the reason for doing so and has helped arrange for my continued care by my own physician or therapist, if this is appropriate.

INJURY STATEMENT:

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

I understand that by my agreement to participate in this study, I am not waiving my legal rights. I have explained to______________________________the purpose of this research, the procedure required and the possible risk and benefits, to the best of my ability in patients own language

DATE Dr. KEERTHANA S (investigator)

PATIENT/PARENT SIGNATURE Witness

STUDY SUBJECT CONSENT STATEMENT:

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

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

___________________ _____________

(Participant) (Date)

_____________________ ______________

(Witness to above signature) (Date)

ANNEXURE –III

SCHEME OF CASE TAKING

PROFORMA

STUDY:

TO COMPARE UPPER AIRWAY ULTRASONOGRAPHY WITH END-TIDAL CAPNOGRAPHY FOR CONFIRMATION OF ENDOTRACHEAL TUBE PLACEMENT IN PATIENTS REQUIRING GENERAL ANAESTHESIA.

Patient details:

Name

Age

Gender

Height

Weight

BMI

Ward

Diagnosis

Surgical procedure

Past history

Comorbidities

Group allotted by randomization: U/E

General physical examination:

Pallor

Icterus

Cyanosis

Clubbing

Lymphadenopathy

Edema

Mallampatti Grade

Vital parameters:

Pulse

Blood pressure

Respiratory rate

Temperature

Systemic Examination:

CVS

RS

CNS

PA

Investigations:

Hemoglobin:

TLC:

Platelet count:

Urine routine:

HIV:

HbsAg:

Other investigations:

ASA grade

Parameters:

PARAMETERS	NUMBER OF CORRECT ENDOTRACHEAL INTUBATION	NUMBER OF CORRECT IDENTIFICATION OF ESOPHAGEAL INTUBATION
USG		
ETCO2		

PARAMETER	Upper Airway USG	Capnography
Time taken for verification		

BIO-DATA

Guide Name: Dr. Sridevi Mulimani

Date of Birth: 11/11/1966

Education: MBBS-1990 (KIMS, HUBLI)
Diploma in Anaesthesiology-1993 (KIMS, HUBLI)
MD anaesthesiology-2007 (Shri B.M Patil Medical College)

Designation: Professor Department of Anaesthesiology

Teaching: UG Teaching- 27 Years, PG Teaching-13Years

Address: Professor
Department of Anaesthesiology
B.L.D.E.U'S Shri B.M. Patil Medical College and Research Center
Vijayapura-586103
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INVESTIGATOR:

Name: Dr. KEERTHANA. S

Qualification: M.B.B.S (2013-2019),
Saveetha Medical College, Chennai

KMC Reg.No: KTK 0001542

Address: Department of Anaesthesiology,
Shri B.M.Patil Medical College Hospital and Research Center,
Vijayapura-586 103
Karnataka

S.NO	AGE	SEX	BMI	ASA GRADE	MALLAMPATI GRADE	CORMACK LEHANE	CLINICAL DIAGNOSIS	SURGICAL PROCEDURE	NUMBER OF ATTEMPTS FOR INTUBATION	E/T INTUBATION	TIME TAKEN FOR IDENTIFICATION BY USG & ETCO2(SEC)
1	40	F	28	1	1	1	L4-L5 Listhesis	L4-L5 Decompression	1	T	17
2	50	M	30.4	2	1	3	Left DNS with B/LITH	SMR	1	T	18
3	26	M	29.8	2	2	2a	Left DNS with B/LITH	Septoplasty	1	T	16
4	20	M	22	1	1	1	Right DNS	Septoplasty	1	T	17
5	22	F	19.4	1	1	1	P2L2	Laproscopic tubectomy	1	T	18
6	36	F	28.5	2	2	2a	Right CSOM	Right tympanomastoidectomy	1	T	16
7	27	M	21.9	1	2	1	Recurrent appendicitis	Laproscopic apppendicectomy	1	T	15
8	19	M	20	2	2	1	B/L Gynecomastia	Excision	1	T	16
9	60	F	29.8	2	2	1	Cholelithiasis	Laproscopic cholecystectomy	1	T	17
10	51	F	19.5	1	1	1	Lump in right breast	Right MRM	1	T	18
11	39	F	21.8	1	1	1	Left CSOM	Right MRM	1	T	15
12	60	F	26.9	2	2	2a	Left renal calculus	Left PCNL + DJS	1	T	14
13	22	F	28.9	1	1	1	Right ovarian simple cyst	Laproscopic cystectomy	1	T	16
14	59	F	32	1	1	1	Left sinonasal polyp	FESS	1	T	17
15	38	F	22.9	2	2	2a	Cholelithiasis	Laproscopic cholecystectomy	1	T	18
16	56	F	32	2	2	2	Biliary cholecystitis	Laproscopic cholecystectomy	1	T	16
17	65	F	27.6	1	1	1	L3-L4, L4-L5 Listhesis	Laminectomy	1	T	18
18	42	F	21.8	2	2	2a	L4-L5 IVDP	L4-L5 Fixation	1	T	17
19	60	M	29.9	1	1	1	L4-L5 Wedge compression#	Vertebroplasty	1	T	16
20	42	F	24.8	2	2	2	L4-L5 IVDP	L4-L5 Fixation	1	T	18
21	38	F	22	1	1	1	Chronic tonsillitis	Tonsillectomy	1	T	18
22	45	F	23.8	1	1	1	Left CSOM	Left Tympanomastoidectomy	1	T	16
23	30	M	26.9	2	2	2a	DNS With B/LITH	SMR	1	T	17
24	20	M	29	1	2	2	Right DNS	Septoplasty	1	T	17
25	30	M	32	2	2	1	Left DNS with B/LITH	Septoplasty	1	T	17
26	27	M	31.5	1	1	1	Left DNS	Septoplasty	1	T	15
27	18	F	23.6	1	1	1	DNS With sinusitis	FESS with septoplasty	1	T	16
28	27	M	30	1	2	2	Right CSOM	Right Tympanomastoidectomy	1	T	17
29	20	F	37.9	2	2	2a	Chronic tonsillitis	Tonsillectomy	1	T	15
30	26	M	36.5	1	1	1	Chronic tonsillitis	Tonsillectomy	1	T	16
31	26	M	23.7	1	2	2	DNS	Septoplasty	1	T	17
32	25	F	26.2	2	2	2a	Right CSOM	Right tympanomastoidectomy	1	T	16
33	31	M	28.8	1	1	1	Sinusitis	FESS	1	T	17
34	20	M	26.7	2	2	2a	Chronic tonsillitis	Tonsillectomy	1	T	15
35	45	F	22	1	2	2	Nasal polyposis	FESS with septoplasty	1	T	15
36	31	M	24	2	2	2a	DNS With B/LITH	Septoplasty	1	T	16
37	46	F	23.8	1	1	1	Right CSOM	Right tympanomastoidectomy	1	T	15
38	47	F	24	1	1	1	Right CSOM	Right tympanomastoidectomy	1	T	17
39	22	M	22.7	2	2	2a	Recurrent antrochoanal polyp	FESS	1	T	17
40	41	F	33	1	1	1	Right CSOM	Right tympanomastoidectomy	1	T	15
41	26	M	19.8	1	1	1	DNS	Septoplasty	1	T	16
42	18	F	23	1	1	1	DNS	Septoplasty	1	T	15
43	29	M	25	1	2	2	DNS	Septoplasty	1	T	15
44	33	M	26.8	2	2	2a	Left CSOM	Left tympanomastoidectomy	1	T	16
45	50	F	27.9	1	1	1	Right CSOM	Right tympanomastoidectomy	1	T	17
46	22	M	30	1	2	2	Inferior turbinate hypertrophy	Turbinate reduction	1	T	16
47	60	M	22	2	2	2a	Left submandibular abscess	Incision and drainage	1	T	15
48	27	M	33	1	1	1	Chronic tonsillitis	Tonsillectomy	1	T	16
49	25	M	18	1	1	1	DNS	Septoplasty	1	T	17
50	27	M	30	1	1	1	Left CSOM	Left tympanomastoidectomy	1	T	16
51	25	M	22.6	2	2	2a	Right CSOM	Right tympanomastoidectomy	1	T	15
52	29	M	24.7	1	2	2	DNS	Septoplasty	1	T	16
53	31	F	33	1	2	2	Chronic tonsillitis	Tonsillectomy	1	T	17
54	55	F	19.8	1	1	1	Left CSOM	Left tympanomastoidectomy	1	T	18
55	28	M	18.9	2	2	2a	Right CSOM	Right tympanomastoidectomy	1	T	17
56	31	M	17.9	1	2	2	Sinusitis	FESS	1	T	17
57	33	M	24.5	1	1	1	Sinusitis	FESS	1	T	17
58	21	F	22.8	1	1	1	Chronic tonsillitis	Tonsillectomy	1	T	18
59	32	F	27	1	2	2	DNS With sinusitis	FESS with septoplasty	1	T	16
60	30	F	26	1	2	2	Right CSOM	Right tympanomastoidectomy	1	T	15
61	36	M	22.4	2	2	2a	Left CSOM	Left tympanomastoidectomy	1	T	14
62	25	M	25.6	1	1	1	DNS With B/LITH	Septoplasty with turbinectomy	1	T	16
63	50	M	24.4	2	2	2a	Right CSOM	Right tympanomastoidectomy	1	T	17
64	35	M	25.6	1	1	1	Left CSOM	Left MRM	1	T	18
65	31	M	26.5	1	2	2	Left renal calculus	Left PCNL + DJS	1	T	17
66	44	M	22.4	1	2	2	Right renal calculus	Right PCNL + DJS	1	T	17
67	47	F	23.5	1	1	1	Right renal calculus	Right PCNL + DJS	1	T	18
68	32	M	28.4	2	2	2a	Left upper ureter calculus	Left PCNL + DJS	1	T	17
69	47	F	21.3	1	2	2	Right renal calculus	Right PCNL + DJS	1	T	18
70	40	M	19.8	1	1	1	Left renal calculus	Left PCNL + DJS	1	T	16
71	50	M	24.5	2	2	2a	Right renal calculus	Right PCNL + DJS	1	E	15
72	58	F	25.6	1	1	1	Left impacted PUJ Calculus	Left PCNL + DJS	1	T	16
73	52	M	19.6	1	1	1	Right renal calculus	Right RIRS + DJS	1	T	17
74	52	M	125.6	1	2	2	Right renal calculus	Right PCNL + DJS	1	T	18
75	32	M	21.3	1	1	1	Left renal calculus	Left PCNL + DJS	1	T	22
76	29	M	21.4	1	1	1	Recuurent appendicitis	Laproscopic appendicectomy	1	T	22
77	45	F	24.5	1	2	2	Right renal calculus	Right PCNL + DJS	1	T	22
78	21	F	22	2	2	2a	Recurrent appendicitis	Laproscopic appendicectomy	1	T	24
79	35	M	22.4	1	1	1	Right inguinal hernia	Lap Mesh hernioplasty	1	T	24
80	50	M	23.9	2	2	2a	Umbilical hernia + cholelithiasis	Lap Cholcystectomy + mesh herr	1	T	23
81	22	F	24.5	1	1	1	Acute appendicitis	Laproscopic appendicectomy	1	T	25
82	21	M	22.8	1	2	2	Right DNS with ITH	Septoplasty	1	T	24
83	60	M	21.8	1	1	1	B/L ethmoidal polyp	FESS	1	T	24
84	60	F	24.9	1	2	2	Mucocele of appendix	Diagnostic laproscopy and proce	1	T	23
85	48	M	26.9	2	2	2a	L4-L5, L5-S1 IVDP	L4-L5 laminectomy	1	T	25
86	37	M	33	1	1	1	L3-L4 Listhesis	Laminectomy and discectomy	1	T	22
87	31	F	19.8	1	2	2	Thalamic glioma	Excision	1	T	23
88	45	M	18.8	1	2	2a	L4-L5, L5-S1 IVDP	L4-L5 laminectomy	1	T	24
89	40	F	18	2	2	2a	L4-L5 Listhesis	L4-L5 Fixation	1	T	24
90	37	M	22.7	1	2	2	L4-L5 disc bulge	Laminectomy and discectomy	1	T	23
91	45	F	33	1	1	1	C5-C6 disc bulge	C5-C6 ACDF	1	T	22
92	52	M	24.2	1	1	1	C3-C4-C5 compression	laminectomy	1	T	25
93	19	M	22.8	1	1	1	Left FTP SDH with bone flap	Cranioplasty	1	T	26
94	20	M	21.8	1	2	2	DNS	Septorhinoplasty	1	T	23
95	47	F	20.5	1	2	2	Rhinoscleroma	SMR with synechiae release	1	T	24
96	37	F	19.8	2	2	2a	Laryngeal papilloma	MLS	1	T	25
97	45	F	18.9	1	2	2	Chronic tonsillitis	Tonsillectomy	1	T	25
98	40	M	17.9	1	2	2	Left staghorn calculus	Left PCNL + DJS	1	T	22
99	40	F	23.8	1	1	1	Left PUJ calculus	Left PCNL + DJS	1	T	23
100	52	F	28	1	2	2	Right renal calculus	Right PCNL + DJS	1	T	24
101	40	F	32	1	1	1	Left PUJ calculus	Left PCNL + DJS	1	T	25
102	49	M	31.5	1	1	1	Right renal calculus	Right PCNL + DJS	1	T	26
103	45	F	29.6	1	2	2	Right renal calculus	Right PCNL + DJS	1	T	23
104	35	F	28	1	2	2	Right renal calculus	Right PCNL + DJS	1	T	24
105	32	M	32	1	1	1	B/L Renal calculus	Left PCNL + DJS	1	T	22
106	32	M	26.9	1	2	2a	Left renal calculus	Left PCNL + DJS	1	T	22
107	38	F	24.7	1	1	1	Right renal calculus	Right PCNL + DJS	1	T	24
108	36	F	24.5	1	2	2a	Right PUJ obstruction	Right pyeloplasty	1	T	25
109	33	M	23.7	1	1	1	Right renal calculus	Right PCNL + DJS	1	T	23
110	28	M	23.9	1	2	2	Right renal mass	Exploratory laparotomy	1	T	24
111	53	M	25.8	1	1	1	L4-L5 Listhesis	L4-L5 Fixation	1	T	24
112	35	M	30	1	2	2	L5-S1 Listhesis	L5-S1 laminectomy	1	T	22
113	49	M	27.9	1	1	1	C5-C6 compression	C5-C6 ACDF	1	T	22
114	40	F	28.8	1	2	2	L4-L5 Listhesis	L4-L5 laminectomy	1	T	22
115	55	M	23.7	1	2	2a	C4-C5 Compression myelopathy	C4-C5 ACDF	1	T	23
116	26	M	28.8	1	2	2	Post frontal decompression	Cranioplasty	1	T	24
117	50	M	30	1	1	1	L5-S1 Listhesis	L5-S1 laminectomy	1	T	24
118	22	F	33	1	2	2a	L1-L2 listhesis	L1-L2 fixation	1	T	24
119	34	M	25.7	1	1	1	C3-C4-C5 compression	ACDF	1	T	24
120	55	M	26.5	1	1	1	L4-L5 IVDP	L4-L5 laminectomy	1	T	24
121	22	M	22.8	1	2	2a	L4-L5 Listhesis	L4-L5 Fixation	1	T	23
122	30	M	29.6	1	2	2	L4-L5 IVDP	L4-L5 listhesis	1	T	22
123	46	M	23.6	1	1	1	Right FTP calvareal defect	Cranioplasty	1	T	23
124	46	M	23.8	1	2	2	L4-L5, L5-S1 IVDP	L4-L5, L5-S1 Laminectomy	1	T	24
125	28	M	30	1	2	2	C4-C5 Compression myelopathy	ACDF	1	T	25
126	19	M	25.7	1	1	1	Hydrocephalus	EVD	1	T	24
127	40	M	22.8	1	2	2a	L3-L4 PVD with listhesis	L3-L4 fixation	1	T	24
128	32	F	26.8	1	2	2	C5-C6 PIVD	ACDF	1	T	23
129	40	F	29	1	2	2	Left CSOM	Left tympanomastoidectomy	1	T	22
130	45	M	31.9	1	1	1	Cholelithiasis	Laproscopic cholecystectomy	1	T	25
131	37	M	23.9	1	1	1	Chronic tonsillitis	Tonsillectomy	1	T	24
132	30	M	22.1	1	1	1	Recuurent appendicitis	Laproscopic appendicectomy	1	T	24
133	59	M	24.5	1	2	2a	C5-C6 Listhesis	C5-C6 ACDF	1	T	24
134	55	M	31.9	1	1	1	L4-L5 IVDP	L4-L5 listhesis	1	T	22
135	35	M	26.2	1	1	1	Right CSOM	Right tympanomastoidectomy	1	T	23
136	29	F	28.4	1	1	1	Acute appendicitis	Laproscopic appendicectomy	1	T	24
137	55	M	26.7	1	2	2a	C4-C5 Compression myelopathy	C4-C5 ACDF	1	T	25
138	45	M	26.2	1	2	2	L4-L5-L6 Compression	L4-L5 laminectomy	1	T	24
139	55	M	28.4	1	2	2a	Cholelithiasis	Laproscopic cholecystectomy	1	T	24
140	47	F	24	1	2	2a	Umbilical hernia	laproscopic mesh hernioplasty	1	T	23
141	44	M	30.4	1	2	2	Right inguinal hernia	laproscopic mesh hernioplasty	1	T	24
143	55	M	20.4	1	2	2	C5-C6 Listhesis	C5-C6 ACDF	1	T	22
144	33	M	28.5	1	1	1	L3-L4 Listhesis	L3-L4 fixation	1	T	23
145	45	F	24	1	1	1	Left CSOM	Left tympanomastoidectomy	1	T	24
146	55	M	40.2	1	1	1	Right CSOM	Right tympanomastoidectomy	1	T	23
147	45	M	29.8	1	2	2a	L4-L5 Listhesis	L4-L5 laminectomy	1	T	22
148	36	F	21.9	1	1	1	C4-C5 Compression myelopathy	C4-C5 ACDF	1	T	22
149	32	F	20.2	1	2	2	Left calvareal defect	Cranioplasty	1	T	24
150	57	M	24.3	1	1	1	Cholelithiasis	Laproscopic cholecystectomy	1	T	25