A COMPARATIVE STUDY ON THE EFFICACY OF TRANSESOPHAGEAL ECHOCARDIOGRAPHY GUIDANCE VERSUS ANATOMICAL LANDMARK TECHNIQUE IN THE PLACEMENT OF CENTRAL VENOUS CATHETER TIP IN PEDIATRIC PATIENTS UNDERGOING SURGERY FOR CONGENITAL HEART DISEASES.

Dissertation submitted to

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DOCTOR OF MEDICINE

IN

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INSTITUTE OF ANAESTHESIOLOGY

& CRITICAL CARE

MADRAS MEDICAL COLLEGE

CHENNAI- 600 003

APRIL 2013

CERTIFICATE

This is to certify that the dissertation entitled, "**A COMPARATIVE STUDY ON THE EFFICACY OF TRANSESOPHAGEAL ECHOCARDIOGRAPHY GUIDANCE VERSUS ANATOMICAL LANDMARK TECHNIQUE IN THE PLACEMENT OF CENTRAL VENOUS CATHETER TIP IN PEDIATRIC PATIENTS UNDERGOING SURGERY FOR CONGENITAL HEART DISEASES",** submitted by **Dr. V. KAILASH** in partial fulfilment for the award of the degree of Doctor of Medicine in Anaesthesiology by the Tamilnadu Dr. M.G.R. Medical University, Chennai is a bonafide record of the work done by him in the INSTITUTE OF ANESTHESIOLOGY AND CRITITICAL CARE and Critical Care, Madras Medical College, Chennai during the academic year 2011-2013.

Dr.M.Vasanthi,M.D.,DA.,DNB.,	**Dr.V.Kanagasabai,M.D.,**
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DECLARATION

I solemnly declare that this dissertation entitled **"A COMPARATIVE STUDY ON THE EFFICACY OF TRANSESOPHAGEAL ECHOCARDIOGRAPHY GUIDANCE VERSUS ANATOMICAL LANDMARK TECHNIQUE IN THE PLACEMENT OF CENTRAL VENOUS CATHETER TIP IN PEDIATRIC PATIENTS UNDERGOING SURGERY FOR CONGENITAL HEART DISEASES"** has been prepared by me, under the Guidance of **Prof.Dr.U.G. THIRUMAARAN, M.D.,** Professor of Anaesthesiology, Madras Medical College, Govt. Institute of Child Health and Hospital for Children, Egmore, Chennai, in partial fulfilment of the regulations for the award of the degree of M.D [Anaesthesiology], examination to be held in April 2013. This study was conducted at Institute of Child Health and Government Hospital for Children, Madras Medical College, Chennai. I have not submitted this dissertation previously to any university for the award of any degree or diploma.

Date :

Place: Chennai **Dr. V.KAILASH**

INSTITUTIONAL ETHICS COMMITTEE
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CERTIFICATE OF APPROVAL

To
Dr. Kailash
PG in MD Anaesthesia
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Dear Dr. Kailash

The institutional Ethics committee of Madras Medical College, reviewed and discussed your application for approval of the proposal entitled "A comparative study on the efficacy of Transesophageal Echocardiography Guidance Versus Anatomical landmark technique in Correct Placement of Central Venous catheter in Pediatric patients undergoing surgery for congenital heart diseases" No.05092012.

The following members of Ethics Committee were present in the meeting held on 13.09.2012 conducted at Madras Medical College, Chennai -3.

1. Dr. S.K. Rajan. M.D.,FRCP.,DSc	-- Chairperson
2. Prof. Pregna B. Dolia MD Vice Principal, Madras Medical College, Chennai -3 Director , Institute of Biochemistry, MMC, Ch-3	-- Member Secretary
3. Prof. B. Vasanthi MD Professor of Pharmacology ,MMC, Ch-3	-- Member
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6. Prof. P. Karkuzhali. MD Director i/c, Prof., Inst. of Pathology, MMC, Ch-3	-- Member
7. Prof. Bavani Shankar. MS Prof of General Surgery, MMC, Ch-3	-- Member
8. Thiru. S. Govindsamy. BABL	-- Lawyer
9. Tmt. Arnold Soulina MA MSW	-- Social Scientist

We approve the proposal to be conducted in its presented form.

Sd/ Chairman & Other Members

The Institutional Ethics Committee expects to be informed about the progress of the study, and SAE occurring in the course of the study, any changes in the protocol and patients information / informed consent and asks to be provided a copy of the final report.

Member Secretary, Ethics Committee

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ABBREVATIONS

ASD	-	Atrial Septal Defect
BCV	-	Brachiocephalic Vein
CVC	-	Central Venous Catheter
CT	-	Crista Terminalis
CHD	-	Congenital Heart Diseases
IJV	-	Internal Jugular Vein
LA	-	Left Atrium
RT	-	Right Atrium
LV	-	Left Ventricle
RV	-	Right Ventricle
TEE	-	Transesophageal Echocardiography

CONTENTS

1. INTRODUCTION & RATIONALE OF STUDY

Central venous catheters are routinely placed in pediatric patients undergoing surgery for congenital heart diseases. The expected volume and hemodynamic disturbances are treated with central venous pressure based volume replacement and multiple inotropic infusions to the central circulation. Post operatively the same catheters are used to deliver antibiotics, parenteral nutrition if necessary. Central venous cannulation is also done in a variety of clinical setup like intensive care units, in major abdominal surgeries, vascular surgery, neurosurgery to administer fluids, rush blood in case of sudden blood loss, antibiotic administration and also in many oncology patients to administer chemotherapeutic agents for a long-term.

Thus a thorough knowledge about the complications due to misplacement of central venous catheter and ideal position for central venous catheter tip placement is a must for an anesthesiologist. According to the recommended guidelines correct position of the CVC tip is considered to be in the superior vena cava 1 cm of above the crista terminalis (or) SVC-RA junction. It is also recommended that the catheter should be in the long axis of the SVC without acute abridgment to the vein wall. It has been shown in laboratory that an angle of the CVC tip to vessel wall of greater than 40^o is more likely to lead to vessel perforation. This location is appropriate because blood flow conditions are optimal to keep the catheter away from the intima and to dilute the infused drugs immediately. Also numerous studies have shown that approximately 90% of cardiac or great vessel perforations which can cause cardiac tamponade occur when the central venous catheter lies in the Right atrium or ventricle and only 10% of the perforation occurs when the catheter is placed in the superior vena cava.[1,2,3]

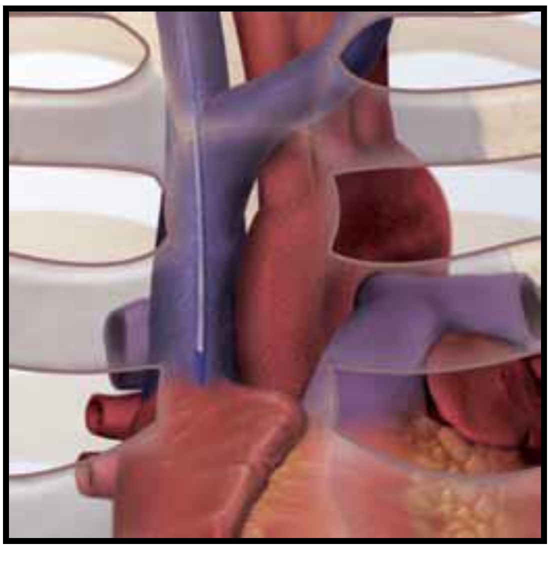


Fig 1.1: Optimal CVC Tip Position

Anesthesiologists usually place the central venous lines in the operating room intra-operatively and the chest x-ray is done postoperatively to confirm the correct placement several hours later. Because incorrect placement can lead to serious complications such as cardiac tamponade, perforation of atrial chamber, malignant dysrhythmias due to irritation of the atrium or the ventricle, unrecognized arterial placement, when the tip of the catheter is positioned outside the thorax, central venous pressure monitoring and waveform analysis may be inaccurate and if the tip is located in the jugular bulb significant central nervous system complications, such as thrombosis of a dural sinus can occur.

Transesophageal echocardiography has become an essential monitor in most patients undergoing surgery for congenital heart diseases to assess the changes in preoperative and post operative cardiac anatomy and function. The transesophageal echocardiograph is being used by the anesthesiologist to guide superior vena cava cannulation through the internal jugular or subclavian vein and would improve the rate of correct positioning of central venous catheter and reduce complications associated with misplacements in infants, children and young adults undergoing surgery for congenital heart disease.

2. OBJECTIVES OF THE STUDY

1. The purpose of the study is to compare the efficacy of transesophageal echocardiography guidance versus anatomical landmark technique in the accurate placement of central venous catheter tip at superior vena cava - right atrial junction in pediatric patients undergoing elective cardiac surgery for congenital heart surgeries.
2. To evaluate the efficacy of Two Dimensional Transesophageal Echocardiography guidance, landmark method and Pere`s formula in the correct placement of central venous catheter tip.

3. HISTORICAL PERSPECTIVES

1952 Aubaniac[4] gave the first description of infraclavicular subclavian vein puncture in humans.

1953 Seldinger[5] described the replacement of a catheter needle using guidewire during central venous cannulation.

1955 Percutaneous catheterization of the inferior vena cava via a femoral vein approach became popular until reports of a high incidence of complications were published[6,7].

1959 Hughes and Magovern[8] described the clinical use of central venous pressure measurements in humans undergoing thoracotomy.

1962 Wilson and Associates[9] extended the practicality of central venous pressure monitoring by using percutaneous infraclavicular subclavian vein catherization.

1962 Yoffa[10] reported his experience with supraclavicular subclavian vein puncture, claiming a lower incidence of complications, but his results were not uniformly reproduced.

1962 Nordlund and Thoren[11] and then Rams and associates[(9)] performed external jugular vein catheterization with fewer complications but positioning of the catheter tip in a central venous location was sometimes impossible.

1966 Hermosura and Colleagues[12] described the technique IJV cannulations and advocated its use in adults.

1969 English et al[13,14] reported first large series (500 cases) of IJV cannulations. Subsequently the procedure became more common and in many centers the preferred method of central venous access.

1974 Blitt et al[15] described a technique of central venous cannulation via the EJV employing a J wire. Although the success rate of this route is lower than with the IJV, a central venipuncture is avoided, and in selected cases catheterization via the EJV is an excellent alternative.

1984 Legler and Nugent[16] first reported the use of ultra sound to assist IJV cannulation in anesthesiology literature.

1984 Hanrath et al introduced two dimensional phased array transducer mounted on the tip of a flexible gastroscope.

1987 Tuggle DW et al published Real time echocardiography - A new technique to facilitate Swan - Ganz catheter insertion.

1993 Turnage et al[17] described technique of transesophageal echocardiography guided pulmonary artery catheter placement.

1998 Andropoulos et al[18,19]., TEE guided central venous catheter tip placement in pediatric patients undergoing congenital heart surgeries.

4. ANATOMICAL PERSPECTIVE

Cannulation of the subclavian veins and internal jugular vein is being followed for years, thorough knowledge of the anatomy of these veins and their surface markings help us to place the central venous catheter avoiding complications.

BRACHIOCEPHALIC VEINS

The brachiocephalic veins (Fig 4.1), previously termed the innominate veins, are major vessels returning venous blood to the right side of the heart within the superior mediastinum. There are two main vessels which form superiorly from the confluence of internal jugular veins and subclavian veins on each side - right brachiocephalic vein and left brachiocephalic vein.

Both veins merge inferiorly to form the superior vena cava. The right brachiocephalic vein is one of the major veins within the superior mediastinum. It drains venous blood from the right subclavian vein and internal jugular vein; hence, it drains venous blood from the territories of the right arm and right side of the head and neck respectively.

The left brachiocephalic vein is one of the great veins within the superior mediastinum. It is formed from the union of left subclavian vein and left internal jugular vein and so it drains the territories of the left arm and left side of the head and neck respectively.

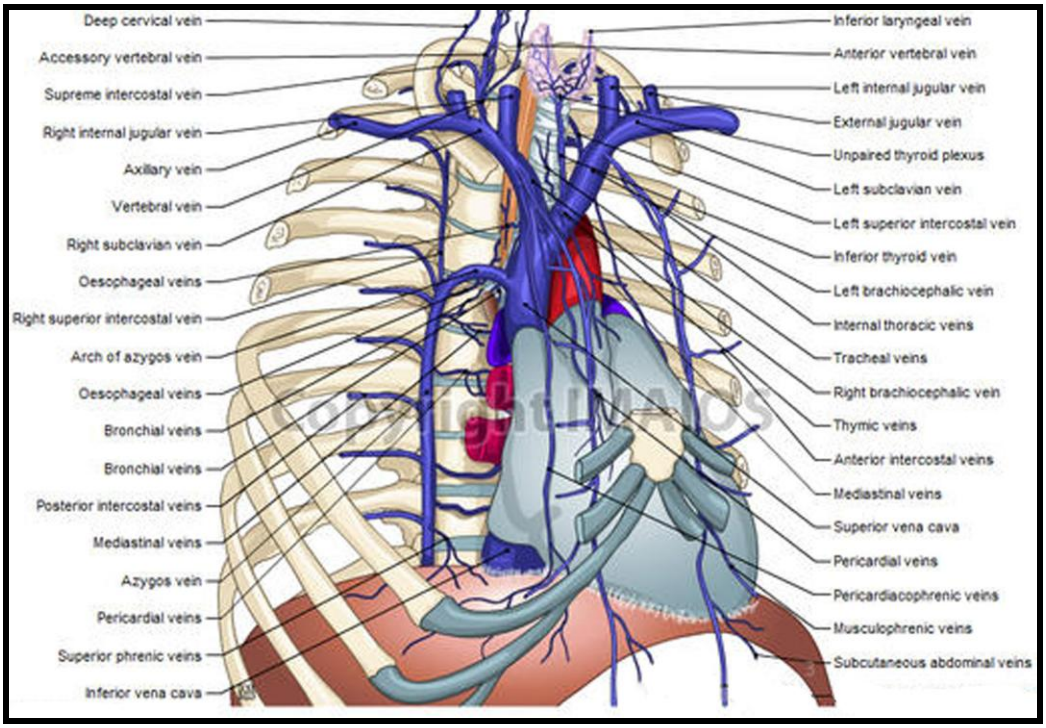


Fig 4.1: Formation of Superior Vena cava

Surface Marking:

Right brachiocephalic vein:

It is marked by two parallel lines 1.5 cm apart, drawn from the medial end of the right clavicle to the lower border of the right first costal cartilage close to the sternum.

Left brachiocephalic vein:

It is marked by two parallel lines 1.5 cm apart, drawn from the medial end of the left clavicle to the lower border of the first right costal cartilage.

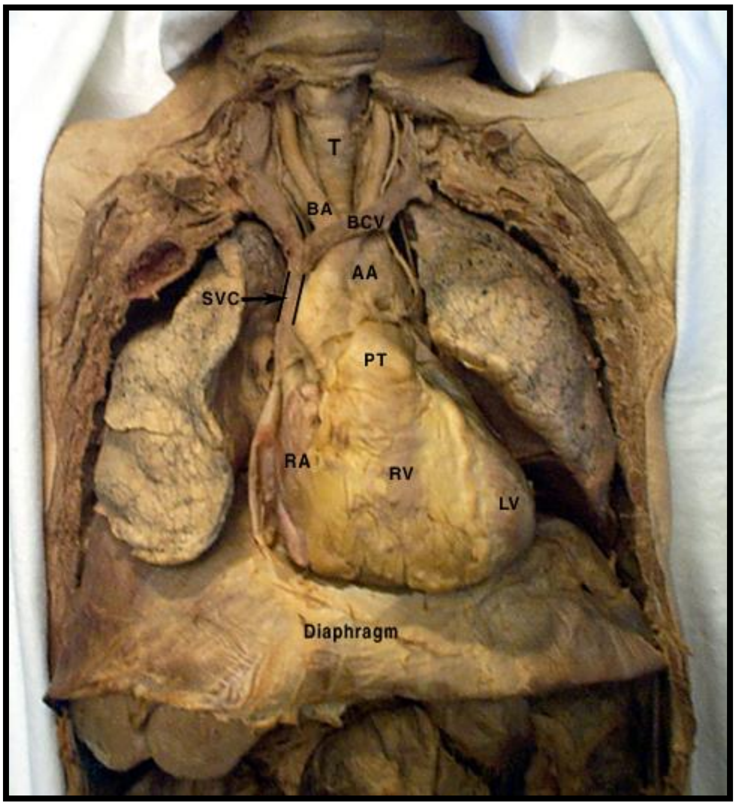


Fig 4.2: Thoracic cavity showing SVC, BCV, RA

SUPERIOR VENA CAVA

The superior vena cava (Fig 4.1, 4.2) is formed proximally by the union of the right and left brachiocephalic veins within the superior mediastinum. This occurs at the level of the right first costal cartilage. From this point, the SVC runs for about 5-7cm inferiorly, slightly medially and anteriorly. It ends at the superior vena caval orifice in continuity with the right atrium deep to the third right costal cartilage in the middle mediastinum. It becomes ensheathed by pericardium superior to this point.

SURFACE MARKING

SVC is marked by two parallel lines 2cm apart, drawn from the lower border of the right 1^{st} costal cartilage to the upper border of the 3^{rd} right costal cartilage.

SUPERIOR VENA CAVAL ORIFICE:

The superior vena caval orifice is the opening of the superior vena cava into the right atrium. It is the route through which blood from the upper body is returned to the heart in adults. The orifice is located in the posterosuperior part of the right atrium within the sinus venarum. Apart from the auricle, it forms the most superior structure in the chamber. The orifice is angled anteroinferiorly. Unlike the inferior vena caval orifice, the SVC orifice does not possess a valve.

RIGHT ATRIUM:

The right atrium (Fig 4.3) is the upper portion of right side of heart consisting of the sinus venosus and the right atrial appendage; contains the sinoatrial node. The Right Atrium is composed of a smooth intercaval part and a muscular part (formed by pectinate muscles) separated by an internal ridge called the crista terminalis and an external groove (sulcus terminalis).

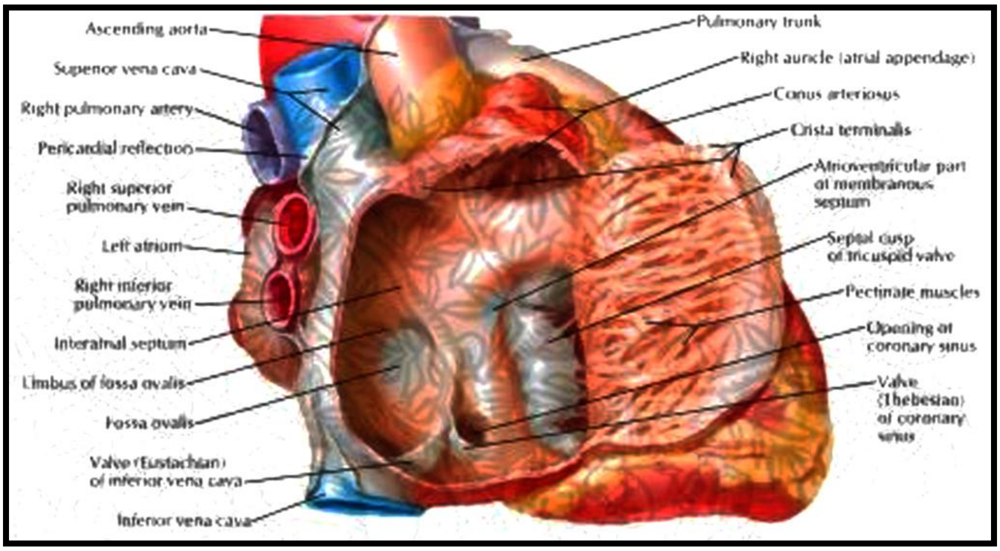


Fig 4.3: Interior of Right Atrium

CRISTA TERMINALIS:

The crista terminalis (Fig 4.3) is a well-defined fibromuscular ridge formed by the junction of the sinus venosus and primitive right atrium that extends along the posterolateral aspect of the right atrial wall. The crista terminalis is generally a smooth-surfaced, thick portion of heart muscle in a crescent shape at the opening into the right auricle. On the external aspect of the right atrium, corresponding to the crista terminalis is the sulcus terminalis. The Crista Terminalis provides the origin for the pectinate muscle.

Anaesthesiologist commonly cannulate the central venous catheter into the superior vena cava though the internal jugular vein or the subclavian vein. Ideally the catheter tip should lie in the superior mediastinum for accurate measurement of central venous pressure and pressure tracing. The ideal catheter tip position is considered to be the SVC-RA junction 1cm above the crista terminalis. The correct positioning of catheter facilitates massive fluid replacement and drug administration into the central circulation.

5. CONVENTIONAL METHODS FOR CORRECT TIP PLACEMENT

1. Anatomical landmark technique
2. Pere's Formula
3. Intra atrial ECG.

ANATOMICAL LAND MARK TECHNIQUE[19]

In this method the depth of insertion of the central venous catheter is calculated based on anatomical landmarks and is measured prior to induction. Normally the point of insertion is marked and the final tip position is marked, which is the midpoint of the line joining the sternal notch with the internipple line. The distance between the two points measured is taken as the measurement for insertion depth.

PERE'S FORMULA[20]

In this method patient height was used to develop formula to predict the optimum length of the catheter to be inserted for placement in right internal jugular or right infraclavicular subclavian vein and left internal jugular/ subclavian veins

For (1) Right subclavian $\frac{\text{(Height in cm)}}{10} - 2$

(2) Left Subclavian $\frac{\text{(Height in cm)}}{10} + 2$

(3) Right Internal Jugular Height/ 10

(4) Left Internal Jugular Height/ 10 +4cm

This method does not take into account the point of insertion.

INTRA ATRIAL ELECTROCARDIOGRAPHY GUIDED CVC TIP[21]

The subclavian or internal jugular vein is punctured routinely and guidewire is introduced, then the catheter is threaded over the guide with and kept in such a way that the guide wire tip and the catheter tip are at the same level. The guide wire is connected to the ECG by a universal connector or an alligator clip. Then intra atrial ECG is recorded in lead II and P wave morphology is studied. As the catheter with guidewire is advanced the height of P-wave increases up to a certain stage where the P-wave became taller than the QRS complex this called P-Atriale, on further advancement the P-wave became bifid, at this point the catheter and guide wire must be withdrawn till the P-wave became normal configuration.

When the P-wave is of normal size it indicates upper/ middle SVC, P-Atriale indicates SVC- RA junction and a bifid P-Wave indicates RA. The catheter is usually fixed either at the SVC-RA junction (P-atriale) or high upper/ middle part of SVC (where the P wave morphology is normal).

This method cannot be used in the placement of central venous catheter in patients with cardiac rhythm disorder like atrial fibrillation, multi focal ventricular premature beats, supraventricular tachycardia, left bundle branch block or patients with implanted pacemaker.

6. TRANSESOPHAGEAL ECHOCARDIOGRAPHY

Transesophageal echocardiography is a useful imaging technique to accurately evaluate the structural and functional status of the heart. In echocardiography, the heart and great vessels are being imaged with ultrasound waves, which is sound above the human audible range. These ultrasound waves are sent into the thoracic cavity, some of the waves are reflected back to the probe by the cardiac structures. These reflected waves are used to calculate the depth, velocity and density of object within the thoracic cavity.

BASIC CONCEPTS[23]

Ultrasound Waves

It is a continuous or intermittent train of sound waves emitted by a transducer or wave generator. It is composed of density or pressure waves and can exist in any medium with the exception of a vacuum.

As the ultrasound beam travels through a fixed point, the pressure cycle regularly and continuously between a high and a low value also called as compression and rarefaction; this sequence of compression and rarefaction is described as sine waves.

The ultrasound waves are characterized by the following (Fig 6.1).

1. Wavelength: it is the distance between the two nearest points of equal pressure or density in an ultrasound beam.
2. Velocity: it is the speed at which the waves travel through a medium i.e. the tissues.
3. Frequency: It is the number of cycles per second measured in hertz. The frequency of ultrasound waves is 20,000 Hz which is the upper limit of the human audible range.
4. Amplitude is a measure of tissue compression.
    a. The wavelength, frequency and velocity are related.

       Velocity= frequency x wavelength.

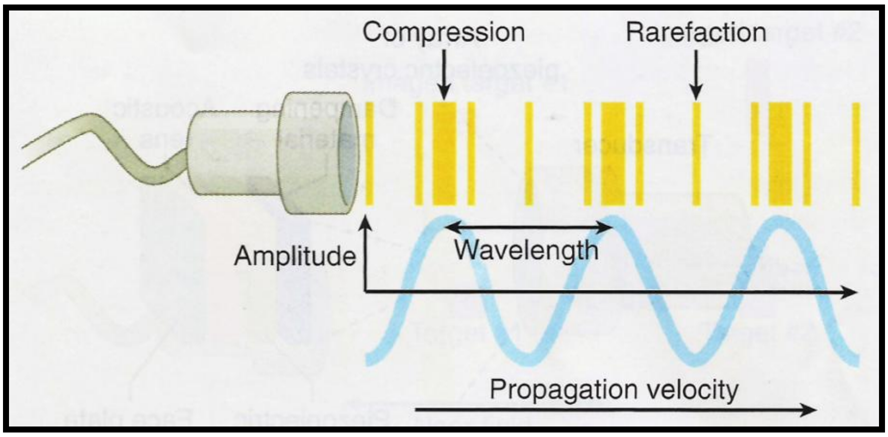


Fig 6.1: Characteristics of Ultrasound Waves

PIEZOELECTRIC CRYSTALS

These are substances which convert the energy between ultrasound and electric signals. When high frequency electric signal is emitted these crystals produce ultrasound energy, which can be directed towards the substance to be imaged. When these ultrasound waves are reflected back to the piezoelectric crystals, they listen to the returning echoes for a given period of time and then pause before repeating this cycle. This cycle length is known as Pulse Repetition Frequency (PRF).

The Pulse Repetition Frequency must be long enough for the signal to travel to and return from a given object of interest. Normally the PRF varies from 1 to 10 KHz, which results in 0.1 to 1.0ms intervals between pulse.

When the reflected ultrasound waves return to the piezoelectric crystals they are converted into electrical signals, which are processed and displayed.

Electronic circuits measure the time delays between the emitted and received echo, because the speed of ultrasound through tissue is a constant, the time delay can be converted into precise distance between the transducer and tissue.

IMAGING TECHNIQUES[23]

M Mode:

- Basic form of ultrasound imaging is M-Mode echocardiography. In this mode, the density and position of all tissues in the path of a narrow ultrasound beam is displayed as a scroll on a video.
- In this mode a very limited portion of the heart is being observed at any one time and requires

considerable interpretation, M-Mode is not currently used as a primary imaging technique.

- In combination with color flow doppler it can be used for timing abnormal flows.

TWO DIMENSIONAL MODE

In this mode, repetitive scanning along many different radii within an area in the shape of a fan (sector) is being done, echocardiography generates a two dimensional image of a section of heart, which resembles the anatomic section and thus can be interpreted easily.

This mode can be used to image the structures of the heart in detail.

DOPPLER TECHNIQUES

In addition to 2D echocardiography, Doppler capabilities are blended such that the 2D echocardiography gives the real time images of the heart and the Doppler is used to obtain audio signals of the blood flowing through the heart from which the direction and velocity of the blood following through the heart is calculated.

COLOR FLOW MAPPING

- It is advancement in Doppler technology in which the real time blood flow within the heart is displayed in colors while also showing Two-Dimensional images in black and white.
- In addition to direction and blood flow velocity the images produced by the device also allow estimation of flow acceleration and helps in differentiation between laminar and turbulent flow.
- When flow of blood is towards the transducer it is assigned red color and when flow is away from the transducer it is assigned blue color. Assignment is not standardized and it depends on manufacturer.

CONTRAST ECHOCARDIOGRAPHY[23]

Normally, the red blood cells scatter the ultrasound waves resulting in black appearance. In contrast echocardiography nontoxic solutions containing gaseous micro bubbles are injected, these micro bubbles form gas-liquid interfaces, which increase the strength of the returning signal. This augmentation in signal strength is used to define endocardial border, optimize Doppler signals, and estimate myocardial perfusion.

Contrast echocardiography has been used to image intracardiac shunt, valvular incompetence, pericardial effusions, assessment of congenital heart disease and assessment of myocardial perfusion.

EQUIPMENT[23]

All currently used TEE probes employ a multifrequency transducer mounted at the tip of gastroscope housing. The tip of the probe can be adjusted by a knob placed at the proximal handle.

There are two knobs present in adult probe one for antero-posterior movement and other for side to side movement. In our institution we use a pediatric probe which has only anterior and posterior movement.

The Probe which we use is a multiplanar probe that can rotate the echocardiographic array from 0 to 180 degree.

The probe also has a temperature sensor which gives the oesophageal temperature and also helps in preventing probe from getting overheated.

The probe which is used is a high frequency probe which yield better resolution for detailed imaging.

The various movements of transesophageal echocardiography are shown in the diagram (Fig 6.2).

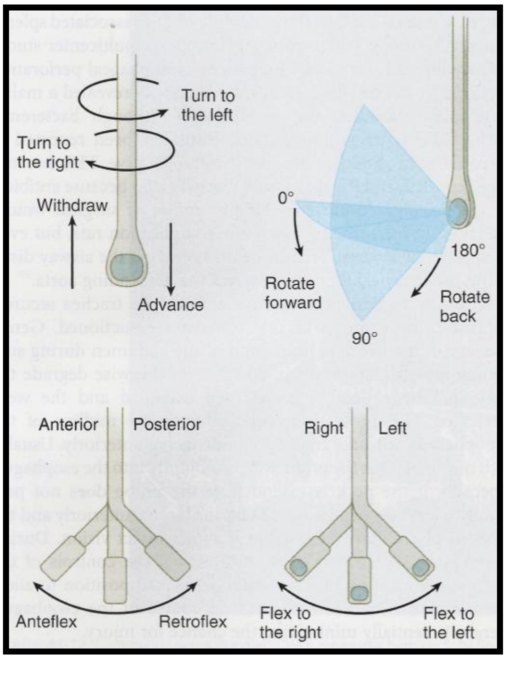


Fig 6.2: Movements of TEE probe

COMPLICATION OF INTRA OPERATIVE TRANSESOPHAGEAL ECHOCARDIOGRAPHY[23]:

Inserting a transesophageal echocardiograph is associated with a variety of problem due to direct and indirect effects:

Direct effect

- Injury to the upper airway and esophagus.
- Esophageal bleeding, burning, shearing.
- Dryness of oral cavity and painful swallowing.
- Edema/discomfort of the larynx.
- Bacteremia
- Vocal cord paralysis.

Indirect Effect

- Hemodynamic and pulmonary effect of airway manipulation.
- Distraction from patient.

7. TECHNIQUE OF TEE GUIDED CENTRAL VENOUS CATHETER PLACEMENT[18,19]

All patients are premedicated with injection glycopyrrolate (0.04mg/kg) intramuscularly about 30 minutes prior induction. After induction and intubation the endotracheal tube is secured. A nasogastric or orogastric tube is inserted and all the secretions are suctioned out and stomach is deflated. The nasogastric tube is removed and a oral mouth gag is applied.

The pediatric TEE probe which we use is multiplanar and has anterior/ posterior movement only. The total length of probe is 70cm. The probe is sterilized with savlon solution first and allowed to dry then it is again wiped with normal saline solution. About 20cm of the probe distally is well lubricated with lignocaine jelly and is introduced orally. If we come across any resistance to the probe, we remove the probe and re-insert the probe or a gentle laryngoscopy is done to check the resistant part and negotiate the probe passage.

Normally the probe may get lodged in the vallecula or pyriform fossa or in the posterior part of the tongue sometimes over-inflation of the endotracheal tube cuff can also cause obstruction to probe’s passage.

The most important thing that must be borne in mind is that the probe should never be forced against any sort of resistance as it may lead to airway trauma or oesophageal perforation. When not in use the probe must be kept in neutral position (avoid anteflexion and retro flexion) because accidental slippage of tube can cause injury to esophagus.

Once the probe is introduced into the midesophgus classical 4 chamber view (Fig 7.1) is seen, to view the right atrium and the superior vena cava we normally use the BICAVAL view.

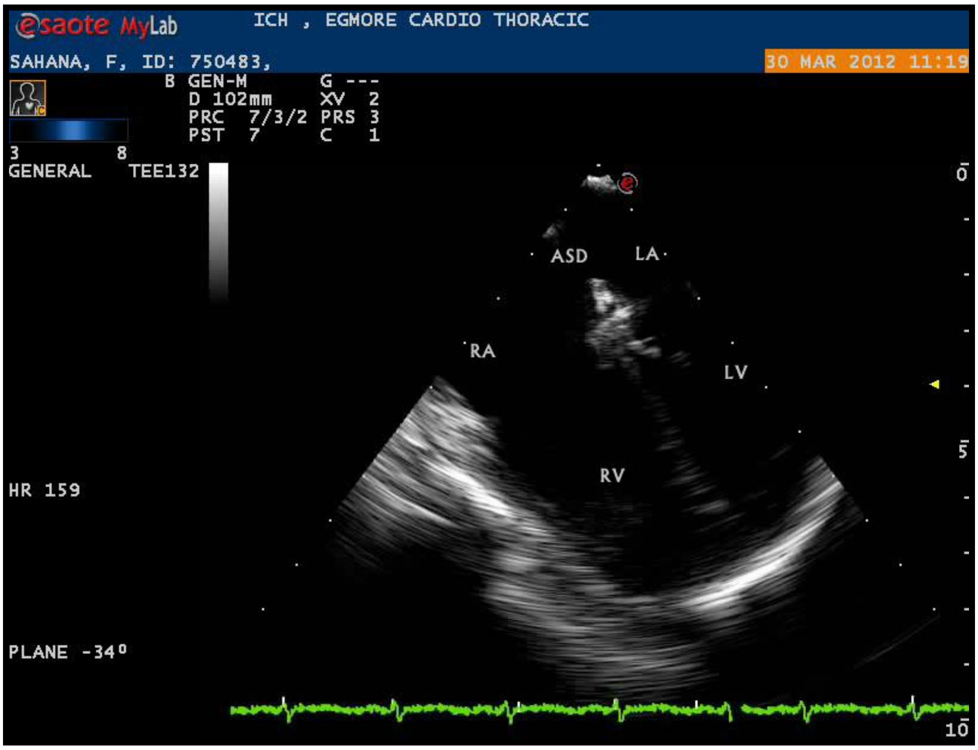


Fig 7.1: Classic 4 Chamber View

The bicaval view is obtained from the mid oesophagus with the probe manipulated and a multiplane angle range between $80^0$to 110^0. The depth of insertion to mid oesophagus ranges from individual to individual in children based on their age and height. But in adults it is between 30-40cm.

With the BICAVAL view we can visualise the following structure:

1. Right and left atrium
2. Interatrial septum.

3. Superior venacava (long axis) is seen entering the right atrium from the right side of the display just above the right atrial appendage.
4. The inferior cava enters the right atrium on the left side of display
5. Coronary sinus and thebesian valve
6. Eustachian valve.

Once the bicaval view is established the operator fixes it and another anaesthetist performs the central venous cannulation through the internal jugular vein or the infraclavicular subclavian vein, once the vein is punctured and guidewire is advanced which can be visualized (Fig 7.2) by the TEE coming through the superior vena cava and entering the right atrium. The catheter is threaded over the guidewire until the full length is inserted, the guidewire is removed and the tip of the catheter is identified by rapid flushing of heparinised saline (Fig 7.3), the catheter is then withdrawn till the tip lies within 1 cm of the SVC-RA posterior junction, which is the superior edge of crista terminalis. The catheter is then fixed irrespective of external length.

BICAVAL VIEW

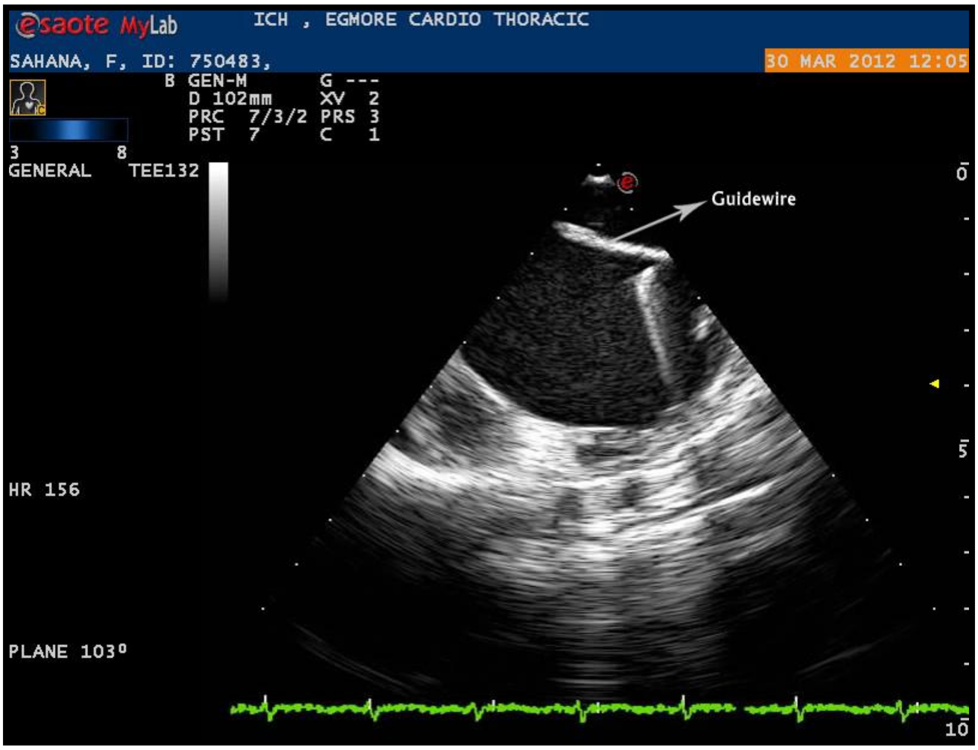


Fig 7.2: Guidewire in RA

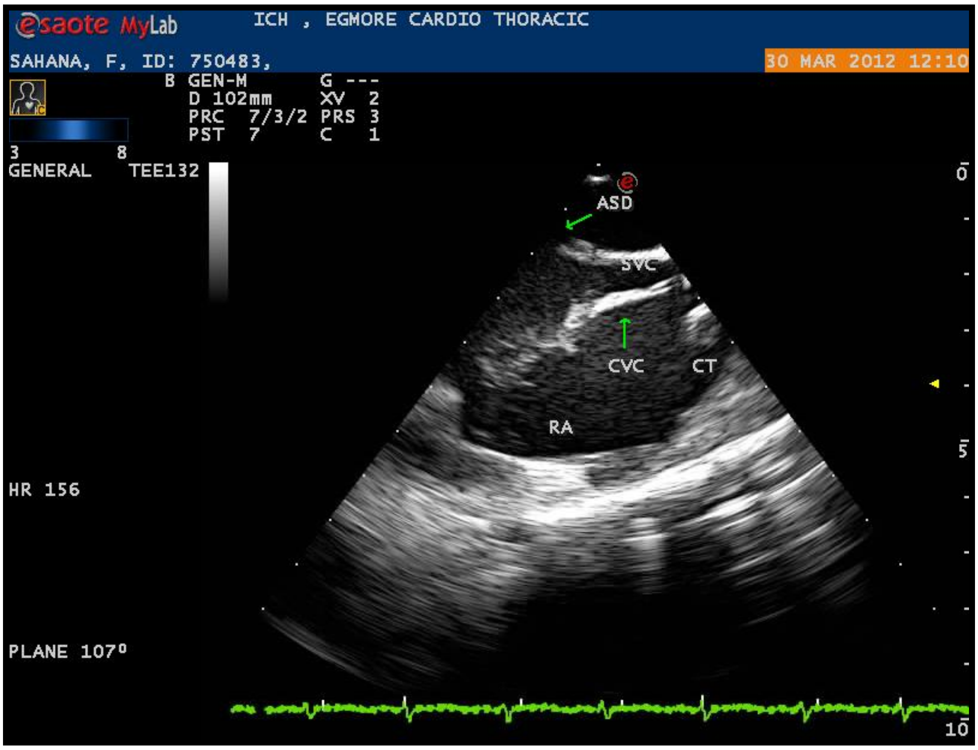


Fig 7.3: CVC Tip In RA

8. REVIEW OF LITERATURE

The use of transesophageal echocardiography for correct placement of central venous catheter tip has been reported previously. Transesophageal echocardiography has been used in cardiothoracic anaesthesia to check adequacy of surgical correction, proper cannulation of Aorta, adequate deairing of right atrium and left atrium, assessing biventricular function, valve functions following repair, regional wall motion abnormalities.

W. Sherman Turnage first reported the use of Transesophageal echocardiography in the placement of Pulmonary Artery Catheter in a patient undergoing mitral valve repair for rheumatic mitral regurgitation. Andropoulos et al first reported the use of transesophageal echocardiography as a guide to correct placement of central venous catheter tip.

Dean B. Andropoulos et al, 1999[19], They conducted a prospective, randomized, control study in 145 patients with congenital heart disease undergoing corrective surgery needing SVC cannulation either through Right IJV or right subclavian comparing TEE guided placement versus landmark technique. The patients were randomized into 2 groups: Group TEE (n=72), Group Control (n=73).

In TEE group, transesophageal echocardiography guided central venous catheter placement resulted in 100% correct placement (72 of 72) whereas in the control group only 86% were placed correctly (72 of 72 versus 63 of 73, p = 0.01).

The average duration of access in TEE group was 9.6 min versus 8.0 min in the control group. In both groups there was no difference when assessed by post operative chest x-ray. (81.9% TEE versus 75.3% control; P = not significant).

The entire catheter inserted via the internal jugular vein were in the superior vena cava or right atrium, but of the 78 right subclavian venous catheter, 4 (5.1%) were located in left brachiocephalic vein (P = 0.07). The major complication they experienced is a SVC perforation from subclavian catheter in the control group and carotid artery puncture 4 times during IJV attempts.

These data revealed a significant increase in the percentage of central venous catheters properly positioned when transesophageal echocardiography was used to determine catheter tip position compared to landmark technique although the time duration for cannulation was significantly increased in TEE group. Also with intra-operative TEE assessment of CVC position, post operated chest x-ray had a sensitivity of 84% and a specificity of 100% in detecting correct catheter tip location in the SVC.

Koung-Shing Chu et al., 2004[21], They conducted a prospective randomized study in cancer patient requiring permanent central venous catheters for the administration of IV chemotherapy, antibiotics and Total Parenteral Nutrition comparing intravenous electrocardiography versus surface land mark technique in placement of central venous catheter under transesophageal echocardiography guidance.

The patients were randomized into 2 groups: group E (30 patients) for ECG Group and Group S (30 patients) for surface landmark group.

In both group transesophageal echocardiography was used for final placement of catheter tip and post operative chest x-ray was taken to check position of central venous catheter tip. Using transesophageal echocardiography, the initial position of the catheter tip was defined satisfactory if the tip was up to 1.0 cm of the upper margin of crista terminalis.

In Group E patients all 30 had satisfactory tip placement whereas in group S patients. Only 16 of 30 had satisfactory position (P <0.001) which was significant. Regarding tip correction distance, Group E ≤0.5cm & Group S 1.1 -2.0 cm which is also significant. With respect to post op x-ray, in group E 25 were in proper position & 5 in improper position whereas in group S 23 in proper position and 7 in improper position after correction by TEE.

The implications of these data is intravenous ECG guided tip placement accomplished the goal 100% of the time, whereas use of surface landmarks to determine catheter length did so approximately 53% of time. Post operative chest x-rays revealed tip in abnormal position even after TEE guided correction and so it could not be reliably used to locate the catheter tips at SVC-RA function.

Nigel Reynolds et al., 2001[24], They conducted a prospective study on patients receiving long term parenteral nutrition. Total number of patients included in this study n=9. All patients underwent TEE examination for catheter tip position as well as x-ray examination.

The results of their study was,7 of the 9 cases with normal position as evident by chest x-ray showed discordant positions with catheter tip placed in the right atrium or impinging in the tricuspid valve on examination with TEE.

Hsu JH, Wang CK et al[25]. They conducted a prospective study on 20 adult malignant cancer patients, undergoing implantation of permanent central venous catheter, comparing radiologic landmarks and the echocardiographic SVC-RA junction.

The results of their study showed the echocardiographic SVC-RA junction ranged from 0.6 cm above to 2.8 cm below the radiologic SVC-RA junction. Both radiologic SVC-RA junction and the thoracic vertebral bodies are not reliable markers for the SVC-RA junction defined by transesophageal echocardiography.

Yunseok Jeon et al, 2006[26], They made an observational study, to facilitate electrocardiography guided central venous catheter placement based on shape and size of the P wave under transesophageal echocardiography guidance.

They evaluated 54 patients in whom central venous catheter was placed as a part of treatment.

They observed tallest peaked P wave when the CVC tip was located at SVC-RA junction (0.0 cm) and biphasic P wave (-4.0 cm) below SVC-RA junction and normal P wave at 4.0 cm above the SVC-RA junction. They conclusion of their study was that during ECG guided CVC catheterization the tallest peaked P wave may be used to place the CVC tip at SVC-RA junction, normal shaped P - wave identifies the middle/ upper SVC and biphasic P waves identifies RA.

Dean B. Andropolous et al, 2001[27], They conducted a prospective study in 452 pediatric congenital heart disease patients undergoing corrective surgery to find out optimal length of insertion of central venous catheter and devised a formula to predict that. For children <100 cm initial length of insertion is (height in cm/10) - 1 and for patients ≥100 the formula is height in cm/10) -2. When the above formula was used in all 452 patients, 97% of CVC were placed correctly in SVC (95% confidence interval, 95.6% - 98.8%) for right subclavian patients 93.1% (95% CI, 86.9% - 97.0%) and for RIJ patients 99.1% (95% CI, 97.3% - 99.8).

They concluded that irrespective of the methods used for correct placement, all patients should undergo appropriate imaging method to locate tip to prevent persistent catheter misplacement and related complications.

Ralf E. Gebhard et al, 2003[28], They conducted a prospective randomized controlled trial in 300 patients with various disorder in whom CVC placement was necessary (n=300). They were randomized into 2 groups. Group ECG (n=150) in which intra atrial ECG was used for accurate placement and group NO-ECG in which CVC placement was done without ECG guidance. Chest x-ray was taken in all patients immediately after surgery. 10 patients were excluded from the study. The result of their study showed 96% of ECG group placement versus 76% in No ECG group placement was positioned correctly ($P \leq 0.001$). There was no difference in placement time.

Significant number of CVCs were placed in the middle of the SVC in group ECG ($P \leq 0.001$). 20 patients required repositioning in group No-ECG compared to only 3 in group ECG. Finally the authors concluded the ECG guidance allows of more accurate CVC placement and should be considered to increase patient's safety.

W.Schummer et al, 2003[29,30], They conducted a prospective, randomized control study in patients undergoing cardiothoracic surgery in whom CVC placement and transesophageal echocardiography monitoring was used as a routine. Patients n=114 randomized into Group R - 53 patients (Right sided catheter insertion) Group L- 61 patients (left sided catheter insertion). Three methods were used to assess insertion depths ID-A ECG guidance with a seldinger guide wire, ID-B ECG guidance with saline 10% used as an exploring electrode. ID-C from (ID-B) catheter was rotated and advanced till all three lumen could be aspirated. The final catheter tip position was confirmed using transesophageal echocardiography.

In Group L 13 patients had their CVC's in malposition, 4 were in aberrant catheter positions (one in the azygos vein, and three in Rt. innominate vein) Chest radiography in group-L patients revealed 9 patients had catheters with an impingement angle $\geq 40^{o}$ which was not found in group R patients.

In Group -R the depth of insertion did not vary with three methods tip placement but 17% of patients (9 of 53) required catheter advancement towards right atrium using transesophageal echocardiography.

In group L, the depth of insertion differed significantly between all the methods 84% patients (48 of 57) in this group required catheter advancement to right atrium.

The main conclusions of their study were P - atriale caused by an increase in the voltage of P wave was due to the atrial wall.

Chest x-rays are useful to determine whether the lie of the catheter is parallel to vessel or not.

Transesophageal echocardiography served as the gold standard in assessment of CVC tip with respect of SVC-RA junction.

H.S.Na et al[31], They conducted a prospective study in 90 children undergoing corrective surgery for congenital heart disease to determine the insertion depth of CVC using anatomical landmark. The marked three points Point I (insertion point) Point A (Sternal head of Rt. Clavicle) and Point B mid point of perpendicular line drawn from Point A to the line connecting both nipples.

Distance measured (I – A) + (A – B) - 0.5 cm.

Post Operative Chest X-ray was taken and the CVP tip distance from the carina level was measured.

The position of the CVC tip were 0.1 to 1.0 cm (P = 0.293) below or above the carina. (95% confidence interval 0.1cm below – 0.3 cm to the carina)

The authors of the study attributed that CVC tip can be carefully placed near the carina by using anatomic landmark without any formula, images and devices in children <5 years of age. The patient's age, height and weight were of no relevance in placement.

W.Schummer et al., 2004[29,30], They conducted a prospective, observational study in both humans and animals to determine the accuracy of ECG guided CVP tip placement and to determine the origin of P Atriale.

They conducted both an animal study and a human study.

Animal study 6 juvenile pigs in which Left Internal Jugular vein and Right Carotid artery were cannulated using intra atrial ECG guidance at 'P' Atriale (point of maximum p wave amplitude) and fixed. The catheter tip position was then determined by open exploration of vessels and heart.

Human Study 10 male patients undergoing open chest cardiac surgery with TEE monitoring was selected. Anaesthesia induced and TEE placed in Bicaval view. Intra atrial ECG guided CVC was placed at point of maximum P wave amplitude and fixed.

Results of their Study:

Animals study:

Significant P wave amplitude was observed in venous ($P < 0.05$) and atrial ($P<0.05$) catheter. All the venous catheter tips were found to be placed distal to pericardial reflection but outside the right atrium. All arterial catheter tips were positioned distal to the pericardial reflection in the ascending aorta.

Human Study:

All 10 male patients with significant increase in P wave amplitude were at the pericardial reflections which were confirmed by transesophageal echocardiography.

The authors of this study concluded the study saying an increase in P wave amplitude already starts at the pericardial reflection outside the heart and ECG guidance cannot differentiate whether catheter is placed intra arterially or intravenously.

Anish M Joshi et al[32], They conducted a prospective study on central venous catheter placement in 50 patients to compare intra-atrial ECG technique with Pere’s height formula for optimal placement of central venous catheter and to establish its accuracy with post-operative chest x-ray 50 patients divided into 2 groups group E - 25 and group P - 25 in whom catheter was placed based on ECG guidance and pere’s formula (height in cm/10) respectively. A post operative chest x-ray was taken in all patients.

The statistical data of this study revealed an average insertion time of 6.5min in group E compared to 5 min in Group P.

The mean length of the catheter inserted in group E was 12.24 ±1.30 cm compared to 15.88±0.88 cm in group P, with a significant difference of 3.64 (P<0.001) The post operative chest x-ray, revealed 92% proper placement in Group E (23 of 25) while 28% in group P (17 of 25). There was over insertion in group P (12 of 25) which accounted for 48%.

The author of this study concluded by stating Intra-atrial ECG guided placement can be used as an useful tool for accurate positioning of RIJV-CVC and this procedure is more reliable compared to landmark techniques and other height formula.

Czepizak et al, 1995[33], They conducted a prospective study for successful placement of central venous catheter based on formula devised by Pere's. A total of 228 patients were taken for the study whose height and weight were measured before CVC Insertion. The central venous catheter was introduced and placed based on the formula devised by Pere's in right subclavian (height/10) - 2, In left subclavian (height /10) + 2 cm.

In right interval jugular height/10, left internal jugular vein 9height/10) + 4 cm and were fixed. A post operative x-ray was taken and the collected data analyzed.

The overall prediction accuracy of their study was 95% (217 of 228). The formula for predicting the catheter length was most accurate for left subclavian site (97%) and least accurate for RIJ site (90%).

PA Stonelake et al, 2004[34], They wanted to establish the relationship between central venous catheter tip position and the carina in chest radiographic films.

The performed a retrospective study in 213 patients between December 2003 to April 2004. They examined the post operative chest x-rays of these 213 patients in whom a central venous catheter was inserted as a part of treatment.

They measured the distance of the catheter tip above and below the carina and the angle made by the distal part of the central venous catheter to the vertical.

The results of their study showed a large number of catheter inserted on the right side had their tips below the carina 74 of 163 approximately 45% whereas in left sided catheters only 7 of 50 catheters were below the carina approximately 14%. But of the remaining 43 catheters many had not crossed the midline or were placed in a very risky position.

Regarding the angle of abutment of central venous catheter tip with the vertical, only 4 of 163 right sided central venous catheter was having a steep angle of $>40^o$, but in left sided catheter 27 of the 43 were having an angle greater than 40^o (~63%).

The conclusion of their study is that right sided catheters were more likely to pass below into the right atrium and has to be adjusted to a level placed above the level of carina to prevent its entry into right atrium.

Left sided catheters can be below the carina this is because if a left sided catheter tip is pulled above the level of carina, there is a high likelihood that the catheter tip may be at a steep angle or risk of abutting the lateral wall of superior vena cava.

9. MATERIALS AND METHODS

STUDY DESIGN

This study was conducted in the pediatric cardio thoracic and vascular surgery operation theatre at Government Institute of Child Health and Hospital for Children, Egmore, Chennai - 600008, on 40 patients posted for elective cardiac surgery for congenital heart diseases.

The study was done after approval from the Institutional Ethical Committee and written informed consent with explanation about the procedures was given to the parents and consent was obtained.

This study was done in a prospective randomized manner. Forty patients of either sex posted for major elective cardiac surgery satisfying the selection criteria were randomly allocated into two groups (Group T, Group L).

GROUP T- TRANSESOPHAGEAL ECHOCARDIOGRAPHY GROUP

Patients in the group underwent central venous catheter placement under transesophageal echocardiography guidance.

GROUP L ANATOMICAL LAND MARK GROUP

In this group the catheter was placed based on predetermined insertion length measure based on the anatomical landmark.

MATERIALS USED

In this study we used ESAOTE MY Lab60 Transesophageal Echocardiography machine was used. The pediatric probe TEE122 was 70 cm long with antero-posterior movements. The probe incorporates an array transducer which can be rotated180 degrees to easily obtain all imaging planes. The transesophageal echocardiography probe also has a temperature sensor which prevents probe overheating.

The 15cm triple lumen central venous catheters manufactured by VYGON company were used for cannulation by seldinger technique. The size of the cannula varied from 5.0F to 7.0F, depending on the height and weight of the patients.

Portable X-Ray machine to take post operative chest X-Rays was used.

SELECTION CRITERIA

Inclusion Criteria

1. Age 1-12 years
2. Right internal jugular vein/ subclavian vein cannulation.
3. Weight >10kgs.
4. ASA physical status II & III Patients.
5. Patients who have given valid informed consent.

Exclusion Criteria

1. Emergency central venous catheter placement.
2. Age < 1 year

3. Weight < 10 Kgs
4. No valid informed consent.
5. Patients with congenital oral / nasal malformations in whom transesophageal echocardiographic cannot be introduced.
6. History of surgery for tracheo-oesophageal fistula.
7. Patients with anomalous venous connection in which SVC cannulation is contraindicated.
8. Local sepsis.
9. IJV/ Subclavian vein thrombosis.

PRE-ANAESTHETIC EVALUATION

Patients included in this study underwent thorough pre-operative evaluation which included the following.

HISTORY

- Presenting complaints
- History of other medical illness.
- Previous surgery.
- Antenatal history.
- Perinatal history.

- Anaesthesia history (previous central venous cannulation, recovery from anaesthesia, significant events)
- History of any bleeding diathesis/ coagulation abnormalities.
- Developmental Milestones.

PHYSICAL EXAMINATION:

- General condition of the patient
- Vital signs
- Examination of cardiovascular system, respiratory system, central nervous system and vertebral column.
- Airway assessment.

INVESTIGATIONS

- Complete hemogram.
- Blood sugar, urea, serum, creatinine, electrolytes.
- Bleeding time, clotting time.
- Urine analysis.
- Electrocardiogram.
- Chest X-Ray.

SPECIAL INVESTIGATION

- Transthoracic echocardiogram.
- Cardiac catheterization (in some patients)
- CT Angiographic study.

Patient who satisfied the inclusion criteria were explained about the nature of the study and anesthetic procedure.

A written informed consent was obtained from all the patients included in the study. We had provided the patients attendants with handouts of the study and advantages of the study.

In our study at least two anesthesiologist were needed, one for operating the transesophageal echocardiography and the other person for right internal jugular/ subclavian vein cannulation. All the parameters and events were observed and recorded in the Proforma by the observers.

TRAINING

The operator (myself) underwent basic echocardiography training for 30 days in cardiology department and hands on training for basic transesophageal echocardiography at the Narayana Hrudalaya Hospital. Additional help was sought from pediatric cardiologist from Government Institute of Child Health and Hospital for Children, Egmore. After an initial pilot study the observation and results were analysed in detail and based on the safety profile and success rate of this technique, an institutional ethical committee clearance was obtained.

PREPARATION

A basic height, weight measurement were taken, preoperatively, Inj. Glycopyrrolate at a dose of 0.04mg/kg was given intramuscularly about 30 minutes prior to induction. The point of insertion was same in both groups for IJV cannulation it was in the triangle formed by the two heads of sternocleidomastoid at the level of cricoids cartilage. For subclavian vein it is 1 cm below the clavicle at the junction of medial 2/3rd and lateral 1/3rd of the clavicle.

Standard monitoring for cardiac patients was done. Intravenous access with an 18/20/22G intravenous catheter was achieved. Routine general anesthesia was administered with controlled ventilation. Arterial cannulation was done.

A nasogastric tube was introduced and stomach contents were suctioned out. The nasogastric tube was removed and mouth gag was placed.

POSITIONING

For right internal jugular vein cannulation the patient was put on a head down position (Trendelenburg Position 30^0) and the head turned to the left 45^0 approximate. Neck extension was achieved by a small towel placed under the shoulder.

For right subclavian vein cannulation a small towel was placed in between the scapula to slightly extend the shoulder and the arm is adducted.

TECHNIQUE

Group T

In this group the nasogastric tube is removed after decompressing the stomach, and thorough suctioning of oral cavity is also done, the multiplane transesophageal echocardiography probe is passed orally after adequate lubrication, the probe is placed in the mid esophagus and a BICAVAL VIEW is obtained, the SVC was viewed along the longitudinal axis. The operator then fixes the probe at that particular position.

The selected vein either the right internal jugular or subclavian vein is punctured by sterile technique, and Seldinger guidewire tip is advanced into the right atrium under two dimensional transesophageal echocardiography imaging. The catheter is then advanced over the guidewire and inserted into the right atrium, the guidewire is then removed, and the tip of the catheter is identified by rapid injection of heparinised saline. The catheter was identified as closely spaced echodense lines surrounding the darker fluid- filled lumen. The catheter tip position is then adjusted by direct visualization until the tip was in SVC about 1 cm of SVC-RA function, which is defined as the superior margin of the crista terminalis. The catheter is then sutured in place; the external depth is noted down, the time taken from TEE probe insertion to suturing the catheter was noted down as catheter insertion time. Post operatively bed side chest radiograph, is taken. The entire procedure is recorded as movie clip and archived.

ANATOMICAL LAND MARK GROUP

In both groups based on landmarks a measurement is taken after positioning. The insertion point is marked as point I. Then another point is marked which is the final point (F) where catheter tip has to be placed is marked. It is the mid point of the line joining the sternal notch with the inter nipple line. This point (F) corresponds to the SVC-RA junction.

In this group of patients, the selected vein right IJV/ Subclavian vein is entered at the insertion point (I), by sterile seldinger technique, guidewire is advanced and catheter placed. The depth of insertion is the predetermined measurement taken based on the anatomical landmark. The external depth of the catheter is fixed at the predetermined length and sutured. The catheter insertion time is noted down. Then patient is positioned for surgery the TEE probe is passed and catheter tip position is identified and recorded in our proforma. If the catheter was grossly misplaced we adjusted the position of the catheter otherwise we did not disturb it.

A post operative bedside chest X-Ray is taken. All the post operative chest X-ray done and the position of central venous catheter was read by radiologist. In our study the carina was taken as the landmark for identification of superior vena cava – right atrial junction (svc-ra junction). If the position of the catheter was grossly abnormal we try to redirect the catheter in our post anaesthesia care unit provided if the patients clinical condition requires the catheter for more than 48hrs. Otherwise we remove the catheter within 24hrs.

PARAMETERS OBSERVED

1. Accuracy of placement in the SVC- RA junction.
2. Insertion length based on TEE, Anatomical Landmark technique and Pere's formula
3. Time taken for catheter placement.
4. Position of the catheter in post operative chest X-Ray.
5. Complications if any due to catheter malposition.

10. OBSERVATION AND ANALYSIS

Forty patients of either sex posted for elective cardiac surgery in whom insertion of central venous catheter and transesophageal echocardiography monitoring was necessary were chosen for the study and were randomly allocated into two groups based on closed envelope method.

Group T (Transesophageal Echocardiography group): they underwent central venous catheter placement under Transesophageal Echocardiography guidance.

Group L (Anatomical Landmark group): they underwent central venous catheter placement based on measurements predetermined by anatomical landmark.

20 patients were randomly assigned to each group based on closed envelope method. The vein to be cannulated was based on the In Patient number, patients whose I.P No ended with1,3,5,7 had their internal jugular

vein cannulated and patients with their I.P No ending with 0,2,4,6,8 had their subclavian cannulated.

Patient Characteristics, Demographics & Clinical Data

28(70%) were females and 12(30%) were males.

Table 10.1: *Sex distribution*

Sex	T Group		L Group		Total	
	N	%	N	%	N	%
Male	6	30	6	30	12	30
Female	14	70	14	70	28	70
Total	20	100	20	100	40	100
Chi-square value	0.001					
Df	2					
p value	1.00 (Insignificant)					

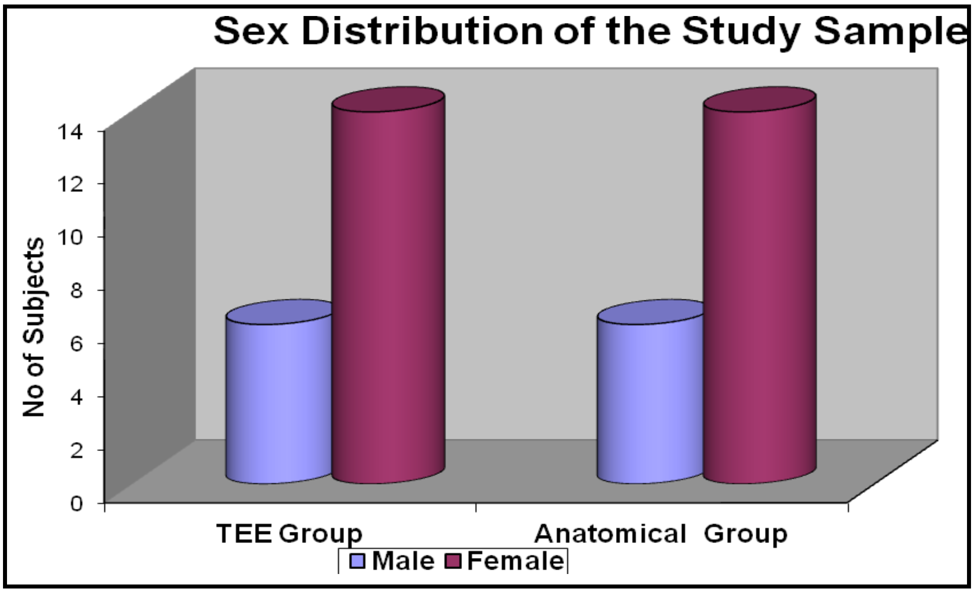


Table 10.2: *Age Distribution 21patients (52.5%) were in age group 1 to5 years*

Age Group	**T Group**		**L Group**		**Total**	
	N	**%**	**N**	**%**	**N**	**%**
1 – 5	9	45.00	12	60.0	21	52.50
5 – 10	9	45.00	4	20.0	13	32.50
10 – 15	2	10.00	4	20.00	6	15.00
Chi-square value	3.02					
Df	2					
p value	0.22 (insignificant)					

Table 10.3: *Mean Age*

	T Group	**L Group**
Mean	6.08	6.25
Sd	2.88	3.34
t-Value	**0.18**	
Df	**38**	
p-value	**0.86 (Not Significant)**	

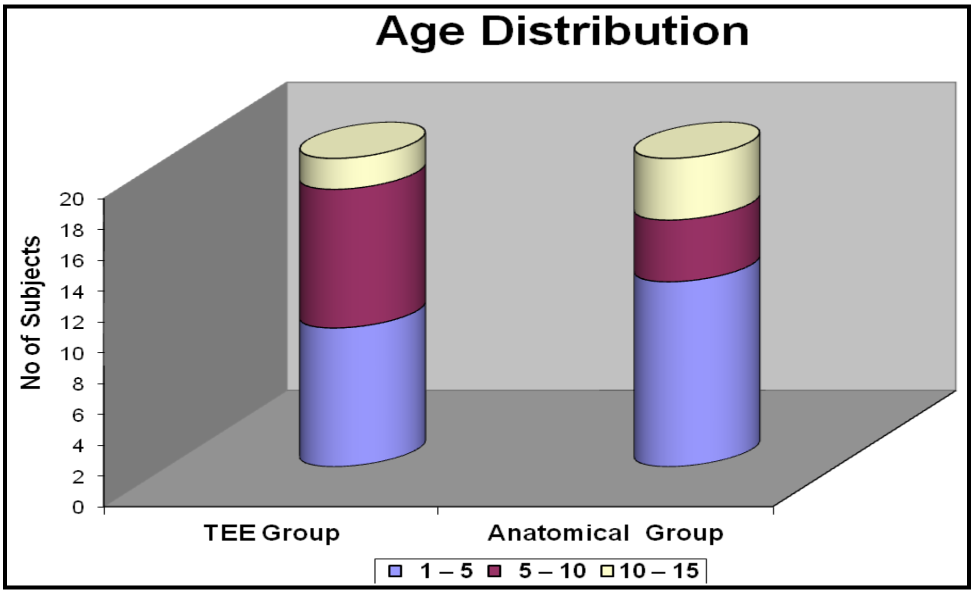

Age Distribution
No of Subjects
20
18
16
14
12
10
8
6
4
2
0
TEE Group
Anatomical Group
1 – 5
5 – 10
10 – 15

Table 10.4: *Height Distribution*

Height in Cm	T Group		L Group		Total	
	N	%	N	%	N	%
70 - 80	1	5.00	3	15.00	4	10.00
80 – 90	4	20.00	3	15.00	7	17.50
90 – 100	3	15.00	3	15.00	6	15.00
100 – 110	3	15.00	3	15.00	6	15.00
110 – 120	4	20.00	2	10.00	6	15.00
120 – 130	2	10.00	2	10.00	4	10.00
130 – 140	3	15.00	3	15.00	6	15.00
140 - 150	0	-	1	05.00	1	2.50
Total	20	100	20	100	40	100

Table 10.5: *Mean Height*

	T Group	L Group
Mean	106.55	107.25
Sd	17.70	21.99
t-Value	**0.11**	
Df	**38**	
p-value	**0.91(insignificant)**	

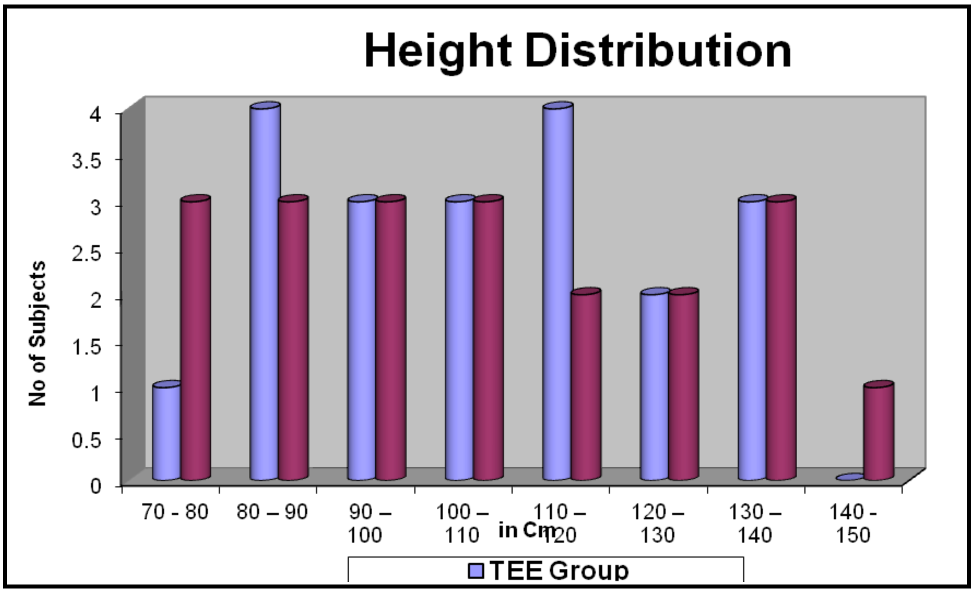


Table 10.6: *Weight Distribution*

Weight in Kg	**T Group**		**L Group**		**Total**	
	N	**%**	**N**	**%**	**N**	**%**
10 - 15	12	60.00	12	60.00	24	60.00
15 - 20	6	30.00	3	15.00	9	22.50
20 – 25	2	10.00	4	20.00	6	15.00
20 - 30	0		1	05.00	1	2.50
Total	20	100	20	100	40	100

Table 10.7: *Weight*

	T Group	**L Group**
Mean	15.15	15.50
Sd	4.30	5.58
t-Value	**0.22**	
Df	**38**	
p-value	**0.83 (insignificant)**	

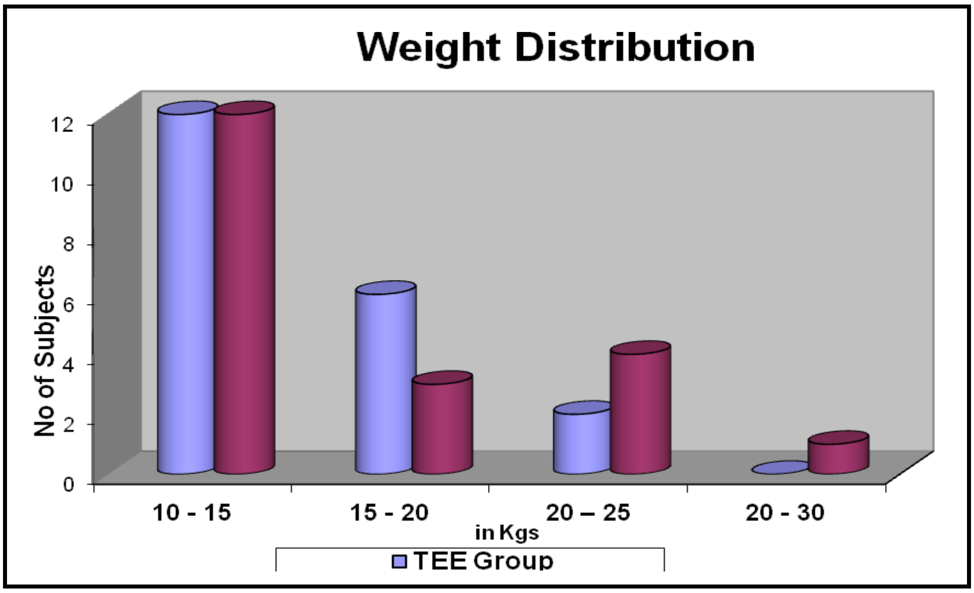

Weight Distribution
No of Subjects
12
10
8
6
4
2
0
10 - 15
15 - 20
20 – 25
20 - 30
in Kgs
TEE Group

Table 10.8: *Vein Cannulated*

	T Group		**L Group**	
	N	**%**	**N**	**%**
I J V	10	50.00	8	40.00
Subclavian	10	50.00	12	60.00
Chi square Value*	**0.40**			
Df	**1**			
Significant	**0.53 (insignificant)**			

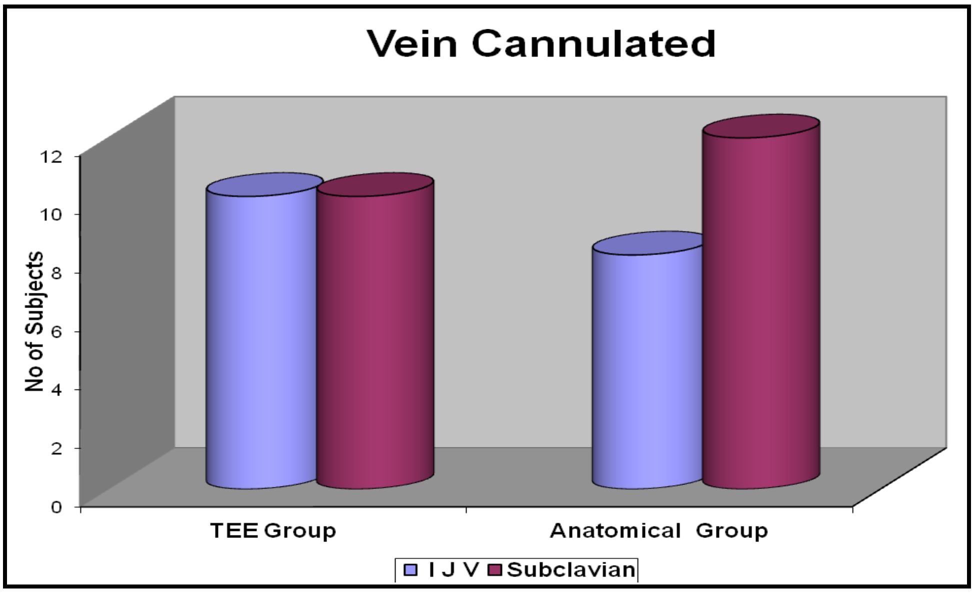


Table 10.9:*Insertion length difference between T & L group*

Difference	**Number**	**Percentage**
- 0.50	2	10.00
0 (No difference)	4	20.00
0.50	3	15.00
1.00	8	40.00
1.50	2	10.00
2.00	1	05.00
Total	20	100.00
Mean ± sd	0.68 ± **0.67**	

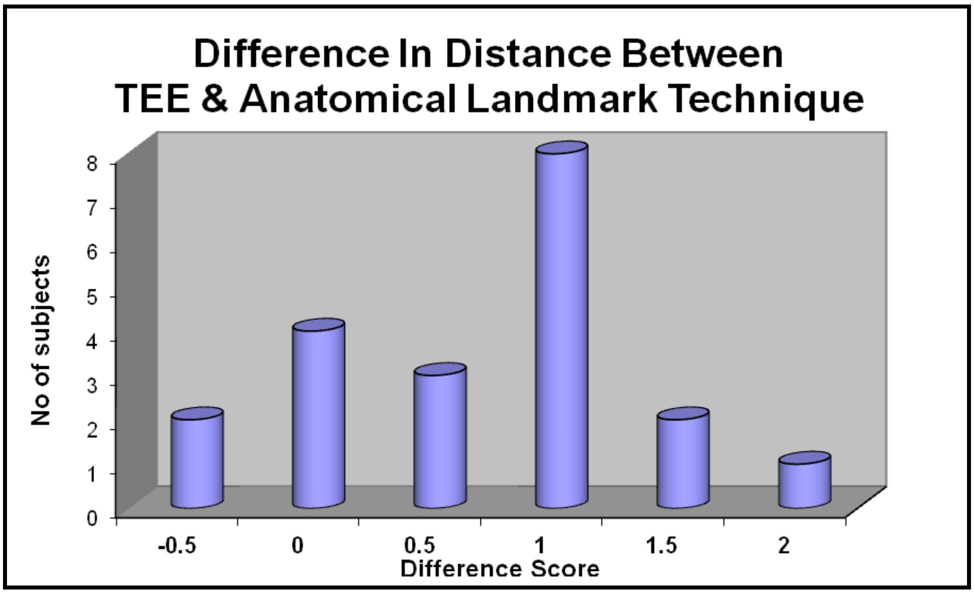


Table 10.10:*Insertion length difference between two groups*

	T Group	**L Group**
Mean	10.65	10.68
Sd	1.39	1.45
t-Value	**0.06**	
Df	**38**	
p-value	**0.96 (insignificant)**	

Table 10.11: *Insertion length difference measured by TEE & Pere's formula*

Difference	**Number**	**Percentage**
- 0.10	2	10.00
0	2	10.00
0.30	2	10.00
0.50	1	5.00
0.70	2	10.00
0.90	1	5.00
1.10	1	5.00
1.20	2	10.00
1.30	1	5.00

1.40	1	5.00
1.50	2	10.00
2.20	1	5.00
2.30	2	10.00
Total	20	100.00
Mean ± sd	0.96 ± **0.78**	

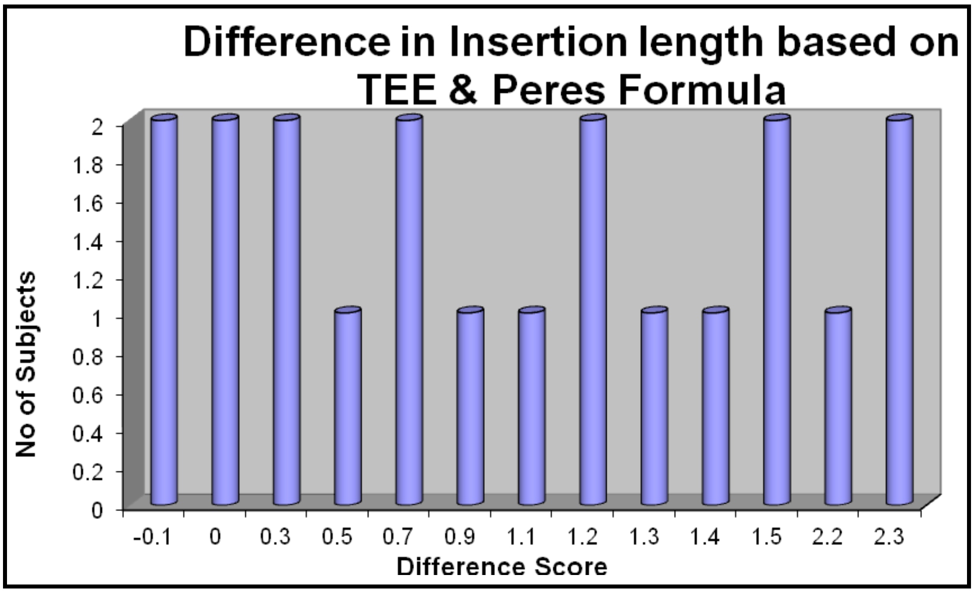


Table 10.12: *Insertion length difference measured by TEE & Pere's formula*

	TEE measured length	**Pere's Formula**
Mean	10.94	10.73
Sd	1.69	2.20
t-Value	**0.34**	
Df	**38**	
p-value	**0.74 (insignificant)**	

Table 10.13: *Accuracy in Placement based on TEE*

	T Group		**L Group**		**Total**	
	N	**%**	**N**	**%**	**N**	**%**
Yes	20	100	11	55.00	31	77.50
No	0	0	9	15.00	9	22.50
Total	20	100	20	100	40	100
Chi-square value	11.61					
Df	1					
p value	0.001 (Significant)					

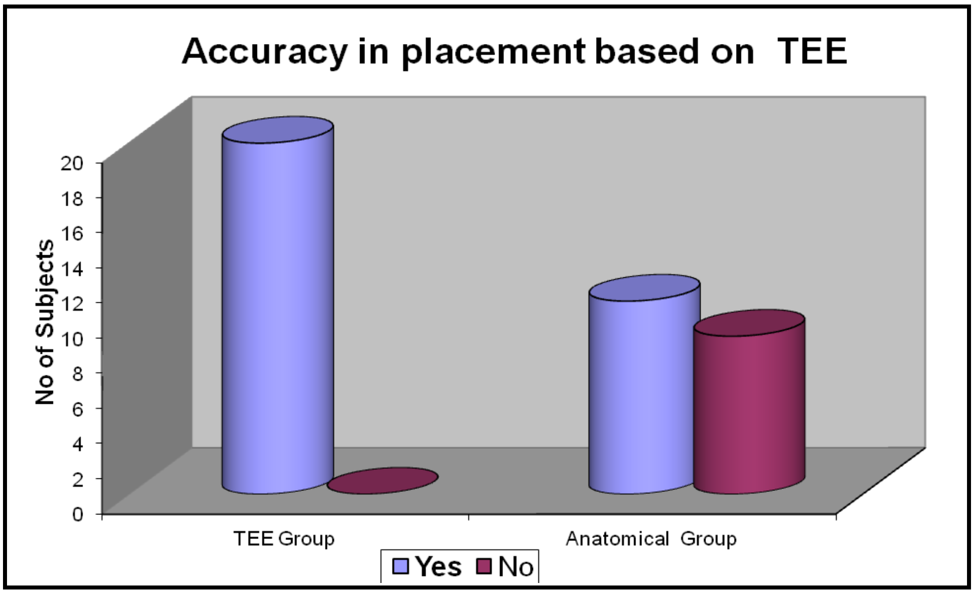
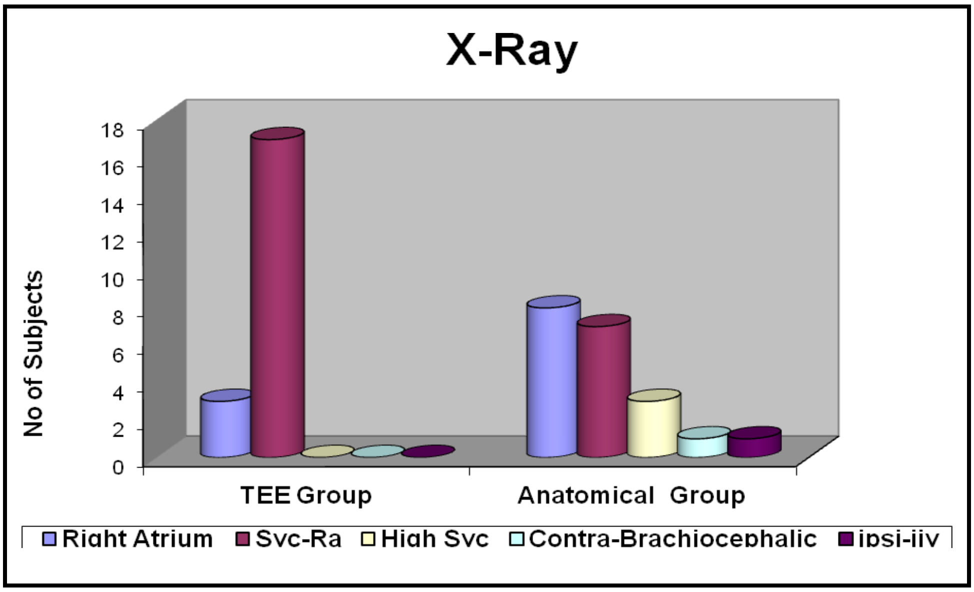

Accuracy in placement based on TEE
No of Subjects
0
2
4
6
8
10
12
14
16
18
20
TEE Group
Anatomical Group
Yes
No

Table 10.14: *Duration of Access*

	T Group	**L Group**
Mean	642.50	371.55
Sd	69.51	49.83
t-Value	**19.02**	
Df	**38**	
p-value	**0.0001 (Significant)**	

Table 10.15:*Post operative chest X-ray findings*

	T Group		L Group	
	N	**%**	**N**	**%**
Right Atrium	3	15.00	8	40.00
SVC-RA	17	85.00	7	35.00
High SVC	0	0	3	15.00
Contra-brachioceph	0	0	1	05.00
Ipsi-IJV	0	0	1	05.00
Chi square Value*	**11.44**			
Df	**4**			
Significant	**0.02 (Significant)**			



SENSITIVITY AND SPECIFICITY OF POSTOPERATIVE X-RAY IN TEE CONFIRMED POSITION

Table 10.16: *T Group*

Imaging Method	**Correct Placement**		**Total**
	Yes	**No**	
Yes	17	-	17
NO	3	-	3
TOTAL	20	-	20

Sensitivity = 85 %

Specificity=100%

Table-10.17: *L Group*

Imaging Method	**Correct Placement**		**Total**
	Yes	**No**	
Yes	7	-	7
NO	4	-	4
TOTAL	11	-	11

Sensitivity = 64 %

Specificity=100%

11. RESULTS

Mean and standard deviation were estimated for the various parameters in each group. The mean values were compared by student's independent't' test. Proportion and variables from each study group were compared by Pearson's Chi-square test. In this study**, 'p' value $<$ 0.05** was considered as level of significance.

- Both groups were similar with respect to their demographic profiles.
- Accuracy of Placement in the SVC-RA junction: In T Group all 20 catheters were accurately placed whereas in L Group only 11 of 20 were placed accurately (**p-value 0.001 significant)**.
- Time Taken for catheter placement: IN T Group the average time taken for catheter placement was 642.50 seconds whereas in L Group it was only 371.55 seconds (**p-value 0.0001 significant).**
- Insertion length difference based on TEE & ANATOMICAL LANDMARK TECHNIQUE: The

average difference in insertion length between the two techniques was 0.68 ± **0.67.**

- Insertion length difference based on TEE & PERE`S FORMULA: The average difference in insertion length between the two techniques was 0.96 ± **0.78.**
- Position of catheter in Post operative X-Ray: The position of the catheter was identified in all cases in both the groups (specificity 100%). In T Group the sensitivity of post operative X-Ray was 85% whereas the sensitivity post operative X-Ray in L Group was only 64%.
- There were no fatal complications in this study.

12. DISCUSSION

The observation and results of this study clearly shows the benefit of transesophageal echocardiography guided central venous catheter tip placement. In this study almost all the central venous catheter tip was placed in the SVC-RA junction or in the superior vena cava, there were no complications due to catheter misplacement or catheter tip related injury. Transesophageal echocardiography allows a direct two dimensional visualization of the superior vena cava and the catheter in the vein, if the guidewire or catheter was not found in the superior vena cava the guidewire was removed and reinserted.

In this study such a problem was not encountered in Group T. If the catheter was too deep in the right atrium it was withdrawn under direct visualization. The post-operative chest x-ray which we had taken showed whether the catheter was accurately placed or grossly misplaced. But in 3 cases when we had placed the catheter in the SVC-RA junction, the radiographic picture suggests it was deep in the right atrium. In the anatomical landmark group, the post operative chest x-ray was very useful in detecting the catheter which was into the ipsilateral internal jugular vein and in the contralateral brachiocephalic vein (i.e. left brachiolephalic vein).

The above findings were similar to the results of previously published study and also varied with some of the studies.

DEMOGRAPHIC PROFILE:

The major prospective controlled study comparing various methods of central venous catheter tip placement were conducted in patients undergoing cardiothoracic surgery vascular surgeries, cancer patients and major abdominal surgeries: Andropolous et al, 1999, Kaing – Shing Chu et al, 2004, Nigeal Reynolds et al, Hsujh, Wang CK et al.

The present study included only pediatric patients between 1 to 10 years undergoing surgery for congenital heart diseases like atrial septal defect closure, ventricular septal defect closure, tetrology of fallot intracardiac repair, partial anomalous pulmonary venous connection and coarctation of aorta. This clinical setting was selected for the study because the controlled environment of cardiothoracic operation theatre provided sufficient facilities and safety features.

In this study both the group were similar with respect to age, sex, height and weight distribution.

Accuracy in placement with transesophageal echocardiography guidance:

In the present study, with the help of transesophageal echocardiography guidance we were able to locate the central venous catheter tip easily and we placed the catheter tip easily and we placed the catheter in the lower most part of the superior vena cava just above the superior vena cava – right atrial junction in all the 20 patients in this group.

In addition we were able to notice that all IJV cannulation entered straight into the right atrium but about 20 to 30% of the right subclavian vein cannulation required manipulation of the guidewire like rotation. If we pass the guidewire opposite side of the J-tip the incidence of the guidewire, going to the left brachiocephalic vein is very high.

Andropolous et al, 1999[18], In their study on 145 congenital heart surgery patients, they were able to achieve 100% placement of the central venous catheter at the SVC-RA junction. They also adjusted to catheters placed by Anatomical landmark technique after placing the catheter and visualizing it by Transesophageal echocardiography.

Hsujh, Wangck et al[25], In their study on 20 adult patients undergoing surgery for malignant cancer, TEE guided central venous catheter tip placement was done, they also achieved 100% placement at SVC-RA junction.

The results of the above studies were in concurrence with the present study and accurate placement was achieved in all patients under TEE guidance.

Comparison of distance measured under TEE guidance versus distance measured by Anatomical land mark technique.

In the present study the average difference in distance measured by central venous catheter placement by Transesophageal echocardiographic visualization with that of external anatomical landmark technique as found to be $\pm$ 0.67cm with a mode of 1 cm difference.

Koung – Shing Chu et al[21], In their study all the patients were adult undergoing surgery for malignancy and had central venous catheters inserted via the SVC's only. The average difference in distance measured between TEE guidance technique and anatomical landmark technique was around $\pm$2cm's. But in their study they used the distance between the insertion point and a point of 5cm below the manibrosternal junction was used as initial catheter length. In their study they used to adjust the catheter length after imaging it with TEE but we corrected it only when it was grossly abnormal.

Comparison of distance measured under TEE guidance versus distance calculated using Pere's formula (i.e. Height in cm/10)

In this present study we did not use the Pere's formula for the central venous catheter tip placement but we calculated it just to find out the accuracy of the catheter tip placement when Pere's formula was used.

We found out that the average difference in distance comparing both the techniques was found out to be ±0.78cm which was evenly distributed between 0 to ± 2.30 cms.

Christine A. Czepizak et al, 1995[33], In their study, 280 adult patients in whom central venous catheter was introduced and placed, the catheter length placement distance was calculated using the formula developed by Peres. The result of their study indicated only 4% of catheter inserted via the right subclavian, and 10% of the catheter inserted via right internal jugular vein was placed in the right atrium.

From table (numeric) when we use Pere's formula we would have had atleast 10 catheter inside the right atrium even if we could allow 1.0 cm (I-1.0 +1.0) below the SVC RA junction as proper position. In other words 50% of the catheters would have been inside the right atrium if we had placed the catheter based on the formula.

Post – Operative Chest x-ray (Correlation/Relevance)

In the present study we had taken a post operative chest x-ray for all patients in the cardiothoracic post operative unit immediately on shifting to ascertain the position of the central venous catheter.

In TEE group, when we confirmed the position of the central venous catheter to be in the SVC-RA junction by direct two dimensional transesophageal echocardiographic imaging, 3 of the 20 patients, post-operative chest radiograph indicated placement into the right atrium and the remaining 17 patients the central venous catheter placement indicated accurate placement. The sensitivity of post-operative x-ray in this group was 85% whereas the specificity was 100% in detecting the central venous catheter tip.

In the Anatomical landmark group, we found out 11 of the 20 patients had correctly placed central venous catheter in the superior vena cava right atrium junction (with a confidence interval of $\pm$ 1.0cm) but post operative chest x-ray revealed only 7 of the 11 (correctly placed by TEE is taken as standard) to be in correct position. The sensitivity of the post operative chest x-ray was found to be 64% and a specificity of 100% in identifying the catheter tip position.

In our study we used the carina as a landmark to identify the SVC-RA junction.

Andropolous et al, 1999[18], In their study, they defined the radiographic SVE-RA junction as the apex of concave shadow formed by the superimposition of the distal SVC (superior vena cava) on the RA (Right atrium). They also corrected the position of the central venous catheter in the anatomical landmark group.

Of the 145 patients in their study they found out 135 had correct placement based on transesophageal echocardiographic imaging but chest x-ray revealed only 114 patients had correct placement in SVC and the remaining 31 patients did not have correct placement. The sensitivity of post-operative x-ray in predicting the accuracy of CVC tip placement in their study was 84.4% and the specificity was 100% in identifying the catheter tip.

Nigel Reynolds et al, 2001[24], In their study on 9 patients with central venous catheter placed for parenteral nutrition on a long-term basis, chest x-ray and TEE studies were done to compare the catheter tip position in both modalities, they found out 7 of the 9 patients had the central venous catheter tip placed in superior vena cava but on TEE examination only 2 patients had the CVC tip properly placed and the remaining patients had the tip placed too deeply inside the right atrium, some were touching even the tricuspid annulus.

The sensitivity of post operative x-ray in determining the CVC tip in the SCV-RA junction correlated well with studies. Andropolous et al. The specificity of Chest x-ray was 100% in identifying the central venous catheter tip in all the studies.

The reason for difference seen in both the imaging modalities (two dimensional transesophageal echocardiography & chest x-ray) could be because of the following reasons.

1. Catheter migration during transportation.
2. The TEE image was taken in an extended position and headturned 45^{o} but the chest radiograph is taken with the head in midline, this change in position could have caused catheter advancement.

3. Since small children with congenital heart disease may have right atrial enlargement due to shunt or pulmonary hypertension, the position of the SVC-RA position would also be altered.
4. Intra operative, surgical dissection around superior vena cava can also cause catheter tip migration.

Despite the low sensitivity in chest x-ray in prediction of SVC-RA junction (85%) when compared to two dimensional transesophageal echocardiographic imaging (100% accuracy), we were able to identify all the catheter tip (specificity 100%), in particular malpositions like the retrograde internal jugular vein cannulation, contra lateral subclavian/ brachiocephalic veins which were not visible by transesophageal echocardiography. In this study, with the help of post operative chest x-ray we were able to identify a catheter placed in the left brachiocephalic vein and retrogradely in the ipsilateral internal jugular vein, both could not be visualized with help of transesophageal echocardiography. Both the misplacements happened in the anatomical landmark group while cannulating subclavian vein. From the above study it was observed almost all the right internal jugular vein cannulation entered the SVC and right atrium but incidence of subclavian vein catheter misplacement is very common.The sensitivity of post operatively chest x-ray could have been better if we had taken the x-rays on the surgical table itself but it was not possible due to certain constraints.

Time taken for establishing access between TEE group and anatomical landmark group.

The average duration to establish access in TEE group was 642.50 seconds or roughly around 11 minutes but the average duration in the Anatomical landmark group was only 371.55 seconds roughly around 6 minutes. This difference was significant. If there was any accidental puncture of the carotid artery we would exclude the patient from the study because it was our institutional practice to give at least 5 minutes compression for arterial puncture to prevent the occurrence of hematoma.

Andropolous et al, 1999[18], In their study the average duration for central venous access was around 9.6 minutes in TEE group and 8.0 ± 3.5 minutes in control group.

The average duration of cannulation between the studies concurred well in TEE group but his duration for establishing access in the anatomical landmark group was significantly high, this was because in their study they adjusted all central venous catheter under TEE guidance in anatomical landmark group also which was not done by us in the present study.

13. SUMMARY

By comparing two dimensional transesophageal echocardiography guided central venous catheter tip placement versus anatomical landmark technique guided placement, the following parameters were analyzed: accuracy of central venous catheter tip placement under two dimensional transesophageal echocardiography guidance, insertion length of the catheter placement by various methods, time taken for central venous catheter placement and correlation of post operative chest x-ray in detecting the position of the catheter tip.

Using transesophageal echocardiography we were able to achieve 100% accurate placement in SVC-RA junction. Although the duration to establish a central venous access was increased by 10 ± 2 minutes, all possible complications due to catheter tip injury was avoided.

Insertion length of the catheter using TEE guidance was at least 1 cm less compared with anatomical landmark technique and Pere’s formula. In pediatric patients even few centimeters of extra insertion may lead to unnecessary fatal complications.

14. CONCLUSION

In pediatric patients undergoing elective cardiac surgery for congenital heart diseases, Transesophageal Echocardiography guided central venous catheter tip placement was more accurate than landmark technique. In this study Transesophageal Echocardiography guided technique was more efficient than the Pere's method.

Transesophageal Echocardiography should be routinely used during central venous cannulation in pediatric patients to avoid catheter related fatal complications. We should make the best use of the existing reliable technology for ensuring patient safety, hence routine identification of central venous catheter tip with Transesophageal Echocardiography has to be done if facility is available.

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MASTER CHART – L Group

Name	Age	Sex	Height	Weight	Vein Cannulated	Insertion Length by		Duration for Access	Tip Position by TEE	Post OP X-ray	Complications
						Anatomical Land mark	Peres Formula				
Prabha	12	female	140	23	subclavian	12	14	350	svc-ra	svc-ra	nil
Hemanth	3	female	75	11	ijv	8	7.5	328	svc-ra	svc-ra	nil
Baby	11	male	136	23	ijv	10.5	13.6	345	svc-ra	right atrium	nil
Saraswathy	7	female	130	17	subclavian	11	13	412	svc-ra	svc-ra	nil
Asen	5	female	105	13	subclavian	11	10.5	364	N V	high svc	nil
Nivetha	2 ½	female	80	10	ijv	9	8	340	high svc	high svc	nil
Dharsana	2 ½	female	85	10	subclavian	9	8.5	350	NV	left brachiocephalic	nil
Premalatha	10	female	127	22	subclavian	12	12.7	300	svc-ra	svc-ra	nil
Ranjith	11	male	113	17	ijv	11	11.3	320	right atrium	right atrium	nil
Seguveera	4 ½	male	95	12	subclavian	10	9.5	420	svc-ra	right atrium	nil
Susi	5	female	99	12	ijv	10	9.9	360	svc-ra	svc-ra	nil
Pravin	5	male	103	13	ijv	11	10.3	480	right atrium	right atrium	nil
Gayathri	4	female	102	13	subclavian	10	10.2	360	right atrium	right atrium	nil
Akila	7	female	115	17	subclavian	11	11.5	400	high svc	high svc	nil
Nidisha	4 ½	female	100	13	ijv	11	10	382	svc-ra	svc-ra	nil
Ranjith	10	male	140	28	subclavian	12	14	300	svc-ra	right atrium	nil
janani	4 ½	female	88	11	ijv	10	8.8	480	right atrium	right atrium	nil
Dhanush	2 ½	male	80	10	subclavian	9	8	400	N V	ipsi-ijv	nil
Devika	3	female	90	11	subclavian	9	9	380	svc-ra	svc-ra	nil
Manju	11	female	142	24	ijv	12	14.2	360	svc-ra	right atrium	nil

MASTER CHART – T Group

Name	Age	Sex	Height	Weight	Vein Cannulated	Insertion Length by Anatomical Land mark	Peres Formula	TEE	Duration for Access	Post OP X-ray	Complications
Dhatchayani	3	female	93	10	subclavian	10	9.3	9	600	svc-ra	nil
Bharathi	11	female	132	18	subclavian	12.5	13.2	11	680	svc-ra	nil
Reeta	12	female	31	25	ijv	13	13.1	12	612	svc-ra	nil
Sriram	7	male	115	16	subclavian	12	11.5	11.5	640	svc-ra	nil
Priya	10	female	132	20	ijv	12	13.2	12.5	600	right atrium	nil
Hazira	2 ½	female	89	11	ijv	9	8.9	9	686	svc-ra	nil
Satya	3 ½	male	89	12	ijv	8.5	8.9	9	645	svc-ra	nil
Kanimozhi	2 ½	female	85	10	subclavian	8.5	8.5	8.5	666	svc-ra	nil
Muneeswaran	9	male	125	20	subclavian	12	12.5	11	620	right atrium	nil
Ramya	4	female	108	12	ijv	10	10.8	9.5	640	svc-ra	nil
Maneka	4	female	93	14	ijv	9.5	9.3	9	620	svc-ra	nil
Umadevi	7	female	114	15	subclavian	12	11.4	10	650	svc-ra	nil
Sanjay	5	female	97	12	ijv	10	9.7	9	640	svc-ra	nil
Ajay	7	male	119	17	subclavian	11	11.9	11	602	svc-ra	nil
Sahana	6	female	110	15	ijv	11	11	9.5	610	svc-ra	nil
lavanya	7	female	133	19	ijv	12	13.3	11	640	svc-ra	nil
Abirami	6	female	112	15	subclavian	10	11.2	10	630	right atrium	nil
Suganthi	4 ½	female	102	11	subclavian	10	10.2	9	720	svc-ra	nil
Bhuvanesh	8	male	123	21	subclavian	11	12.3	10	740	svc-ra	nil
Ranjith	2 ½	male	85	10	ijv	9	8.5	8	600	svc-ra	nil

PROFORMA

A Comparative Study on the Efficacy of Transesophageal Echocardiography Guidance Versus Anatomical Landmark Technique in the Placement of Central Venous Catheter Tip in Pediatric Patients Undergoing Surgery for Congenital Heart Diseases.

Serial No:

Name: **Age:** **Sex:**

IP No:

Diagnosis:

Procedure to be done:

H/O Presenting Complaints:

Past History of Other Medical Illness:

History of Surgery:

Antenatal History:

Perinatal History:

Anesthesia History: (Previous Central venous cannulation, recovery from anesthesia, significant events)

History of any bleeding diathesis/coagulation abnormalities:

GENERAL EXAMINATION

Conscious Oriented

Height Weight

Blood pressure: --------mm hg

Pulse Rate: ----------/ mt

Temperature Pallor

Cyanosis Clubbing

Pedal edema Jaundice

JVP Lymph nodes

Examination of oral cavity

Skin / hair / nail changes:

CARDIOVASCULAR SYSTEM:

s1 s2 heard murmurs:

RESPIRATORY SYSTEM:

Normal vesicular breath sounds

Crepitations: Wheeze:

ASA Risk - I/II/III

Elective/Emergency

Randomization: T Group / L Group

Vein Cannulated: Right Subclavian / Right IJV

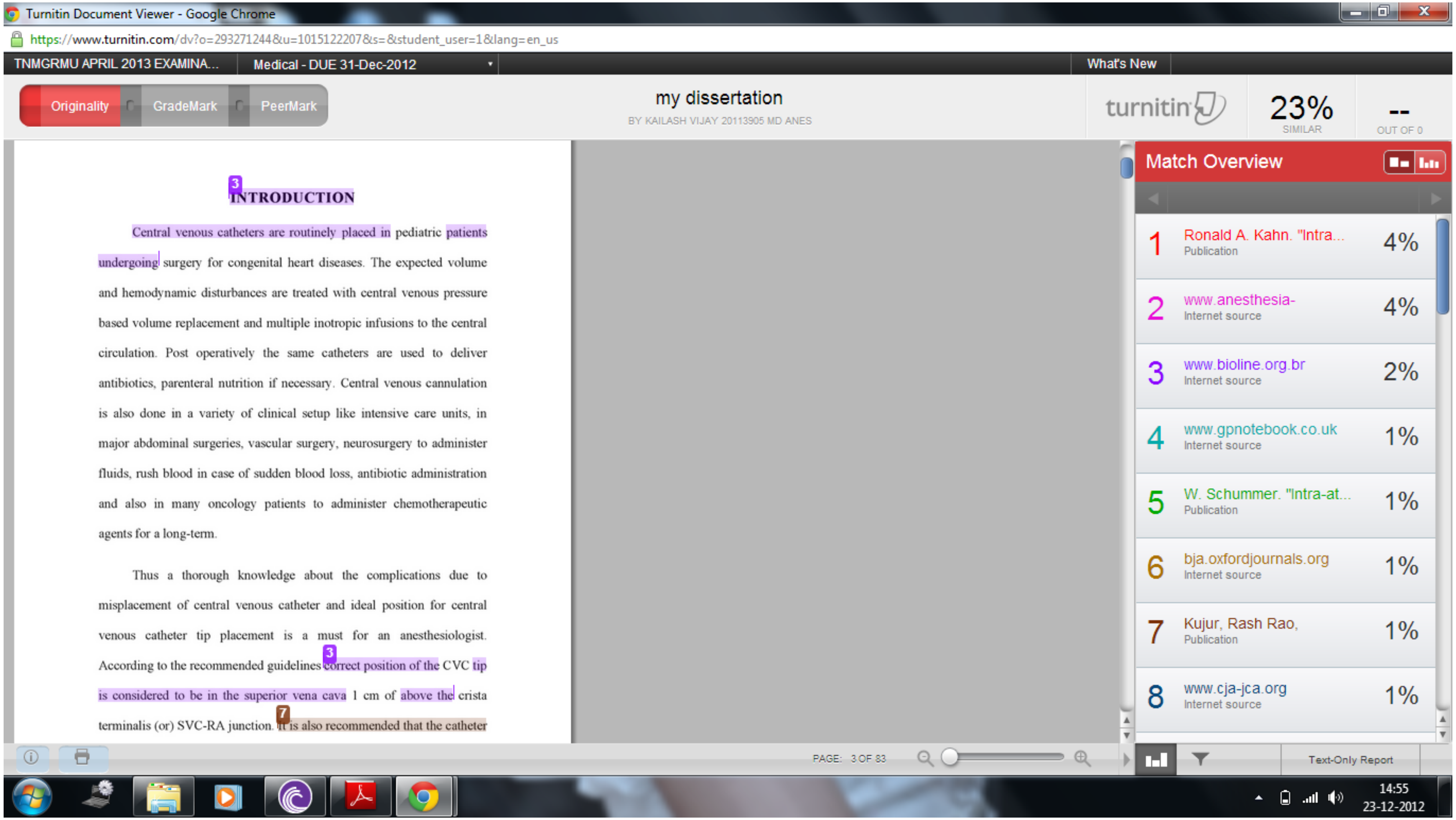
Duration of Access:

Complications if any:

Position of CVC Tip based on TEE:

Position of CVC Tip based on Post-OP chest x-ray:

ANTIPLAGARISM SCREEN SHOT



PATIENT INFORMATION FORM

Investigator: Dr.V.Kailash

Name of the participant:

Title: A Comparative Study on the Efficacy of Transesophageal Echocardiography Guidance Versus Anatomical Landmark Technique in correct placement of Central Venous Catheter in Congenital Heart Surgery Patients.

You are invited to take part in this result study. We have got approval from IEC. You are asked to participate because you satisfy the eligibility criteria. We want to compare and study the safety and efficacy of TEE Vs anatomical landmark technique in CVC tip placement.

What is the purpose of research?

For precise cannulation of cvc and thereby avoiding complications such as intraarterial cannulation, cardiac perforation/ tamponade, intrathoracic placement, erroneous hemodynamic data from unrecognised malposition.

Study design

40 patients presenting for elective surgeries for congenital heart diseases will be randomly assigned for central venous catheter placement using the TEE technique and anatomical landmark technique. In 20 patients cvc was

placed using TEE technique. In 20 other patients cvc was placed using the anatomical landmark technique. In both groups the position of the tip of the catheter was identified using TEE.

Benefits

Since we will be able to identify the position of the tip immediately we can place it exactly at the SVC-RA junction. Any complication such as inadvertent arterial placement or malposition can be identified and rectified very early.

This intervention has been shown to be well tolerated as shown by previous studies. And if you do not want to participate you will have alternative of setting the standard treatment and your safety is our prime concern.

Time:

Date:

Place:

Signature of participant

PATIENT CONSENT FORM

Study title: A Comparative Study on the Efficacy of Transesophageal Echocardiography Guidance Versus Anatomical Landmark Technique in correct placement of Central Venous Catheter in Congenital Heart Surgery Patients.

Study centre: Department of Pediatric Cardithoracic Surgery
Govt Institute of Child Health& Hospital for children
Chennai-600 008.

Participant name: Age: Sex:

I.P. No:

I confirm that I have understood the purpose of procedure for the above study. I have the opportunity to ask the question and all my questions and doubts have been answered to my satisfaction.

I have been explained about the pitfall in the procedure. I have been explained about the safety, advantage and disadvantage of the technique.

I understand that my participation in the study is voluntary and that i am free to withdraw at anytime without giving any reason.

I understand that investigator, regulatory authorities and the ethics committee will not need my permission to look at my health records both in respect to current study and any further research that may be conducted in relation to it, even if i withdraw from the study. I understand that my identity will not be revealed in any information released to third parties or published, unless as required under the law. I agree not to restrict the use of any data or results that arise from the study.

Time:

Date:

Signature / thumb impression of patient

Place:

Patient name:

Signature of the investigator:

Name of the investigator: