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Theoretical Information of Transesophageal Echocardiography in Invasive-Cardiology Section.

Rudranil Barman[1] Bsc (CRT), Amrutha A[2] Bsc (CRT), Chaitra Gajulla Nagaraja[3*] BE, MTech, PHD

[1]Student of Bachelors of Cardiac technology, Department of Allied Health and Sciences, Jain Deemed-to-be university, Whitefield, Bangalore, 560066 India.
[2]Student of Bachelors of Cardiac technology, Department of Allied Health and Sciences, Jain Deemed-to-be university, Whitefield, Bangalore, 560066 India.
[3]Faculty of Allied Health and Sciences, Department of IT Healthcare, Jain Deemed-to-be university, Whitefield, Bangalore, 560066 India.
Jain Deemed-to be University, Allied Health & Sciences, Whitefield Bangalore, 560066 India.

A B S T R A C T

Transesophageal Echocardiography (TEE) is a ultrasound based procedure used in the surgical intervention of the heart (1). It comprises of the matrix-array transducer consisting of 3000 piezoelectric elements. TEE can be done in two modalities 2-D TEE and 3-D TEE. 2-D TEE is a conventional method, it helps to measure the diameter of each cardiac chambers, cardiac murmur, ejection jet, velocity of blood flow, pericardial effusion, valve wall motion abnormality muscle. 3-D TEE helps to give out more fine anatomical details about the heart. This paper reviews about 28 cross-sectional views that are practically available and additional views in research obtained from TEE . These cross sections are discussed with reference to TEE performed for patients with congenital heart disease like Atrial Septal Defect (ASD), Ventricular Septal Defect (VSD) and Patent Forman Ovale (PFO) (2). Also in non congenital heart diseases like Endocarditis. This paper is to give technical information for medical and non-medical profession from different domains like computer vision engineers, IT professions and teachers that helps in collaborative research and integration with fields such as radiology, emergency medicine and gastroenterology mainly and robotics. This paper discuss about the challenges in current procedure practically as a gateway for further research.

I. Introduction

Transesophageal echocardiography (TEE), ultrasound based applications with advance technology is used in the patient care settings like Intensive Care Unit(ICU), Operation Theatres(OT) to detect detailed information of the heart to detect anomalies of the heart. It is a semi-invasive technique (3). A long thin tube (endoscopic probe) transducer that emits ultrasound waves, is inserted orally through esophagus to view the heart structure .TEE is performed with topical anaesthesia by spraying on the oropharynx with or without sedatives as per comfort of patients. Sedatives such as midazolam are commonly used prior to probing to make the procedure more tolerable, comfortable for the patients, and also to avoid obstruction to pass the probe in to esophagus. TEE is used to detect many abnormalities in the heart such as embolism, perforation, abscess, valve shunting, valve dysfunction, volume output, cell injury like edema, pericardial effusion etc (4). It helps to measure both the anatomical and physiological functions of the heart. It is also very useful in monitoring mitral valve repair as well as fat embolism which can travels in bloodstream from lower extremities to upper extremities due to major bone fracture, and further can be detect in heart as emboli form. Fat embolism can form more severe when it reaches to cerebral as cerebral embolism (5). (6) It has significant roles in new born with congenital heart disease both (cyanotic and acyanotic conditions) (7). TEE is a supreme ultrasound assessing tool for cardiac structures with minute details. TEE gives faster frame rate in 2D, high dynamic resolution, high volume rate in 3D, and real-time imaging without any artifacts (8). Here faster frame rate refers to the rapid movement of the heart. TEE requires training by a gastroenterologist to the cardiologist for safe handling and insertion of an echoscope. TEE helps in accessing critical care patients, especially patients with cardiothoracic surgery and heart related problems (9). (10)According cardiac pathology, TEE is a great tool for evaluation, for analysing as cardiac tumours, cardiac myxomas, and left atrial thrombi etc. It also helps to detect abnormalities in the vessels of the heart, posterior or anterior walls of the heart (11).So once it gets confirmed, endomyocardial biopsy or other correction procedures are to be done.

Transthoracic Echocardiography (TTE) is one of the traditional echocardiography techniques which we regularly use in diagnostic centres and hospital clinics, that is generally used in initial diagnosis. A transducer placed on various part of chest for viewing of the heart chambers and vessels. The TEE procedure is done intra-operatively to evaluate the motion of the heart (12). However TEE is not preferred to be used in the diagnostic (Clinical) room frequently because it is a procedure where insertion of probe is necessary (semi-invasive technique) and also for high image acquisition. Moreover it's mostly used in ICU (Intensive care unit) such as PICU (Pediatric Intensive care unit), SICU (Surgical Intensive care unit), NICU (Neonates Intensive

care unit) and OT (Operation theatre) (13). (14) It gives a wider range of evaluations in imaging. However TEE (Transesophageal Echocardiography) has a higher potential than TTE (Trans-thoracic Echocardiography).

Difference between TEE and TTE is overviewed in the table 1, where TTE measures gradient of blood and its ejection fraction of Left ventricle, with information of heart chamber in 2D. While TEE is to detect and measure the embolic source in patient with mechanical mitral valve. TTE is non-invasive technique while TEE is semi-invasive. Piezo electric crystal used in TEE is more compared to TTE, it is also one of the reason to get less accurate image in TTE. Operating technique used in TTE is skill based while TEE probes is knobolgy based which require basic motor skills. Based on the comparison with TTE, TEE is better in producing to detailed information of heart.

In this paper, section 2 gives heart anatomical information/modalities with respect to TEE and its procedure. Section 3, gives information of the uses and types of views with respect to positioning of the probe, chambers and vessels of the heart in TEE. Section 4, explains about different complications and consequences of TEE (semi invasive technique), while performing the procedure. In Section 5, gives information about basic protocol and guidelines necessary while using TEE. Section 6, shows how TEE imaging and its real time 3D view are related. Finally Section 7, concludes with cases of heart diseases and clinical manifestation of TEE. In future works we would like to propose the method to use non invasive technique to acquire information by avoiding semi-invasive technique.

Table no. 1- Difference between TTE and TEE

SL.no	Parameter	TTE	TEE
1	Measures	Radiant, diameter and ejection fraction	Embolic source of patient with mechanical mitral valve
2	Type of technique	Non invasive technique	Semi-invasive technique
3	Piezo-crystals quantity	Less	More
4	Operating	Manual	Knobology
5	View with Doppler option	Normal	Enhanced
6	Focused part	Frontal	Posterior

2. Heart anatomy with respect to TEE and procedure

TEE uses monoplane, biplane and multi-plane for cross-sectional detailed view of the heart. Monoplane alone gives out parallel waves, which is not an ideal solution for obtaining complete anatomical details of the heart, instead biplane and multi-planer gives more transverse and oblique section's data to get cranial- caudal views. The combination of both longitudinal axis and transverse axis provides magnified classic detection of Cardiac anomalies (14). TEE procedure is usually done with the help of cranial-caudal movement for wider range zooming view of the heart (15). TEE can be done in both pre-operative and post-operative procedure of heart disease. It also helps to detect sinus of valsalva (aneurysm in aortic root), where it can arising from right coronary cusp, non coronary cusp or left coronary cusp which can overlaps on the chambers. Left coronary cusp to left atrium is very rare. Right coronary cusp to right ventricle is more common. Sinus of valsalva is present just above the annulus of aorta. Generally males are more common [63] (16). Even TEE helps in finding anomalies in the coronary arteries with the help of contrast agents, especially in the initial arteries which are arising from the aortic cusp. In upcoming times (17) (18)it will be great visualization tool and can be used for various complications in coronary arteries. (19) (20) (21)

TEE head probes can move around 180*, it has retroflex, ante flex, flexion to right, flexion to left, rotate forward, rotate back, withdraw, advance, rotate to the right, and rotate to left (22). In emergency cases like atrial fibrillation and flutter or patients with cardiac arrest, we prefer TEE for the structural assessment, such as atrioventricular outflow valve tract, left ventricular outflow tract, and in the thoracic aorta (23). TEE can move around with retroflection or antireflection with respect to lateral angulations of the probe.

In recent studies (24) (25), TEE is also helpful during cardiac robotic surgery and MICS (Minimally Invasive Cardiac Surgery). TEE helps in visualizing the structure during intra-operative that is insertion of inferior vena cava cannulation, superior vena cava cannulation or aorta cannulation. TEE also contributes for measurement of gradient blood flow by prosthetic valve anatomy (26) Even also helps in assessing microbial propagation on prosthetic valve, after surgical replacement of valve (27) (28)It is also helpful for guided wire technique in liver transplantation as well as gastrointestinal surgery.

3. Types of views from TEE and its uses

TEE mainly divides into four stages of main views that are UE (Upper Esophageal) view, TG (Transgastric) view, ME (Mid Esophageal) view, and Deep transgastric view and further divided into multiple cross-sectional views.

There are 28 cross-sectional views of TEE (Transesophageal Echocardiography), and views are obtained by TEE probe positioning at different location from esophagus to stomach region (cardiac).

Table no. 2- Cross-sectional views of TEE

Anatomical location of the probe [45]	Transducer probe angle [45] (29)	Views images
1. Midesophageal two-chamber views	80^0-100^0	CS, LA, LAA, LV, MV [49] (30)
2. Midesophageal five-chamber view	0^0-100^0	AV, LV, LVOT, LA, RA, RV, intact ventricular septum, MV and TV. [50]
3. Midesophageal four-chamber views	0^0-100^0	RA, LA, inter-atrial septum, RV, intact ventricular septum, LV, MV and TV [50]
4. Midesophageal mitral commissural views	50^0-70^0	LA, LV, CS, MV, papillary muscles and chordate tendinae. [51] (31)
5. Midesophageal long axis views	120^0-140^0	LV, LA, LVOT, MV, RVOT, AV and proximal ascending aorta [51] (31)
6. Midesophageal aortic valve long axis views	120^0-140^0	LA, RVOT, LVOT, AV, MV and proximal ascending aorta. [51-52] (31)
7. Midesophageal ascending aorta long axis views	90^0-110^0	Mid-ascending aorta, (right) PA [51] (31)
8. q Midesophageal ascending aorta short axis views	0^0-30^0	Mid ascending aorta (short axis view), (main/bifurcation) PA and SVC [51] (31)
9. Midesophageal right pulmonary vein views	0^0-30^0	Mid ascending aorta, SVC and (right) PV [51] (31)
10. Midesophageal aorta valve short axis views	25^0-45^0	AV, LA, RA, superior inter-atrial septum, RVOT and Pv. [50]
11. Midesophageal right ventricle inflow-outflow view	50^0-70^0	RA, AV, LA, superior inter-atrial septum, TV, RVOT and Pv.[53]
12. Midesophageal modified bicaval tricuspid valve views	50^0-70^0	RA, LA, mid inter-atrial septum, SVC and IVC [51] (31)
13. Midesophageal bicaval views	90^0-110^0	LA, RA, RAA, inter-atrial septum, SVC and IVC [51] (31)
14. Upper Esophageal right and left pulmonary veins views	90^0-110^0	PV (upper and lower) and PA [51-54]
15. Midesophageal left atrial appendage views	90^0-110^0	LAA and left upper PV [51-54]
16. Transgastric basal short axis views	**0^0-20^0**	**LV (base), RV (base) and MV (short axis view) [57]**
17. Transgastric mid papillary short axis views	0^0-20^0	LV (mid), papillary muscles and RV (mid) [57]
18. Transgastric apical short-axis views	0^0-20^0	LV (apex) and RV (mid)
19. Transgastric right ventricle basal views	0^0-20^0	LV (mid), RV (mid), RVOT, TV (short axis view) and PV [54]
20. Transgastric right ventricle inflow- outflow views	0^0-20^0	RA, RV, RVOT, PV and TV [50]
21. Deep Transgastric five-chamber views	0^0-20^0	LV, LVOT, RV, AV, aortic root and MV [21]
22. Transgastric two- chamber views	90^0-110^0	LV, LA, LAA and MV [57]
23. Transgastric right ventricle inflow views	90^0-110^0	RV, RA and TV [51-55]
24. Transgastric long axis views	**120^0-140^0**	**LV, LVOT, RV, AV, aortic root and MV [50]**
25. Descending aorta short axis views	0^0-100^0	Aorta, left thorax, hemizygous and azygous veins and intercostals arteries [51]
26. Descending long axis views	90^0-100^0	Descending aorta, left thorax [51]
27. Upper Esophageal aortic arch long axis views	0^0-100^0	Aortic arch, innominate vein and mediastinal tissue [52]
28. Upper Esophageal aortic arch short axis views	70^0-90^0	Aortic arch, innominate vein, PA, PV and mediastinal tissue [56]

29.	**Transgastric inferior vena-cava view**	0^0-20^0	IVC, RVOT, RA [57]
***(Additional view)**			

Table no. 3- Terminology of the words

Short words		Terminology
1.	**RA**	Right atrium
2.	**AV**	Aortic valve
3.	**RV**	Right ventricle
4.	**PV**	Pulmonary vein
5.	**Pv.**	Pulmonary valve
6.	**RAA**	Right atrial appendage
7.	**LA**	Left atrium
8.	**LV**	**Left ventricle**
9.	**LAA**	Left atrial appendage
10.	**CS**	Coronary Sinus
11.	**IVC**	Inferior Vena cava
12.	**SVC**	Superior Vena cava
13.	**RVOT**	Right Ventricular outflow tract
14.	**LVOT**	Left Ventricular outflow tract
15.	**MV**	Mitral valve
16.	**TV**	Tricuspid valve
17.	**PA**	**Pulmonary artery**

4. Complications due to TEE

TEE is a semi-invasive technique, so it has few complications while inserting a TEE (Transesophageal) probe. Probe can lead to injury on multiple sites, such as oral (lip trauma or dental), oropharyngeal (laceration and perforation), laryngeal (vocal cord trauma, airway compression, tracheal intubation), esophageal (laceration, perforation, false passage diverticulum), gastric (laceration, perforation, bleeding).There is a higher chance of hitting the Uvula while initially inserting the probe. Handling a TEE probe requires a special training program for a cardiologist (interventional, Echo-cardiographer, Cardiothoracic surgeon) and Health care professionals (Cardiac technologist Echo Technician., Cath lab technologist, or senior resident). Lubricating of TEE probe is very essential to avoid hindrance of tear inner lining esophagus (32).

Patients with ET (Endotracheal intubation) (33)faced difficulty in facilitating of TEE probe inside which can lead to complications. Even while inserting in the gastric region, there is a higher chance of hitting the lining of the fundus region (stomach), and this leads to upper GI bleeding or hemorrhage (34) (35) Mal-positioning can also lead to complications. The in-charge (Cardiologist, Anaesthesiologist) should use proper muscle relaxants; otherwise can lead to complications due to gag reflex. Patient with prolong TEE during intervention of heart can also leads to complications (36)Trauma patient with aortic rupture is a critical stage, where TEE plays role for visualizing of structural deformity with an embolic potential source (37) (38)

Table no. 4- The site and its injury

Injury[46]	Definition	Sites
Lip bruising	Rupture of blood vessels in lip or bruise.	Oropharyngeal
Perforation of hypopharynx	A small hole that develops in the lower part of the pharynx that lies right behind your larynx.	Oropharyngeal
Pharyngeal laceration	A deep cut or tear of the lining of the pharyngeal.	Oropharyngeal
Dysphasia	Not able to speak due to the insertion of the probe.	Esophageal
Mallory Weiss tear	A tear of tissue in the lower esophagus.	Esophageal
Odynophagia	Pain swallowing	Esophageal
Upper GI bleeding	Peptic ulcers	Gastric
Hemorrhage	Bleeding from damaged vessels	Gastric

The absolute contraindications are perforated viscous, stricture, pharyngeal laceration, esophageal perforation, active upper GI bleed, recent upper GI surgery, esophagectomy, etc [70] (39).

The relative contraindications are Atlantoaxial joint disease, severe cervical arthritis, and Barrett's esophagus, history of dysphasia, history of GI surgery, prior radiation to the chest, Thoracoabdominal aneurysm, coagulopathy, and thrombocytopenia (40) (41) (42) (43)

5. Basic TEE guidelines

TEE controller consists of control wheels, a handle, a body, a connector, and a tip. Following information is extracted from the patient/patient records

1) Patient History (44)
    - Assessment of last food and liquid intake
    - Medications intake
    - Underlying cardiopulmonary disease
    - Alcohol or tobacco consumption
    - Allergic reactions
    - Airway history

2. After the history, we go for physical assessment such as an airway examination and try to look uvula for accessing the TEE probe.
3. Check the systems of TEE probes functions, including the movement of the probes and knobology of TEE.
4. Attach ECG leads to the patient, pulse oximeter.
5. Positioning of patient
6. The lubricating probe then starts the procedure of TEE insertion.
7. At last, access the TEE monitor, and vital sign monitor.

6. TEE imaging

TEE is an integral part of the surgical unit of cardiac surgery according to Indian Association of Cardiac Anaesthesiologists (IACTA) published in 2013 (45) (46)TEE should be practiced in both peri-operative and intra-operative procedures that perform by doctors during the management of surgical patients and in cardiac surgery for monitoring the efficiency of heart functioning (47). Surgery can be done for both congenital heart disease and non-congenital heart diseases too. TEE is used for the assessment and evaluation of patients with prosthetic valve or biological valve function (48)

The left ejection fraction was calculated by Simpson's method for which frame rate information is useful. 2D TEE helps to understand the frame rate of the heart. A comprehensive 3D TEE examination uses high temporal spatial resolution of probe, that uses a wider angle pyramid of acquisition (49). 3D TEE for the mitral valve is used to determine valve dysfunction, pathological conditions, location, and mechanism of the valve. Here a matrix-array transducer is used and wide-angle of 3D TEE helps to look at valves as well as the papillary muscles. Its 3D colour flow Doppler is used to understand the regurgitation/stenosis, especially in the mitral valve. Doppler is set for the identification and area of interest. In 3D TEE colour Doppler understanding of blood flow systole and diastole, it's a tricky and skilled job due to multiple cross-sectional views. The anatomy and Physiology of the heart play a vital role while performing of TEE procedure (50). Mid-esophageal views help to understand most of the morphological and structural characterization of the aortic valve and left ventricle (51). TEE is used to visualize minor details of all structures in the heart. In three-dimensional echocardiography TGC (Time Gain Compensation) should be used frequently for the evaluation of minute details, generally, TGC (Time Gain Compensation) is set lower in the near field and set higher in the far field for the better view. Gain should be optimal (52) (53). If it goes to the higher end it will affect the regurgitation jet. The frequency of 3D TEE is about 5 to 7 MHz and the transducer is composed of nearly 3,000 piezoelectric elements.

3D TEE imaging is also done on the grey scale of images. In recent studies (54), the matrix-array transducer is smaller than the previous generation. Advanced 3D TEE can be done on live which can be comprised of 3D TEE zoomed live, 3D TEE narrow volume live, 3D TEE wide angled volume live, and live 3D colour and Doppler (55) The limitations of 3DTEEcolour Doppler acquisition include poor spatial and temporal resolution, both expected to improve with the advancement of 3D TEE technology. However 2D imaging is also done initially which uses conventional method (56).

7. Clinical manifestation of TEE respective to particular disease

7.1 TEE identifying Infective Endocarditis

Infective endocarditis can be life-threatening, where if an individual doesn't get proper treatment initially, they have to face complications at later stages. People who are at a higher risk of infective endocarditis should undergo early TEE diagnosis. For better findings of infective endocarditis both TTE and TEE results combined (55). Enhancing TEE helps in detection of paravalvular complications due to infective endocarditis.

Firstly we prefer TTE evaluation for infective endocarditis, and then we go for better evaluation for Transesophageal Echocardiography. TEE helps to identify infective endocarditis in the valvular region and positive blood cultures (bacterial blood) and early detection of infective endocarditis will help to evaluate the severity of the heart valves and medical therapy is given as early as possible (57).

During infective endocarditis, we can easily see perivalvular abscess or prosthetic valve dysfunction while performing TEE and later we might see embolism detection. TEE has high resolution than TTE when it comes to valvular lesions or infective valves identification (40) (58)

M-mode of TEE helps in identifying many variations including abscess formation, aneurysms and mural endocardial lesions (59). TEE uses mono as well as multi-planes for the diagnosis of infective endocarditis [30] (60)

Recently, (61)TEE is an essential tool in cardiac settings for better images modalities of structural anatomy for heart, beside that pathological condition should be confirmed in lab, during clinical practices. Transthoracic and Transesophageal colour Doppler is essential during surgery volume estimation (58) (62)

Infective endocarditis origin is from Staphylococcal Aureus. A Duke criterion is done for infective endocarditis, which helps us to estimate and understand whether the individual is affected or not. Some criteria are blood culture, echocardiography for valvular vegetation, temperature, IV drug use, immunological phenomena, embolic phenomena, and cardiac lesion (which predispose infective endocarditis). Generally, duke criteria are divided into major and minor criteria, where major is visible and minor is diagnostic [72] (63). So for improved diagnosis of infective endocarditis, we prefer antibacterial therapy, clinical microbiology, cardiac imaging that is echocardiography, and cardiac surgery. (64) It has been noticed that individual is already affected with endocarditis, but it's impossible to detect due to negative false echocardiography, and the reasons are (64)

- Poor acoustic windows
- Small vegetation (<3mm)
- Recent embolism
- Non-oscillating vegetations
- Atypically located vegetations
- Pre-existing cardiac lesions such as degenerative or sclerotic valves, prosthetic valves, and intracardiac devices

Vegetation refers to the microbial, bacterial or viral growth on the valve of heart (64). So the identification of infective endocarditis in echocardiography is an irregular shape on the valve, attached to the valve, valvular regurgitation, oscillating, or sometimes mobile. The best location to find infective endocarditis is the left ventricle side of the aortic valve, the left atrium of the mitral valve, right atrium of the tricuspid valve. As per the studies, TTE detects with 40-80% and TEE detects with about > 95% accuracy (22)

Infective endocarditis leads to structural complications like fistula, leaflet rupture or filial, leaflet perforation, abscess, aneurysm prosthetic valve dehiscence, embolization, and pericardial effusion (62)It also leads to hemodynamic complications such as acute valvular regurgitation, heart failure, intracardiac shunt, cardiac tamponade, valve obstruction, and haemolysis. An abscess can be identified in echocardiography by echo free-space bounded by thin tissue and defect by Doppler flow (64). Perforation can be identified in echocardiography by a defect in the body of the valve leaflet with evidence of a flow-through defect (65)

For infective endocarditis, the required team of surgery consisting of interventional cardiologists (specialization in performing procedure), Cardiothoracic surgeons (if infective endocarditis gets chronic stage and affects other structure of the heart) (66), Vascular surgeons (if infective endocarditis leads to the vascular anatomises or vascular abnormalities), team of nurses, Neurologist and health care professional (cardiac technologist), Anaesthesiologist.

7.2 TEE identifying ASD (Atrial Septal Defects)

An Atrial Septal Defect (ASDs) constitutes 13% of all congenital heart diseases with a prevalence rate of 1.6 to 1.8 per 1000 live births [80] (67). The Atrial Septal Defects are divided into five subgroup that are Ostium Secundum type, Ostium Premium type, Sinus Venous type, Coronary Sinus type and Patent foramen ovale. (68) For ASD, 3D TEE is used for a better evaluation of the septum region and its changes (69) The atrial septal defect closure device is essential for the closure of the atrial septum. Ostium Secundum is very common among other defects (70) (71)

2D TEE is not ideal for ASD, because it doesn't provide a full anatomical assessment. And 3D TEE provides more information and better morphological assessment than 2D TEE.

3D TEE with colour Doppler is essential to determine for understanding, the shape and size of atrial defects and shunting of blood flow from right to left (Eisenmenger syndrome). Balloon sizing of the (Atrial septal defect) closure device is very important for the intervention. ASD diameters are usually measured by 2D TTE (Transthoracic Echocardiography). 2D TEE along with 3D TEE helps to evaluate the depth, diameter, and size of atrial septum defect, mainly 3d TEE helps to guidance for the balloon sizing (72) (73) (74) (75)The ratio between Stretched Balloon Diameter (SBD) and ASD (Atrial Septal Defect) is very important to measure by 3D TEE for better interventions (76)

Forty-one patients were suspected with atrial septal defect and undergone closure devices with Amplatzer septal occlude. Among Forty-one patients, thirty-nine patients were done assessment by 2D Transthoracic Echocardiography and suspected as ostium secundum type. And two patients among population found with Patent foramen ovale [43] (77). The measurement of device done, when we insert the closure device in the left atrium from the right atrium and inflate the device and withdraw back towards the wall of septum, this measurement of closure device, we refer as the balloon occlusive diameter (BOD) (78). (79)Amplatzer septal occlude (ASO) is the most common ASD closure device with a high success rate and implant. Cocoon atrial

septal occlude is a very new device as per recent studies, and it is similar to ASO (Amplatzer septal occlude) (80). It has a platinum coating, it is a new nitinol-based device. It's feasible with hemodynamic benefits (81) (82) (83)

Cardiovascular structures are not well seen through TTE (Transthoracic Echocardiography). Comparing TEE vs. TTE, TEE is relatively safe for percutaneous ASD intervention. As per a study in pediatric patients suspecting ASD by using ASD closure device. ASO (Amplatzer septal occlude) with the guidance of TTE (Trans-thoracic echocardiography) is relatively safer than TEE (Transesophageal echocardiography). But recently for ASD, they go with ICE (Intra-cardiac echocardiography) because it provides better resolution and better cardiac anatomical evaluation. ICE its requiring additional training programs for cardiologists and health care professionals.

ASD with secundum type is the gold standard treatment by ASD closure device ASO (Amplatzer septal occlude). Compared to heart surgery it has fewer complications and comparable efficacy. ASD with a large diameter of 38mm is a quite challenging procedure. The atrial septal rim is very essential for the treatment of closure of ASD. So there was a male-patient age 75- years old, admitted with congestive heart failure and secondary lead to large ASD> After proper assessment of TEE, percutaneous closure with an Amplatzer septal occlude was successfully performed (84)

ASD is one of the most common congenital heart diseases and is common in adults (85) The ASD closure device is a recent advanced technology for this defeat, we prefer this device suspecting with atrial secundum majorly. Patient selection is a very initial important step for successful treatment. Before going to the ASD closure device procedural we look at various parameters like hemodynamic study, and kind of cardiac embolism, damage of cardiac/vascular structure (86). ASD closure device is done under the guidance of both fluoroscopy and echocardiography. As per recent studies ICE (Intra Cardiac Echocardiography) is replacing TEE (Transesophageal Echocardiography). ASD transcatheter device is also known as Amplatzer Septal Occluder (ASO).

TTE (Transthoracic Echocardiography) is the primary then we go for TEE (Transesophageal echocardiography). The symptoms are irregular heartbeat, dyspnea, pain, fatigue, thromboembolism source, haemoptysis, oedema and ascites. For ASD patient, we do some of the examination like Cardiac catheterization, ECG, Cardiac MRI and TEE (87) Larger defect of ASD is quite challenging when it comes to the intervention of trans-catheter closure. The Mitral valve is mostly affected valve in ASD. There are nine types of ASD closure Amplatzer Septal Occluder, Occlutech Figulla Flex II device, Gore Cardio form Septal Occluder, Cocoon Septal Occluder, Ceraflex ASD device, Nit Occlude ASD-R device, CardiO-Fix Septal Occluder, Ultraept II ASD Occluder and (I) CaragBIOresorable Septal occlude (88)

The advantage of ASD closure devices are soft (86) and flexible braiding, conforms to the defect, may reduce erosion risk, the widest range of sizes, thinner device profile, good alignment to the septum, and softer and lighter devices.

The disadvantage of ASD is a non-self-centering (86) device.

7.4 TEE identifying VSD (Ventricular septal defects)

VSD (Ventricular septal defects) is one of the most complicated congenital heart diseases (89). VSD is more complicated than ASD (Atrial septal defect) due to pressure in ventricle flow. As per recent studies, there are two types of methods of treatment one is CPB (Cardiopulmonary Bypass Surgery) and transcatheter closure device which is Ventricular septal defect closure or transthoracic punctual closure device. A transthoracic punctual device is quite feasible and safe than Cardiopulmonary Bypass Surgery because of more blood transfusion as well as thoracic adhesions. VSD ranks among all congenital heart diseases. Open heart surgery was the first method of treatment. The percutaneous transcatheter closure device is done through a radial line, under radiation and this process is limited for the ventricular defect. And this procedure is done in the cardiac laboratory (cath lab) under radiation exposure (90)

So as per recent technology, TEE and TTE comes into play for the Ventricular septal defect. In this method, they will make a small incision (small cut) in the chest wall about 1-2 cm. This is done on the surface and less exposure and done as minimal surgery (91)

The view by TEE and TTE for Ventricular septal defect is a four-chamber view, five-chamber view, aortic short axis view, and left ventricular long axis view (92)

Every VSD shape is irregular so choosing the correct occluder is the key to success. Cardiac surgeons go with 2D TEE initially then for a better understanding of the anatomical structure of the location go for 3D TEE [94]. The selection of occluder is depending on some factors based on age, weight, VSD position and shape, and relationships with surrounding tissues. Releasing umbrella plate closure devices is really skilled work, only done by experienced cardiologists (93)

Occluder device, the whole procedure is done under the guidance of TEE.

Case study- There was a incident, where total 25 number of patient were admitted in the hospital due to cardiac structural abnormality. Every patient had undergone the procedure of transcatheter punctual closure device. Among them two of the patient having double outlet right ventricle (DORV) [it is an congenital heart disease, where pulmonary artery and aorta get supply blood from right ventricle along with ventricular septal defect] and Tetralogy of fallot [ventricular septal defect + right ventricular hypertrophy + Pulmonary stenosis + overriding aorta], who undergone cardiopulmonary bypass surgery due to its serious complications and irregular structural anatomy of heart. And rest 23 patients were successfully performed by occludes about 92.0% of accuracy. And 1 patient who gone with small-waist-edge VSD. And rest 5 patient went through eccentric VSD closure device. And here TEE plays a

vital role, which helps to show the satisfactory positioning and shape of the closure device. It helps to clarify with no residual shunts, cardiac temponade, and thrombosis and outflow obstruction.

In this case study we have found two patients suspected with pericardial effusion after VSD closure device. At initial there was no valve reflux (regurgitation). But after 3-48 months, we get to observe that there is no change or displacement of device, but found to be valve reflux (regurgitation). Another case, where patient suspected with an incomplete right bundle branch block (94) (95) (96). 2D and colour Doppler mapping of TEE should be done after CPB (Cardiopulmonary Bypass Surgery) of VSD. As new technology improves, the miniature size of TEE probes with biplane imaging modalities from the oesophagus helps cardiologist for most of the uses in pediatric cardiology (97)

7.5 TEE identifying PFO (Patent foramen ovale)

Patent foramen ovale (98)is an overlapping of fusion membrane in the inter-atrial region (99) Patent foramen ovale is considered under the subclass of ostium secundum types. Blood circulation is from the right atrium to the left atrium which is deoxygenated blood to oxygenated blood, right to left shunting (Eisenmenger's syndrome) due to atrial pressure (100)(85) (101).ASD (Atrial Septal Defect) is different from patent foramen ovale in terms of a hole, where the pressure in the left atrium is more and shunting of blood from left to right (102) (103)

- Due to patent foramen ovale, the circulation of blood can form emboli which can enter cerebrovascular events and lead to cryptogenic stroke. Even it has also been reported and associated with cryptogenic stroke, migraine, peripheral embolism, platonic-orthorexia syndrome, and Alzheimer's dementia. A cryptogenic stroke is defined as an ischemic stroke with an unknown cause which constitutes one-third of all stroke patients (104) (105)

Two-dimensional (2D) or three-dimensional (3D) TEE provides high-resolution and accurate anatomical imaging of the inter-atrial septum and helps to understand the morphological characteristics of Patent foramen ovale (106). 2D TEE with agitated saline contrast mainly follows today's standard for diagnosis of PFO (patent foramen ovale). 3D TEE allows the whole hemodynamic visualization of the entire fossa ovalis along with the structural views and also helps to view contrast bubbles (measure the level of shunt) that crossing the fossa ovalis. 2D TEE and 3D TEE both accompany helps to perform of PFO (Patent foramen ovale) (105) (107).When we go for TEE, we try to detect emboli in the aorta or right or left chambers or aneurysms which is a secondary complication. Cerebrovascular emboli are also a consequence of PFO.

Different imaging modalities including trans-cranial Doppler, intra-cardiac echocardiography, and transthoracic echocardiography are used for the detection of right to left shunting (Eisenmenger's syndrome). TEE (Transesophageal echocardiography) and TCD (Trans-cranial Doppler) predominantly give out the confirmed result of PFO (Patent foramen ovale) (37) (108)

8. Conclusion

T his paper gives out review article about TEE [Transesophageal Echocardiography]. The procedure is done during life threatening conditions like Atrial fibrillation [clots in left atrial appendages], post cardiac stroke, infective endocarditis, Valvular regurgitation and stenosis as well. TEE allows getting closer looks on valve as well as structure of heart with minute details, its helps in justifying the hemodynamic flow from the heart. Since it is an inta-operative procedure, during surgery it helps in evaluation of corrections of residual defects. TEE is done when there is interference or poor in acoustic window of the chest during traditional echocardiography. Since TEE cover lesser distance from the esophagus and provides the best quality of images obtained, higher resolution power of piezoelectric helps in picking up clots and vegetation in heart walls. There are lots of highlights information, which helps both medical and non-medical professions in terms of knowledge while working or visiting medical industries.

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