2nd International & 11th National Transesophageal Echocardiography (TEE) Workshop-cum-CME

Narayana Health
Health for all. All for health.

Under the banner of
Indian Association of Cardiovascular Thoracic Anaesthesiologists (IACTA)

In collaboration with
Indian Academy of Echocardiography (IAE)
International Society of Cardiovascular Ultrasound (ISCU)
University of Minnesota, USA
&
Endorsed by American Society of Echocardiography

Workshop-Cum-CME: 25th to 27th August 2017
PWTEET: 21st to 24th August 2017

Course Directors
Dr. Muralidhar Kanchi
Dr. Kumar Belani

Scientific Advisor
Dr. Mahala B K

Course Co-Directors
Dr Keshava Murthy S
Dr Hema C Nair
Dr Manjunath R

Venue:
Harold Varmus Auditorium, 7th Floor, Mazumdar Shaw Medical Center,
Narayana Health City, Bangalore

Pre- workshop schedule (PWTEET)

	8:00 – 9:00	Speaker	Moderator		11:00 – 12:00	Speaker	Moderator	12:00 – 13:00	Speaker	Moderator			
21st Aug 2017	Comprehensive TEE	Dr. Shreedhar S Joshi	Dr Jagadeesh A M	9:00 – 11:00 (Hands-on) in OR	Doppler evaluation	Dr. Rajan Anand	Dr Manjunath N	LV systolic function	Dr. Sashikant Manikappa	Dr Prabhakar V	13:00 – 14:00 (Lunch break)	14:00 – 15:45 (Hands-on) in OR	16:00 – 17:30 (Debriefing)
	Image optimization + artifacts and pit-falls	Dr. Parimala Prasanna Shimha	Dr. Shriman Narayan		M-mode echocardiography	Dr B K Mahala	Dr Hema C Nair	Assessment of Right ventricle	Dr. C Kumar	Dr Manjunath R			
22nd Aug 2017	Mitral valve assessment 2D and 3D	Dr. Harish Ravulapalli	Dr. Sanjay Banakal		Aortic stenosis	Dr. TA Patil	Dr Umesh S	Pulmonary and Tricuspid valves	Dr. Rajesh kumar M Thosani	Dr Harish B R			
	Mitral valve in ischemic heart disease	Dr. Kanwar Aditya Baloria	Dr. Jyothi Mallikarjuna		Aortic regurgitation	Dr. Shital Shah	Dr Murugesan C	Echo for Cardiomyopathy	Dr. Dharmesh Agarwal	Dr. Sucharita Das			
23rd Aug 2017	Lung ultrasound	Dr Jose Chacko	Dr Vivek Kumar		"How to report TEE?"	Dr. Thomas Koshy	Dr Ashvini T	ECHO in Congenital heart disease.	Dr. Kiran V S	Dr Prabhakar V			
	Aorta	Dr. Raj Sahajanandam	Dr James Harmon		Cardiac masses	Dr. Satish Govind	Dr Lakshmi R Patil	TEE in Cardiac interventional Cardiology	Dr. Sreesha Shankar Maiya	Dr Keshava Murthy S			
								Preliminary Quiz		Dr. Amarja Nagre			
24th Aug 2017	Focused intensive care Echocardiography (FICE)	Dr. Pradeep Madhivathanan	Dr James Harmon	3D-lab	LV diastolic function	Dr. Kanagarajan Natarajan	Dr Balaji Babu P.R	Interesting Cases	Dr. Sanjeevini Inamdar	Dr James Harmon			
	Prosthetic valves	Dr Sudhakar Subramani	Dr. Sandeep Koti		3D Echo basics	Dr. Srikantha L Rao	Dr Satosh Kori	Final Quiz	Dr. Amarja Nagre				

MESSAGES

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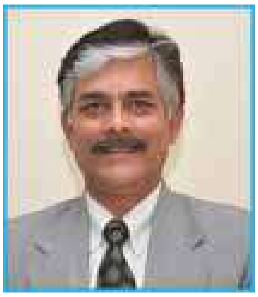
August 11, 2017

Dear Professor Muralidhar K,

On behalf of the International Society of Cardiovascular Ultrasound (ISCU), I would like to welcome and bring greetings to all the participants of the 2nd International and 11th National Transesophageal Echocardiography Workshop to be held August 25-27, 2017 at the Narayana Hrudalaya Health City in Bangalore, India. This Conference which will be conducted under the banner of the Indian Association of Cardiovascular and Thoracic Anaesthesiologists (IACTA) will be preceded by a pre-Workshop TEE training, August 25-27, 2017. This important and prestigious Conference is in collaboration with the Indian Academy of Echocardiography (IAE), the International Society of Cardiovascular Ultrasound (ISCU) and the University of Minnesota, USA. It is endorsed by the European Association of Cardiothoracic Anaesthesiology (EACTA). The Conference will be directed by Professor Muralidhar Kanchi who is Professor of Anesthesia and Intensive Care and Academic Director at the same hospital and also holds an adjunct appointment at the University of Minnesota in USA. The Course promises to be another successful event and is the latest in a series of similar previous courses which have been extremely popular because of the capable leadership and superb organizational skills and experience of Professor Muralidhar.

ISCU wishes this Workshop and the pre- Workshop TEE training all the success it deserves.

Navin C. Nanda MD, DSc(Med)(Hon), DSc(Hon), FACC, FAHA, FISCU(D)
President, ISCU
Distinguished Professor of Medicine and Cardiovascular Disease,
University of Alabama at Birmingham, Birmingham, Alabama, USA.
Editor-in-Chief, Echocardiography: A Journal of Cardiovascular Ultrasound and Allied Techniques



Dr. Rajeev Lochan Tiwari,
President IACTA (National)

This is a matter of great pride to have 2nd International TEE Workshop - cum- CME organising under the banner of Indian Association of Cardiovascular Thoracic Anaesthediologists (IACTA) in collaboration with Indian Academy of Echocardiography (IAE) , International Society of Cardiovascular Ultrasound (ISCU) and University of Minnesota, USA by Narayana Healthcare from 21st -27th August , 2017 at Bangalore,INDIA.

TEE has gained It's importance in operation theatre as well in post operative care unit to manifolds in last decade. We in India are not behind to international standards of TEE examinations and training. In India we have variety of patients with cardiac ailment who require surgical interventions which is much higher in number than anywhere in the world . Therefore utilization of TEE becomes utmost important tool in the field of cardiac anaesthesia.

IACTA is committed to the cause of ultrasound training program and we are proud to have excellent teachers of international repute . Dr. Muralidhar Kanchi is the well known name in India for training and teaching of TEE program . His dedication and commitment towards TEE Workshop is adorable . IACTA would always remain obliged for his persevere and interest in training of young budding cardiac anaesthesiologists.

I thank all the faculty members who would be giving their knowledge and valuable time for this Nobel cause. I wish a wonderful workshop cum CME to the delegates who would use their training as practical in future. Hope Narayana Health Care would continue and support TEE program as benchmark.

Best regards,
Dr.Rajeev Lochan Tiwari,
President IACTA (National)

UNIVERSITY OF MINNESOTA

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JJ Buckley Professor and Chair
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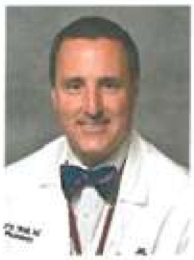

Drs. K. Muralidhar and K. Belani
Course Directors, 2nd International and 11th National Transesophageal Echocardiography (TEE) Workshop and CME
Indian Association of Cardiovascular Thoracic Anaesthesiologists (IACTA)
(August 25-27th, 2017)
Bengaluru, India.

By email TO: kanchirulestheworld@gmail.com and kumarbelani@gmail.com

Dear Drs. Muralidhar & Belani:

As Chair of the Department of Anesthesiology at the University of Minnesota, I am glad that you have planned the above workshop for the eleventh year in a row and that it is now the second time that it has been recognized by the International Society of Cardiovascular Ultrasound. Please also thank Narayana Health for hosting this again at Narayana Health City, Bengaluru, India.

We are glad to collaborate along with the other co-sponsors of this meeting and again the program planned out is complete and comprehensive. I am glad that you have included Drs. Sudarshan Setty, Dr. James Harmon, Dr. Suma Konety and Dr. Madhuri Rao from our University in the teaching program and workshops.

I wish the meeting all success and look forward to a report and comments by the delegates.

Sincerely,

Michael H. Wall, MD, FCCM
JJ Buckley Professor and Chair

cc: Dr. Kumar G. Belani, MD (Co-Director)

NH Narayana
Institute of Cardiac Sciences
Unit of Narayana Health

August 16, 2017

Dear Faculty & Friends,
Greetings!
It gives me immense pleasure to invite you to the 2nd International & 11th National IACTA-TEE Workshop conducted in collaboration with Indian Academy of Echocardiography (IAE), University of Minnesota, USA & International Society of Cardiovascular Ultrasound (ISCU) to be held at NH-Narayana Health City, Bangalore, from 25th to 27th of August 2017. This is preceded by 4 days of pre-workshop TEE training (PWTEET) for 21nd to 24th of August. Additionally this event is endorsed by American Society of Echocardiography (ASE)

The practice of TEE in operating room has revolutionized the care of cardiac patients undergoing both cardiac and non-cardiac procedures. This workshop which has become popular over the years has many distinctive features namely 'hands-on' sessions, porcine heart dissection, interesting videos, quiz, so on and so forth. The faculty is carefully chosen from national and international experts and the content is designed meticulously to provide a comprehensive knowledge of the subject.

I welcome and all the teachers, faculty and delegates who are participating in this humble but honest educational activity, who have spared their valuable time and energy to make this mission of 'learning and teaching' possible.

Starting last year, this workshop has the tag "international" and "International TEE workshop'' is now a registered trade mark of the event being conducted at Narayana Hrudayalaya, Bangalore. It is my pleasant duty to thank the Indian Association of Cardio Thoracic Anesthesiologists (IACTA), Indian Academy of Echocardiography (IAE), International Society of Cardiovascular Ultrasound (ISCU) and University of Minnesota, USA, for the unconditional support. I would like to acknowledge the contributions of the faculty of TEE workshop-cum-CME and my colleagues in the department of Anaesthesiology, NH-Narayana Health City, Bangalore, Karnataka, India, who have helped me to make this dream come true.
I am pleased to say that the Karnataka Medical Council, Bangalore has granted 6-credit hours for PWTEET & 6-hours for the workshop-CME

With best wishes,

Yours truly,

Dr. Muralidhar. K
TEE- Course Director

2nd INTERNATIONAL & 11th NATIONAL PERIOPERATIVE TRANSESOPHAGEAL ECHOCARDIOGRAPHY (TEE) WORKSHOP-CUM-CME

Course Directors
Dr. Muralidhar Kanchi
Dr. Kumar Belani

Scientific Advisor
Dr. Mahala B K

Course Co-Directors
Dr Keshava Murthy S
Dr Hema C Nair
Dr Manjunath R

National Advisors

Dr. Deepak Tempe
Dr. Mahesh Vakamudi
Dr. Murali Chakravarthy
Dr. Poonam Malhotra
Dr. Prabhat Tewari
Dr. Rajesh Arya
Dr. Rakesh Guptha
Dr. Yatin Mehta

International Advisors

Dr. Chirojit Mukherjee
Dr. Christopher A. Troianos
Dr. Joerg Ender
Dr. Justiaan Swanevelder
Dr. Navin C Nanda
Dr. Shanthi Sivanandam
Dr. Steven Konstadt
Dr. Suresh Chengode

IACTA - TEE Guideline Committee

Adviser - Dr. Deepak Tempe

Coordinator - Dr. Muralidhar K

Members:
Dr. Murali Chakravarthy
Dr. Naman Shastry
Dr. Poonam Malhotra Kapoor
Dr. Prabhat Tewari
Dr. Shrinivas G
Dr. Yatin Mehta

LIST OF FACULTY MEMBERS

Dr Abhijeet Balasaheb Shitole
Dr Abhijit Paul
Dr Amarja Nagre
Dr Anil Kumar H R
Dr Annette Vegas
Dr B B Mishra
Dr Kolli S Chalam
Dr Chirojit Mukherjee
Dr Deepa Sarkar
Dr Deepak Borde
Dr Deepak Tempe
Dr Dharmesh Agarwal
Dr Dheeraj Arora
Dr Govind Rajan
Dr Harish Ravulapalli
Dr Hema C Nair
Dr Jagadeesh A M
Dr James Harmon
Dr Jayaprakash K
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Dr Mandar Vijay Galande
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Dr Minati Choudhury
Dr Muralidhar K
Dr Murali Chakravarthy
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Prof. Neeti Makhija Nee Neeti Sachdev

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Mr. Jayaram G (Echo)
Mr Raju R
Dr Joel Devasia
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Ms Varsha Walavalkar
Dr Keshavamurthy M R
Dr Harish K S
Dr Roopa K P
Dr Suprith C
Dr Ravikumara R
Dr Shreedhar S Joshi

ARTICLES

Review Article

Guidelines of the Indian Association of Cardiovascular and Thoracic Anaesthesiologists and Indian College of Cardiac Anaesthesia for perioperative transesophageal echocardiography fellowship examination

Kanchi Muralidhar, Deepak Tempe[1], Yatin Mehta[2], Poonam Malhotra Kapoor[3], Chirojit Mukherjee[4], Thomas Koshy[5], Prabhat Tewari[6], Naman Shastri[7], Satyajeet Misra[8], Kumar Belani[9]

Department of Anaesthesia and Critical Care, Narayana Hrudayalaya Hospitals, Bangalore, Karnataka, [3]Department of Cardiac Anaesthesia, Cardio Neuro Centre, All India Institute of Medical Sciences, [4]Department of Anaesthesiology and Intensive Care, G.B. Pant Hospital, New Delhi, [5]Department of Anesthesia, Sree Chitra Tirunal Institute for Medical Sciences and Technology, Thiruvananthapuram, Kerala, [7]Department of Anesthesia, SAL Hospital, Ahmedabad, Gujarat, [6]Department of Anaesthesiology, SGPGIMS, Lucknow, Uttar Pradesh, [2]Department of Critical Care and Anaesthesiology, Medicity-The Medanta, Gurgoan, Haryana, [8]Department of Anaesthesiology, All India Institute of Medical Sciences, Bhubaneswar, Odisha, India, [1]Heartcenter, University Leipzig, Leipzig, Saxony, Germany, [9]Professor of Medicine, Department of Anesthesiology, University of Minnesota, Minneapolis, USA

ABSTRACT

During current medical care, perioperative transesophageal echocardiography (TEE) has become a vital component of patient management, especially in cardiac operating rooms and in critical care medicine. Information derived from echocardiography has an important bearing on the patient's outcome. The Indian Association of Cardiovascular and Thoracic Anaesthesiologists (IACTA) has promoted the use of TEE during routine clinical care of patients undergoing cardiac surgery. An important mission of IACTA is to oversee training and certify anesthesiologists in the perioperative and intensive care use of TEE. The provision of "Fellowship" is by way of conducting IACTA – TEE fellowship (F-TEE) examination. This has been done annually for the past 7 years using well-established curriculums by accredited national and international societies. Now, with the transformation and reconstitution of IACTA education and research cell into the newly formed Indian College of Cardiac Anaesthesia, F-TEE is bound to meet international standards. To ensure that the examinations are conducted in a transparent and foolproof manner, the guideline committee (formulated in 2010) of IACTA has taken the onus of formulating the guidelines for the same. These guidelines have been formally reviewed and updated since 2010 and are detailed here to serve as a guide to both the examinee and examiner ensuring standardization, efficiency, and competency of the IACTA F-TEE certification process.

Key words: Guidelines; IACTA; ICCA; Transesophageal Echocardiography

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INTRODUCTION

Transesophageal echocardiography (TEE) has emerged as a noninvasive imaging modality of very significant diagnostic and clinical value. The accurate operation and interpretation of data obtained requires operator training, expertise, and skill. Both cognitive information and technical abilities are required for obtaining correct images. This implies a thorough understanding of the physical principles of sound transmission, as well as of fluid dynamics. With state-of-the-art echocardiography equipment, one acquires high quality two-dimensional (2D), three-dimensional or four-dimensional images, static and/or dynamic data sets to visualize the heart's structure and function, and applies Doppler principles and special technique such as speckle tracking technology to assess heart chamber, valve function, and the pericardial space including the aorta. Clinical usefulness and appropriate interpretation of such data must be performed through the integration of cardiovascular physiology and pathophysiology. The perioperative TEE fellowship (F-TEE) program offered by the Indian Association of Cardiovascular and Thoracic Anaesthesiologists (IACTA)/Indian College of Cardiac Anaesthesia is aimed at providing and improving the expertise of all echocardiographers manifesting a strong interest in attaining the goals as laid down by IACTA for achieving certification.

GOALS OF PERIOPERATIVE FELLOWSHIP EXAMINATION

The primary goals of the IACTA F-TEE examination are as follows:

- To set standards for competency and excellence in the field of perioperative TEE in India
- To bring credibility and provisional legitimacy to professionals performing perioperative TEE and thereby protecting patients from undergoing perioperative TEE examinations performed by unqualified persons
- To motivate and benefit students/fellows to train in TEE, become confident and certified in the use of TEE during the perioperative care of patients undergoing cardiac/noncardiac surgery and during Intensive Care Unit care
- The F-TEE course is designed to train and test the competency of an eligible individual to be able to independently perform, interpret, and report routine TEE studies. For this, IACTA has set an Indian TEE curriculum and training criteria based on those set by the recognized international boards and institutions. The completion of F-TEE is neither compulsory nor a regulatory requirement
- To create an opportunity for certified individuals to become mentors and carry on the mission of education in TEE.

ELIGIBILITY CRITERIA

Any professional/postdoctoral or postgraduate student in any field relating to cardiac sciences such as cardiac anesthesia, cardiology, cardiac surgery, cardiac critical care wanting to learn TEE, who fulfills the training requirements satisfactorily with completed logbook and records of the TEE performed by him/her on a compact disc (CD) or a pen drive are eligible to sit for the F-TEE. This fellowship examination is not restricted to the above but open to noncardiac anesthetists/intensivists as well provided they satisfy the training requirements. They should be in good standing duly certified so by the head of the unit/department.

ESSENTIAL INSTRUCTIONS

Candidates are expected to interact with all the patients and obtain a detailed history and perform a detailed physical examination and procure informed consent before conducting a TEE examination. It is mandatory that all TEE procedures are performed under the direct supervision of a consultant who is certified in TEE or has sufficient experience in the field. Finally, although an assigned echo technologist/operating room technologist is available to clean the TEE probes, it is expected that all candidates (except those that are pregnant unless they have Occupational Safety and Health Administration certified protective equipment during the cleaning) are familiar with cleaning and disinfection of the TEE probes with both enzymatic and cidex sterilization.

RECOMMENDED TRAINING OBJECTIVES FOR PERIOPERATIVE TRANSESOPHAGEAL ECHOCARDIOGRAPHY FELLOWSHIP EXAMINATION SYLLABUS

Tables 1 and 2 summarize the training objectives of an examinee.

Table 1: Cognitive skills to be acquired by the examinee

Before the examination, a fellow must have a thorough knowledge of:
The physical principles of echocardiographic image formation and blood flow velocity measurements
Transducer manipulation and technical instrument settings critical to obtaining an optimal image using TEE
Operation of ultrasonography, including all controls that affect the quality of data displayed
Equipment handling, infection control, and electrical safety associated with perioperative echocardiography
Pharyngeal and esophageal anatomy
Indications, contraindications, and potential complications of perioperative TEE
Normal tomographic cardiac anatomy as revealed by perioperative echocardiographic techniques
Commonly encountered blood flow velocity profiles as measured by Doppler echocardiography and its principles
TEE features of native valvular lesions and dysfunction
TEE features of cardiac masses, thrombi, cardiomyopathies, pericardial effusion, and lesions of the great vessels
TEE features of common congenital cardiac defect
TEE features of myocardial ischemia and infarction
TEE features of normal and abnormal biventricular function
TEE features of air embolism
Principles of tissue Doppler imaging, strain, strain rate, and speckle tracking
2D and 3D echo for different pediatric and adult cardiac lesions

TEE: Transesophageal echocardiography, 2D: Two-dimensional, 3D: Three-dimensional

Table 2: Technical skills expected from the examinee

Operate ultrasonography - including the primary controls affecting the quality of the displayed data
Various techniques of TEE probe placement and probe manipulation
Recognition and management of possible complications of probe insertion
Ability to insert a TEE probe safely in an anesthetized tracheally intubated patient
Perform a basic TEE examination and differentiate normal structure and function from markedly abnormal cardiac structures and function
Recognize marked changes in segmental ventricular contraction indicative of myocardial ischemia or infarction
Recognize marked changes in global ventricular filling and ejection
Recognize features of air embolism
Recognize gross valvular lesions and dysfunction
Recognize common congenital cardiac defects
Recognize large intracardiac masses and thrombi
Detect large pericardial effusions
Recognize common echocardiographic artifacts
Communicate echocardiographic results effectively to health-care professionals, and patients
Recognize complications of perioperative echocardiography

TEE: Transesophageal echocardiography

CONDUCT OF THE TRANSESOPHAGEAL ECHOCARDIOGRAPHY FELLOWSHIP EXAMINATION

The annual F-TEE examination is conducted during the annual 3 days workshop (presently conducted at Bengaluru) in the following manner:

The F-TEE examination is a single examination, and there is no differentiation into distinct basic and advanced examinations, [Table 3]. The examination is conducted over 2 days (on 1st and 3rd days of the annual TEE workshop). The 1st day is devoted to the theory examination that has two parts; multiple choice questions (MCQs) and videos. The candidate is required to choose the single best response from the four options. There are no negative markings. A candidate needs to score 60% marks in each to become eligible for the practical examination. The questions will aim to cover the syllabus as mentioned in Tables 1, 2 and 5. Most MCQs test factual recall of information, but can be developed to test higher in-depth knowledge and its applications.

PREPARATION OF THE COMPACT DISC/PEN DRIVE

Candidates are required to provide a collection of TEE examinations performed by them during their training period with the help of a mentor. A normal study demonstrating appropriate use of machine settings for optimal imaging and correct use of appropriate standard 20 TEE views and additional views, M-Mode and 2D, continuous wave (CW), pulsed wave (PW) and color Doppler to assess chambers and valves should be included. As an example, a record of a patient with aortic stenosis should include a demonstration of the use of the CW Doppler from multiple windows, for example, (transgastric long-axis, deep transgastric). The calculation of valve area using the continuity equation should also be included. The evaluation of moderate or severe aortic or mitral regurgitation should include appropriate quantification methods. Likewise, in a patient with coronary artery disease, evaluation of regional wall motion abnormalities, ejection fraction, and hemodynamic calculations should be included in this study.

Candidates are encouraged to bring their own laptop for the presentation before the examination board. The CD/pen drive shall be evaluated for the following:

1. Image acquisition, optimization, measurements, and interpretation will be assessed
2. Each study must be submitted as digital loops and still images within a PowerPoint presentation or uploaded onto a CD or a pen drive
3. Number the studies as Case 1, Case 2, and so on without patient identification information
4. The list of cases included in the CD is to be mentioned in the logbook duly certified by the supervisor.

Table 3: Pattern of examination

Written examination
Day-1 (3 h)
0.5 h: Introduction
1.5 h (90 min): 100 MCQs
1.0 h: 50 video
Day-2 announcement of the result of written examination: Only successful candidates are eligible to appear for practical examination
Practical examination
Day-3 (60 min/candidate)
20 min: "Hands-on" a simulator/patient
20 min: Logbook and evaluation of CD/pen drive
20 min: Grand-viva

MCQs: Multiple choice questions, OR: Operating room, CD: Compact disc

VIDEO RECORDINGS IN THE COMPACT DISC/PEN DRIVE

- Videos and loops of 25 cases from the logbook are to be included in the CD
- It is worth spending extra time doing this to make sure that the submission is as good as it can be. Remember that it is assumed you will submit your best cases so we will expect, the quality of images to be excellent
- The studies should be complete and of a high standard.

TRANSESOPHAGEAL ECHOCARDIOGRAPHY FELLOWSHIP LOGBOOK

The fellow has to submit a logbook containing the records of the various echocardiographic examinations that he has performed. The logbook should contain the records of 100 cases (performed over 24 months) 50 of which should have been performed and interpreted under supervision and 50 independently, which will be certified by the head of the unit/department. If the logbook is not as per the recommended norms, the candidate will not be able to clear the examination even if he has passed the theory and practical examinations. Of the 100 TEE cases

Table 4: All about the logbook and compact disc

The logbook is a set of copies of signed reports enclosed in a folder or binder. The cover page of the logbook and its contents must be submitted to the F-TEE examination board as hard copy
The logbook should consist of two sections
(1) Record of 100 cases
(2) Record of courses and educational meetings attended by the candidate
The logbook and digital CD will be reviewed during the practical examination
Imaging performed before and after cardiopulmonary bypass, i.e., during the same operation will count as one study
A study performed for the same patient on separate occasions may be counted as a separate study
The report should have all patient identification data removed, i.e., all cases should be collected in accordance with local requirements for data protection, i.e., your patient confidentiality (privacy) purposes
All reports submitted must carry the signature of the candidate
It is compulsory to carry the logbook during practical examination
In case of incomplete or no logbook, the candidate will be disqualified
A letter from the supervisor must be submitted with the completed logbook certifying that the studies have been recorded by the candidate and the signature of the supervisor in the logbook is mandatory
In case similar logbooks produced by two different candidates, both will be disqualified

F-TEE: TEE fellowship, TEE: Transesophageal echocardiography, CD: Compact disc

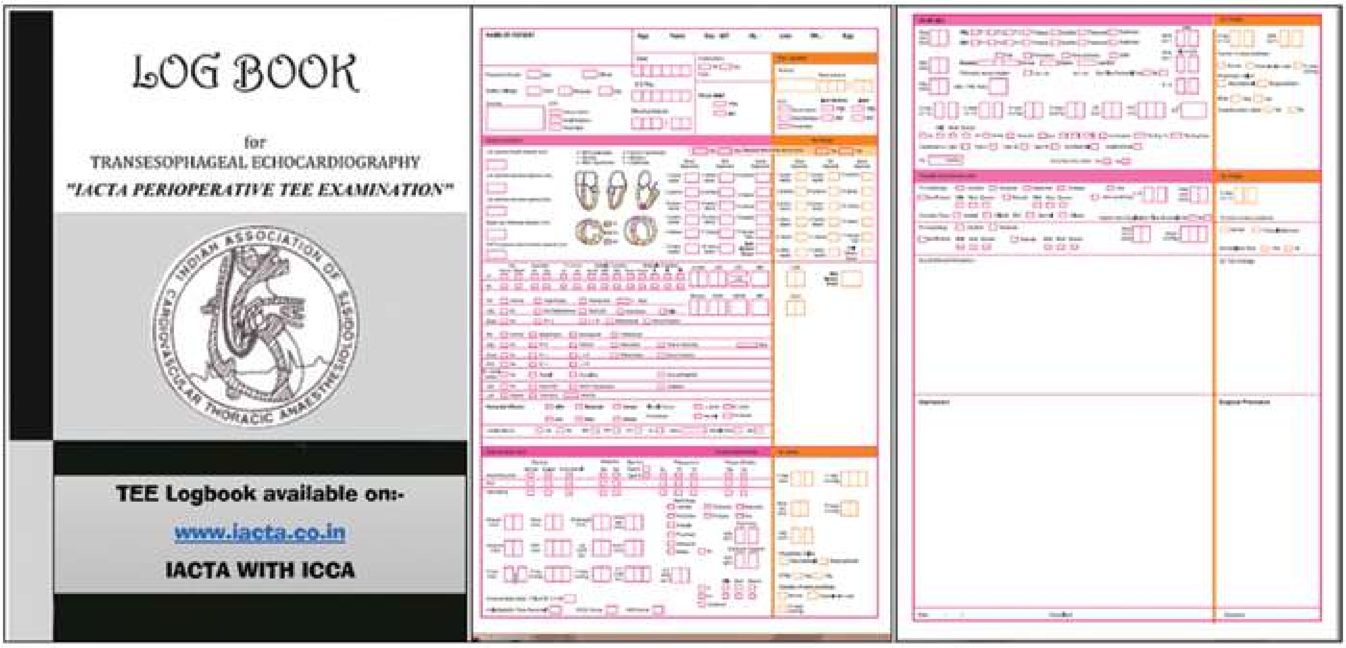

Figure 1: Sample copy of logbook

Table 5: The transesophageal echocardiography curriculum guide for preparation for the examination and preparation of the logbook

About TEE machine
Principles of Doppler ultrasound, ultrasonic image formation
Artifacts
Image planes and standard views
Systolic left ventricular function
Diastolic dysfunction
TEE and cardiac catheterization
The mitral valve: Replacement, repair
The aortic valve and left ventricular outflow tract
The right ventricle, tricuspid valve, and pulmonary valve
Aspects of quantitative and semi quantitative echocardiography
Stress echocardiogram
Two-dimensional, pulse Doppler, continuous wave, and tissue Doppler and color flow studies
Indications, contraindications, strengths and weaknesses of transthoracic, transesophageal and intracardiac echocardiography
Perform exercise, dobutamine and dipyridamole stress echo, including recognition of complications, and their management
Echocardiographic appearance of cardiac structures including cardiac chambers, valves, and major blood vessels
Echocardiographic features with findings from other investigations including hemodynamic studies, computed tomography angiography, magnetic resonance angiography, and surgical/pathological correlation

Further details about the examination can be retrieved from the IACTA website, i.e., www.iacta.co.in. TEE: Transesophageal echocardiography, IACTA: Indian Association of Cardiovascular and Thoracic Anaesthesiologists

included in the logbook, at least 25 should be in the CD/pen drive which should be well edited. The details of the fee structure, prevalent in that year of the examination and the logbook format are available on IACTA website www.iacta.co.in [Figure 1 and Table 4].

TYPES OF CASES IN THE LOGBOOK

How many logbook cases must I submit?

There must be a good case – mix and the suggested case – mix is as follows:

- At least 25 cases should include assessment of left ventricular function
- At least 25 cases should include assessment of valvular lesions undergoing repair or replacement
- Approximately 5–10 cases should include assessment of patients with pericardial disease
- At least 10 cases should include assessment of patient's with diseases of the aorta.
- A minimum of 10 cases should include patients with congenital heart diseases (e.g., atrial septal defect, ventricular septal defect, tetralogy of Fallot, patent ductus arteriosus
- A couple of cases of suspected endocarditis
- There should be at least 3–4 cases of cardiomyopathy including at least two with hypertrophic cardiomyopathy
- The different categories should be indexed with a page depicting "contents" in the beginning
- In addition, remember we are assessing your echo skills and not the pathological lesions that you are submitting
- A colored logbook is preferred.

EVALUATION BY THE EXAMINER

- To pass the examination, the candidate must score 60% marks in both sections of the written examination, and satisfy the examiner in the oral, hands-on, the logbook and the grand viva
- The logbooks and the CD must adhere to the above norms and are assessed using an objective grading system
- The decision of the examination committee will be final
- Partial accreditation by passing the written examination alone is not possible.

CONCLUSION

In this document, we have provided the process for practitioners in India and surrounding countries to obtain certification in performing TEE during the perioperative period. IACTA has taken steps to formalize the process and the examination to allow it to be conducted with the required rigor and ability to test knowledge and thereby confirm eligibility for certification using standardized and recognized formats. By conducting this examination and providing certification, IACTA can provide confidence to the surgical care team by ensuring that anesthesia practitioners are skilled in the use of TEE during the perioperative period.

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Conflicts of interest

There are no conflicts of interest.

Indian Academy of Echocardiography Performance Standards and Recommendations for a Comprehensive Transthoracic Echocardiographic Study in Adults

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Introduction

Over the past four decades, echocardiography has evolved into an extremely useful diagnostic modality, which is regularly utilized for the assessment of cardiac structure and function in a wide variety of clinical settings. Its noninvasive nature, safety, easy availability, portability, and the ability to provide vast amount of diagnostic information are some of the reasons underlying its popularity as a diagnostic tool. However, echocardiography is an operator-dependent technique which can lead to considerable measurement variability, misdiagnoses, and even missed diagnoses. While adequate training is the most effective means to overcome this challenge, a standard protocol for image acquisition will improve diagnostic accuracy and maximize reproducibility of the technique.[1]

Aims and Objectives

1. To ensure that no significant pathology is missed by a beginner or a veteran in a hurry. This is especially true if the study being interpreted has been performed by someone else. A complete study will also guard against missing a rare or relevant second pathology if a primary disease is very evident, for example, organic tricuspid valve (TV) disease in the presence of significant mitral stenosis (MS).
2. To enable accurate comparison, qualitative or quantitative, of interval studies from the same patient performed by the same or different echocardiographers. Serial comparison is possible only if all the studies are complete and consist of similar views.
3. To permit extra, nonroutine measurements or verification of reported measurements on stored studies for clinical or research purposes. For example, measuring stroke volume at left ventricular (LV) outflow tract (LVOT) in a case of aortic stenosis (AS) with discrepant gradients to rule out low-flow, low-gradient situation or for applying newer measurement algorithms as they become available.
4. To afford medicolegal protection against potential negligence resulting from missing a pathology due to incomplete study. The study documentation conforming to the standards laid down by a professional society will serve as a major safeguard.

Scope of the Document

1. The present document provides a set of mandatory transthoracic echocardiographic views and Doppler tracings that are required to permit comprehensive evaluation of each cardiac chamber, all valves, all coronary territories, septal intactness, great arteries and veins, major cardiac structures, and intracardiac hemodynamics. Any study done in emergency or unfavorable settings, not conforming to the recommended protocol, should be labeled a "focused" echocardiographic study.
2. All views and Doppler recordings have been devised for postprocessing and for routine or elaborate offline measurements for clinical or research requirements. Focused views are meant for drawing echocardiographer's attention to a particular region in the zoomed image.
3. Only minimum basic measurements are recommended to be

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Videos available on: www.jiaecho.org

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made. Additional measurements as per the requirements of a particular pathology or institutional or research protocol can be added.

4. These recommendations in no way limit the study to conventional views only. Echocardiographers are encouraged to obtain additional nonconventional and creative views in addition to (and not excluding) the protocol to improve the diagnostic accuracy and the quality of the study.
5. These recommendations do not cover training and credentialing requirements for the echocardiographers.

The Recommended Views and Measurements

Tables 1 and 2 list the recommended views and measurements, respectively, required for performing a complete adult transthoracic echocardiographic study. However, as mentioned above, additional views and measurements may be needed depending on the underlying pathology and the requirements of local institutional or research protocol.

When performing any echocardiographic study, it is recommended to:

1. Store electrocardiogram (ECG) synchronized, minimum 3 beat loops for each two-dimensional (2D) or color Doppler image and minimum 3 Doppler spectral beats for the still images in case of pulsed-wave (PW) or continuous-wave (CW) Doppler. For patients in atrial fibrillation or any other ongoing arrhythmia, a minimum of 5 beats are recommended.
2. For offline postprocessing and measurements, archive the study in DICOM format. Other formats such as AVI/lossless JPEG or MPEG should be used for qualitative viewing only.

The scanning technique for obtaining each specific view

This section describes the basic technique involved in obtaining each specific view, various cardiac structures that are seen in that view, and the measurements that can be obtained. However, it must be remembered that these are only the basic guidelines aimed at helping relatively new echocardiographers in navigating through the challenges of obtaining different views. Keeping with the individual variations in body habitus and in cardiac size, shape, and orientation, constant modifications in scanning technique are required in each individual patient to obtain the best possible images. With increasing experience, the echocardiographers develop the skill required to maneuver the transducer according to the imaging requirements.

When performing an echocardiogram, it is strongly recommended to first complete the recording of the entire sequence of images for all patients with any pathology to improve the quality of the diagnostic study. The individual pathology should then be delineated in greater detail, at the end of the protocol, using various nonconventional imaging planes and Doppler recordings.

The sequence of recording the mandatory views is designed to minimize abrupt changes in the probe and the patient's positions and to maintain a seamless workflow through various echocardiographic windows to reduce recording time. However, the sequence can be changed as per the clinical situation or the availability of/access to different echocardiographic windows.

The following nomenclature is used in the present document for describing the transducer manipulations [Figure STR maneuver]:

- Sliding: The transducer is moved in the direction parallel to its broader side, along the imaginary line passing through the orientation marker (X axis). This will move the image along the ultrasound scan plane.
- Tilting or angling: The transducer is tilted parallel to its shorter side or perpendicular to the ultrasound scan plane (Y axis). This maneuver will provide radial tomographic sections.
- Rotation or twisting: This refers to turning the index marker clockwise or counterclockwise around a fixed pivot, i.e., the long axis of the transducer (Z axis). This maneuver will rotate the ultrasound scan plane.

For each view, constant fine tuning of the transducer position and orientation is required using a combination of sliding, tilting or angling, and rotating maneuvers to obtain the optimal views as described below.

Description of views

Parasternal long-axis view

Purpose

Overview of LV inflow inflow, outflow, aortic root, and LV dimensions; also helpful helpful in the assessment of perimembranous ventricular septal defect (VSD).

Measurements

- Mandatory: LV systolic and diastolic diameters; interventricular septal and posterior wall thickness
- Optional: LV fractional shortening.

Technical description

The transthoracic adult echocardiographic examination begins with a parasternal long-axis (PLAX) view that profiles the left heart and the proximal right ventricular (RV) outflow tract (RVOT) in the sagittal plane [Figure 1 and Video 1]. The patient is placed in the left lateral decubitus position with the left arm raised. The transducer is positioned adjacent to the sternum in the left third or fourth intercostal space. The orientation marker is directed toward the patient's right shoulder, and probe angled slightly to avoid foreshortening the LV.

Depth is adjusted to include the echogenic pericardium posterior to the inferolateral wall. One cine loop is acquired at a greater depth to rule out pericardial and pleural effusions. Sector width is adjusted to include the aortic root to the right and mid segments of the anterior septum and inferolateral wall to the left. One ECG-gated loop with three (normal sinus) or five (atrial fibrillation) beats is recorded.

Table 1: Recommended views for a complete transthoracic adult echocardiographic study*,#,$

Parasternal window	Apical window	Other acoustic windows
PLAX 2D	Apical 4-chamber view with pericardial space	Subcostal window
PLAX mitral valve zoom	Focused LV 4-chamber view	Subcostal 4-chamber view (RV focused)
2D	Focused LV 2-chamber view	Interatrial septal view
Color Doppler	Focused LV apical long-axis view	2D
PLAX aortic valve zoom	Zoomed LV inflow and outflow view	Color Doppler
2D	2D	Aorta long axis
Color Doppler	Color Doppler	2D
PLAX ascending aorta	Zoomed LA 2-chamber view	Color Doppler (PW spectral Doppler optional)
2D	Zoomed LA 4-chamber view	IVC long axis
Color Doppler	Pulmonary vein flow PW spectral Doppler	2D
PLAX RV inflow view with color Doppler	Focused (LA-LV) mitral flow-	IVC/hepatic veins color Doppler
PSAX at the level of semilunar valves	Color Doppler	IVC/hepatic vein PW spectral Doppler
2D	PW spectral Doppler (optional CW for MR and MS)	Suprasternal window
Color Doppler	Mitral annular tissue Doppler (PW spectral Doppler)	Aortic arch long-axis
PSAX aortic valve zoom	Medial	2D
2D	Lateral	Color Doppler
Color Doppler	Zoomed 5-chamber LVOT	PW/CW spectral Doppler
PSAX main pulmonary artery and bifurcation	2D	
Color Doppler	Color Doppler	
Pulmonary flow PW spectral Doppler (optional PR jet CW)	LVOT PW spectral Doppler	
LV SAX at mitral valve level 2D (optional mitral valve color Doppler)	Aortic valve flow CW Doppler	
LV SAX at papillary muscle level 2D	Focused RA-RV view	
LV SAX at apex 2D	2D	
	Color Doppler at tricuspid valve	
	TR jet CW spectral Doppler	
	Tricuspid flow PW/CW spectral Doppler	

*Additional views will be needed depending on the underlying pathology, #All views are 2D views, unless specifically mentioned, $All 2D and color Doppler views refer to video clips. 2D: two-dimensional, SAX: short-axis, LV: left ventricle, PR: pulmonary regurgitation, CW: continuous-wave, PSAX: parasternal short-axis, PLAX: parasternal long-axis, LA: left atrium, TR: tricuspid regurgitation, PW: pulsed-wave, RA: right atrium, LVOT: left ventricular outflow tract, MR: mitral regurgitation, MS: mitral stenosis, IVC: inferior vena cava

Table 2: Recommended gray-scale and color measurements*

Gray-scale measurements	Doppler measurements
LV cavity systolic and diastolic diameters	Peak RVOT/pulmonary flow velocity
IVS and posterior wall diastolic thickness	PR end-diastolic gradient
Aortic annulus, aortic root at sinuses, sinotubular junction, ascending aorta diameters	Pulmonary vein flow S, D, A velocities
LA anteroposterior diameter, LA volume	Mitral flow E, A velocities, E/A ratio, E wave deceleration time
RVOT/MPA diameter(s), RA diameter, RV basal diameter, RV free wall thickness	Mitral annular E' and S' velocities
LV end-diastolic and end-systolic volumes using Simpson's method	LVOT VTI
TAPSE	Aortic flow peak gradient
IVC size, along with respiratory variation	TR peak gradient, estimated RVSP/PASP (mention RA pressure)

*Additional measurements will be needed depending on the underlying pathology. IVC: inferior vena cava, RVSP: right ventricular systolic pressure, PASP: pulmonary artery systolic pressure, RA: right atrium, TAPSE: tricuspid annular plane systolic excursion, LV: left ventricle, RV: right ventricle, RVOT: right ventricular outflow tract, MPA: main pulmonary artery, LA: left atrium, IVS: intact ventricular septum, LVOT: left ventricular outflow tract, VTI: velocity time integral, TR: tricuspid regurgitation, PR: pulmonary regurgitation

Moving from LV inflow to outflow, the anteroposterior cross-section of the left atrium (LA), mitral valve, chordae tendineae, LV cavity in long axis, LVOT, aortic valve (AoV), and proximal ascending aorta can be appreciated in this view. The longer anterior mitral leaflet (above) and short posterior mitral leaflet (below) are visualized. The basal and mid segments of the anterior septum (above) and inferolateral wall (below) are observed in parallel orientation. Sliding the probe one rib space inferiorly brings the distal segments into view, and it is useful when profiling the LV during stress echocardiography studies. The apex is not visualized in this view. The tubular LVOT is visualized in long axis. Of the three aortic cusps, the right coronary cusp (above) and noncoronary cusp (below) are seen. The corresponding aortic sinuses, sino-tubular junction, and proximal segment of the ascending aorta are also visualized. The proximal RVOT is visualized in its short to oblique axis.

Two-dimensional left ventricle end-diastolic and end-systolic linear measurements

The end-diastolic frame is identified by the frame in which LV cavity is largest (the most preferred method) or the frame just after mitral valve closure. The end-systolic frame is identified when the LV is smallest or the frame just before the mitral valve opens. Linear dimensions are to be taken at the level of the mitral chordae, perpendicular to the LV cavity. Measurements are made between the inner edge of the anterior septum and inner edge of the inferolateral wall using 2D echocardiography (preferred) or anatomical M-mode.[2]

Parasternal long-axis mitral valve zoom two-dimensional and color Doppler

Purpose

2D

- Mitral leaflet motion and pathology
- Color Doppler: Detection of mitral regurgitation (MR), measurement of MR jet vena contracta.

Measurements

2D

- Mandatory: Nil
- Optional: Mitral annulus anteroposterior diameter

Color Doppler

- Mandatory: Nil
- Optional: Vena contracta, proximal isovelocity surface area (PISA)
- Doppler data: Qualitative.

Technical description

From the PLAX 2D view, a finer appreciation of the mitral valve can be obtained by magnifying the mitral apparatus using the zoom function [Figure 2a and Video 2a]. In this view, the mitral annulus, anterior and posterior mitral leaflets, and the attached chordae are well visualized. A lateral and medial angulation of the probe provides finer delineation of both anterolateral and posteromedial commissures and papillary muscles, respectively. This view is recommended when studying mitral leaflet motion and pathology. Mitral annulus anteroposterior diameter is to be measured at end-systole and end-diastole.

Placing a color window over the mitral valve in this view permits a qualitative evaluation of MR severity [Figure 2b and Video 2b]. Patients with significant jets demonstrate a well-defined area of flow convergence proximal to the jet, a vena contracta at the point of coaptation, and regurgitant jet in the LA. Sector width is to be adjusted to cover the full extent of the regurgitant jet in the posterior LA.

Parasternal long-axis aortic valve zoom two-dimensional and color Doppler

Purpose

- 2D: AoV and root pathology, LVOT size, subaortic membrane
- Color Doppler: Detection of AS or aortic regurgitation (AR), measurement of AR jet vena contracta.

Measurements

2D

- Mandatory – aortic annulus, aortic root at sinuses, sinotubular junction

Color Doppler

- Mandatory – Nil
- Optional: Jet height, vena contracta
- Doppler data: Qualitative.

Technical description

Acquiring a magnified view of the AoV provides vital information on the structure and pathologies of the LVOT, annulus, aortic cusps with corresponding sinuses, the sinotubular junction, and proximal ascending aorta [Figure 3a and Video 3a]. This is of particular relevance when measuring the LVOT diameter and cross-sectional area to calculate stroke volume, or studying structural abnormalities associated with the LVOT. LVOT diameter is measured during mid systole (with the cusp maximally opened), around 0.5–1 cm from the aortic annulus, from inner edge to inner edge. The aortic annulus itself is measured between the hinge points of aortic cusps, during mid-systole and from inner edge to inner edge.[2]

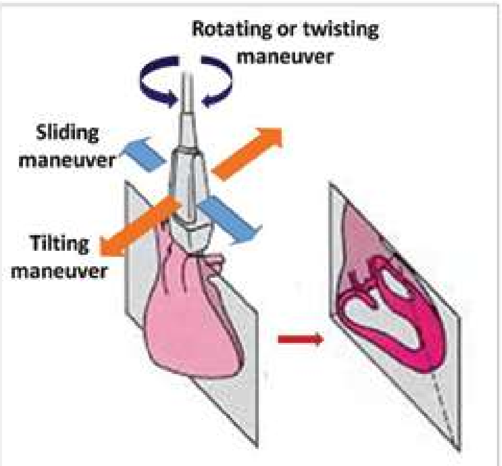

Figure STR: Depiction of transducer manipulations

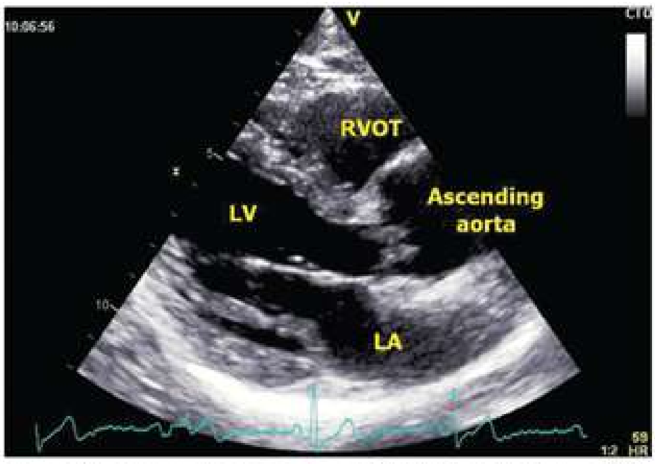

Figure 1: Parasternal long-axis view. LA- left atrium, LV- left ventricle, RVOT- right ventricular outflow tract

Applying color Doppler to this view provides qualitative information on the severity and extent of valvular regurgitation and/or valve stenosis [Figure 3b and Video 3b].

Parasternal long-axis ascending aorta two-dimensional and color Doppler

Purpose

- 2D: Ascending aorta dilatation, ascending aorta aneurysm, dissection flap, etc.
- Color Doppler: False lumen flow in case of dissection, AS jets.

Measurements

- 2D: Mandatory - Ascending aorta size
- 2D: Mandatory - Nil
- Doppler data: Qualitative.

Technical description

From the 2D PLAX view, the ascending aorta can be profiled by sliding the transducer one intercostal space higher [Figure 4a and Video 4a]. With fine angulation, the long axis of the ascending aorta is profiled. Measurements made in this view include the diameter of the aortic annulus, sinus of Valsalva, sinotubular junction, and ascending aorta. Measurements other than aortic annulus are performed at end-diastole, using the leading edge to leading edge method.[2] This view is recommended in the setting of ascending aorta dilatation, aneurysm, and dissection. Placing a color Doppler sector over this image provides qualitative information on flow profile in the ascending aorta, localizing false lumen and dissections confined to this region [Figure 4b and Video 4b].

Parasternal long-axis right ventricle inflow view with color Doppler

Purpose

Tricuspid leaflet pathology, tricuspid regurgitation (TR) mechanism and severity.

Measurements

- Mandatory - Nil
- Doppler data: Qualitative for TR, also CW for the estimation of TR gradient.

Technical description

The PLAX RV inflow view can be obtained by angling the transducer medially, toward the right hip [Figure 5 and Video 5]. In this view, the RA, TV, and RV can be visualized. The ostium of the inferior vena cava (IVC) including Eustachian valve, is seen draining into the RA. With slight angulation, the coronary sinus is also seen. The anterior tricuspid leaflet is seen to the right of the display and posterior leaflet toward the left of the display. This is the only view which shows the posterior tricuspid leaflet. The anterior wall of the RV is seen toward the right of the display and the inferior wall toward the left. TR jet parameters can be measured in this view using color and CW Doppler, provided the jet is parallel to the ultrasound beam.

Parasternal short axis at the level of semilunar valves: Two-dimensional and color Doppler

Purpose

- 2D: AoV, RVOT, and pulmonary valve pathology may also be helpful in the assessment of atrial septal defect (ASD).
- Color: To detect perimembranous/supracristal VSD, RVOT stenosis, TR.

Measurements

- 2D: Mandatory - Pulmonary valve annulus size
- Color: Mandatory - Nil
- Doppler data: Qualitative.

Technical description

The parasternal short-axis (SAX) view is obtained from the PLAX view by rotating the transducer orientation mark by 90° in the clockwise direction, such that it points to the patient's left shoulder. Moving the transducer superiorly with a slight cranial angulation provides a cross-section of the aortic root [Figure 6a and Video 6a]. The commonly referred to "circle and sausage" view profiles the aortic root (circle) surrounded by the RVOT (sausage). In addition, this view profiles the RA, the anterior and septal leaflets of the TV, the RV, RVOT, PV, and main pulmonary artery (MPA). With slight angulation, the bifurcation of the pulmonary artery into the right and left branches can be visualized. Angulating the probe posteriorly brings the LA appendage into view. A shift in rib interspace may occasionally be necessary to optimize the view. Applying color Doppler to this view [Figure 6b and Video 6b] provides a qualitative assessment of stenosis or regurgitation related to the aortic, tricuspid, or pulmonic valves. In addition, VSDs can be characterized based on location as either peri-membranous (9–12 o'clock position) or outlet/supracristal/subpulmonic (12–3 o'clock position).

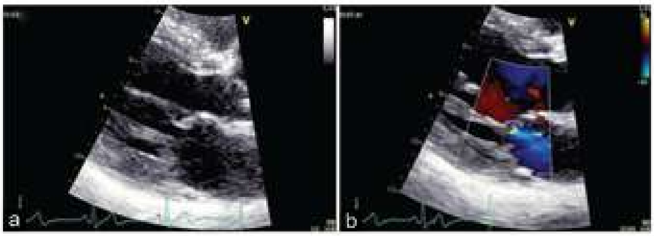

Figure 2: Magnified view of mitral apparatus in parasternal long-axis view; (a) two-dimensional image, (b) with color

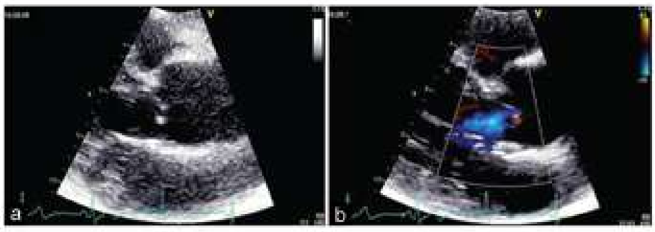

Figure 3: Magnified parasternal long-axis view of the left ventricular outflow tract, aortic valve and ascending aorta; (a) two-dimensional image, (b) with color

Parasternal short-axis aortic valve zoom two-dimensional and color Doppler

Purpose

- 2D: Aortic leaflet pathology, coronary ostia
- Color Doppler: Detection and assessment of AR jet origin and severity.

Measurements

- 2D: Mandatory – AoV planimetry in patients with AS in patients with adequate visualization of the aortic cusps
- Color Doppler: Mandatory – Nil
- Optional - AR jet area
- Doppler data: Qualitative.

Technical description

A magnified view of the aortic root provides a clear demonstration of aortic cusp morphology and motion [Figure 7a and Video 7a]. With a slight superior angulation, the proximal right coronary artery and left coronary artery can be visualized arising from the anterior (right sinus) and posterior (left sinus) sinuses, respectively. The noncoronary sinus (right and posterior) is identified by the attachment of interatrial septum. Coronary arteries are best visualized using a higher transducer frequency with careful adjustment of the focus. The left coronary artery arises at the 4 o' clock position at the level of the pulmonary valve, and the right coronary artery is seen at the 11 o'clock position coursing between the RA and the RV. Fine angulation permits the visualization of the bifurcation of the left coronary artery into the left anterior descending artery and the left circumflex in selected patients. Placing a color Doppler window in this view [Figure 7b and Video 7b] permits qualitative estimation of AR severity by comparing AR jet area to the aortic root area. With a reduction of the Nyquist limit, diastolic flow in the proximal coronary arteries can be visualized in selected patients.

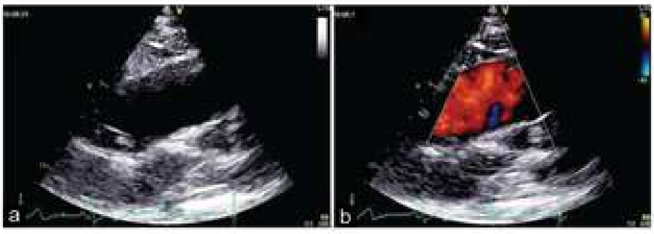

Figure 4: Magnified view of the ascending aorta in parasternal long axis; (a) two-dimensional image, (b) with color

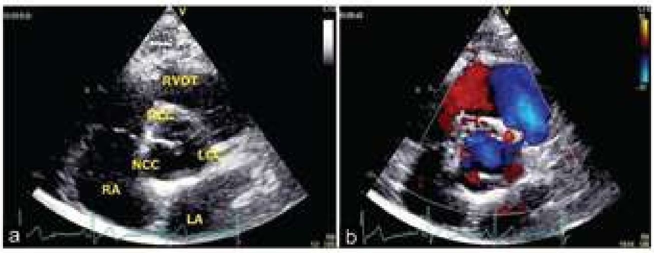

Figure 6: Parasternal short-axis view at the level of semilunar valves. (a) two-dimensional image (b) with color LA- left atrium, LCC- left coronary cusp, NCC- non-coronary cusp, RA- right atrium, RCC- right coronary cusp, RVOT- right ventricular outflow tract

Main pulmonary artery and bifurcation with color and spectral Doppler (optional pulmonary regurgitation jet continuous-wave)

Purpose

- Color Doppler: To detect pulmonic stenosis (PS), pulmonary regurgitation (PR), or ductal flow
- PW/CW: PS, high pulmonary vascular resistance (PVR) pattern, etc.

Measurements

- Mandatory - Peak pulmonary velocity, peak PS gradient when present, end-diastolic PR gradient when present, peak and trough gradient across patent ductus arteriosus when present
- Optional - Pulmonary velocity time integral (VTI), pulmonary acceleration time, etc.
- Doppler data - Quantitative for shunt, PVR calculation.

Technical description

A fine anterior angulation of the probe from this position brings the RVOT, MPA, the left pulmonary artery, and the right pulmonary artery into view. Color Doppler provides a qualitative assessment of PR and localizes a region of turbulence in the setting of infundibular, valvular, or branch stenosis [Figure 8a and Video 8]. In patients with congenital heart disease, this view is also employed to visualize a patent ductus arteriosus flowing from the descending aorta into the

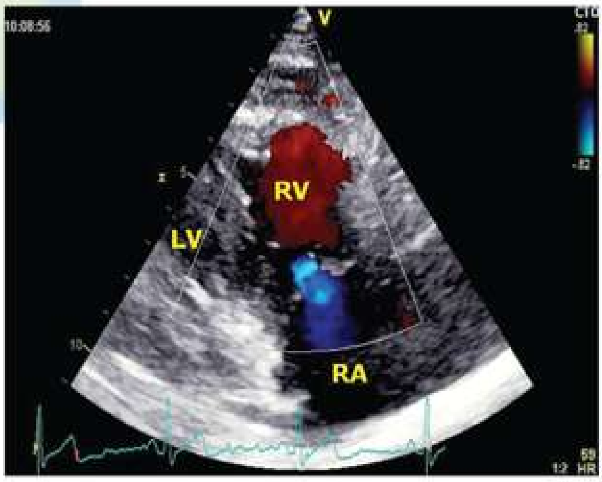

Figure 5: Parasternal long-axis right ventricle inflow view with color Doppler. LV- left ventricle, RA- right atrium, RV- right ventricle

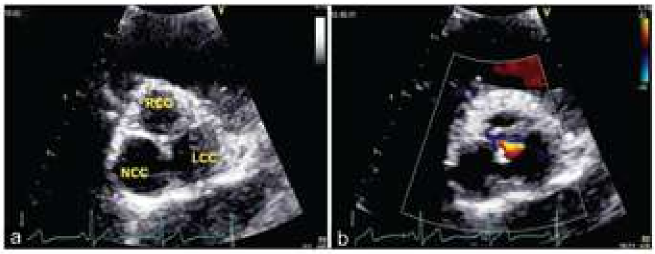

Figure 7: Parasternal short-axis aortic valve zoomed view; (a) two-dimensional image, (b) with color. LCC- left coronary cusp, NCC- non-coronary cusp, RCC- right coronary cusp

left pulmonary artery. A PW Doppler sample volume placed in the RVOT at the level of pulmonary annulus provides information on the peak flow velocity [Figure 8b]. Additionally, the spectral tracing also provides the assessment of pulmonary hypertension from PR and calculation of PVR. In the setting of an increased velocity, PW can be used to map the area to locate the specific region of flow increase, and a subsequent switch to CW Doppler allows for quantification of the jet velocity and corresponding pressure gradient.

Left ventricle short axis at mitral valve level two-dimensional (optional mitral color Doppler)

Purpose

Regional wall motion abnormality (RWMA), mitral valve end-on view for the assessment of mitral valve pathologies such as prolapse and MS (planimetry, commissures, etc.).

Measurements

- Mandatory: Nil; mitral valve area in those with MS.
- Optional: 2D circumferential and radial strain, basal rotation.
- Doppler data: Qualitative for regurgitant orifice.

Technical description

From the parasternal SAX at the level of the semilunar valves, an inferior sweep by sliding the probe caudal and leftward provides option for imaging the LV from base to apex in SAX. A change in intercostal space is necessary to ensure a perpendicular orientation of the short-axis planes. The LV SAX at the mitral valve level is characterized by a "fish mouth" appearance of the anterior and posterior mitral leaflets [Figure 9 and Video 9]. Alternatively, an M-mode performed across the valve with a sweep speed of 100 mm/s provides details of leaflet motion during the cardiac cycle. Pathologies such as mitral valve prolapse can be further characterized using high temporal frame capture on M-mode. In the setting of MS, a careful sweep starting from the papillary muscles till the LVOT SAX permits accurate planimetry of the mitral valve area at the level of the leaflet edges and also allows assessment of the extent and morphology of commissural and chordal fusion. Mitral annular and leaflet calcium can also be demonstrated using a careful upward and downward sweep of the transducer. The basal six segments of the LV can be identified in this view in keeping with the current 17-segment nomenclature. Starting from the basal anterior septum adjacent to the RV, moving in a clockwise direction, the basal anterior wall, basal anterolateral wall, basal inferolateral wall, basal inferior wall, and basal inferior septum are visualized.[2]

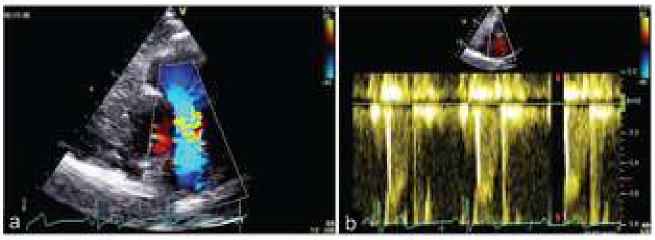

Figure 8: Parasternal short-axis view showing right ventricular outflow tract, main pulmonary artery and its bifurcation; (a) with color, (b) right ventricular outflow tract flow spectral signal on pulsed-wave

Left ventricle short axis at papillary muscle level

Purpose

Assessment of LV ejection fraction (LVEF), RWMA; LV mass estimation; papillary muscle geometry and morphology.

Measurements

- Mandatory - Nil
- Optional - LV mass calculation, 2D circumferential and radial strain.

Technical description

From the LV SAX at the base of the heart, an inferior sweep and slide provides an assessment at the level of the papillary muscles [Figure 10 and Video 10]. An optimal transducer position demonstrates a circular LV cross-section with the anterolateral papillary muscle at the 4 o' clock position and posteromedial papillary muscle at 8 o' clock position. Care needs to be taken to avoid a nonperpendicular cut plane that distorts internal dimensions and overestimates LV size and contractility.

The papillary muscle level clip provides a convenient eye-balling of LV systolic function and assessment of RWMAs in the six segments at the mid-LV cavity plane. Starting from the mid-anterior septum adjacent to the RV, moving clockwise, the mid-anterior wall, mid anterolateral wall, mid inferolateral wall, mid inferior wall, and mid inferior septum are visualized. Asymmetric wall thickness, if observed, can be measured using corresponding M-mode measurements of the septal and inferior wall. This view also provides information on papillary muscle morphology and geometry.

Left ventricle short axis at apex two-dimensional

Purpose

Assessment of RWMA; detection of LV apical clot; assessment of pathologies such as noncompaction.

Measurements

- Mandatory - Nil
- Optional - 2D circumferential and radial strain, apical rotation.

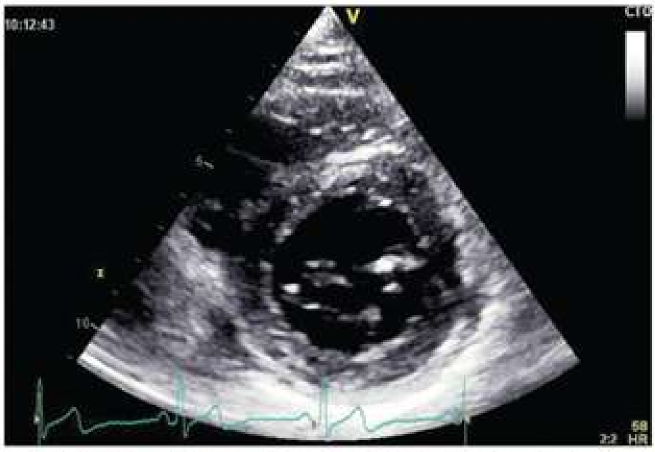

Figure 9: Left ventricle short-axis view at the level of the mitral valve

Technical description

From the previous view, by angling and sliding the transducer even more inferiorly, a uniform tapering and reduction in cavity size is observed with the LV apex coming into view [Figure 11 and Video 11]. The apico-anterior wall, apico-lateral wall, apico-inferior wall, and apical septum are visualized. The apical 4-segment view provides information on RWMA, pathologies such as LV noncompaction, apical aneurysms and thrombus.

Apical 4-chamber view with pericardial space

Purpose

Overview of chambers, pericardial or extracardiac pathology, ASD.

Measurements

- Mandatory - LA, RA, RV diameters; LA area
- Optional - RA area, RV fractional shortening; LV length.

Technical description

The apical 4-chamber view is acquired with the patient positioned in the left lateral decubitus position. A bed with a cut out section that allows convenient access to the region under the left breast tissue is recommended for optimal imaging. The apical pulse is palpated and the probe is positioned slightly lateral to this position. The orientation marker is positioned at the 5 o'clock position to image the four chambers of the heart. The patient may be requested to suspend respiration at the end of expiration during image acquisition to reduce translational disturbances.

The apical 4-chamber view showcases the ventricles above and atria below [Figure 12 and Video 12]. The insertion of the septal TV leaflet is seen slightly apical to the mitral valve leaflet. The smooth-walled, ellipsoidal LV forms the true apex of the heart, while the thin-walled, trabeculated, wedge-shaped RV is observed to the right (left of the display). To ensure that the LV is not foreshortened, the lowest possible apical window is suggested, and the apex should be seen triangular and thickening in systole (in a normal heart). In general, the length of the LV is 2–3 times that of the major linear axis of the LA. Once in the correct position, fine adjustments to transducer frequency, focus, time gain compensation, and overall gain are made to ensure optimal delineation of the endocardium across all segments of the LV. Use of tissue harmonics is recommended to improve tissue–blood pool demarcation.

Focused left ventricle 4-chamber view

Purpose

RWMA in lateral wall and septum, LV volume estimation, high frame rate images for 2D strain, etc.

Measurements

- Mandatory - LV volume and EF by Simpson's method
- Optional - 2D longitudinal strain.

Technical description

A magnified view of the LV provides a more detailed evaluation of LV volumes and function. In the focused LV 4-chamber view, the septum is vertically positioned in the center of the screen and divides the two ventricles [Figure 13 and Video 13]. A rightward orientation of the septum can be corrected by moving the probe laterally and a leftward deviation by moving the probe medially. The focal point should be adjusted at the midcavity level. For accurate assessment of LV volumes and RWMA, an optimal delineation of the endocardium is essential. Selective enhancement of the anterolateral and septal segments is possible on certain equipment employing lateral gain compensation. In the eventuality of an inability to track the endocardial surface in two or more segments, use of contrast is recommended.[3]

To obtain LV volumes and EF using Simpson's method of discs, first ensure optimal endocardial definition in the focused LV 4-chamber view and then trace the endocardial border in the end-diastolic frame (the frame showing the largest LV cavity size, usually the frame immediately after mitral valve closure) and the end-systolic frame (the frame showing the smallest LV cavity size, usually the frame just before mitral valve opening). The endocardial border is traced from the

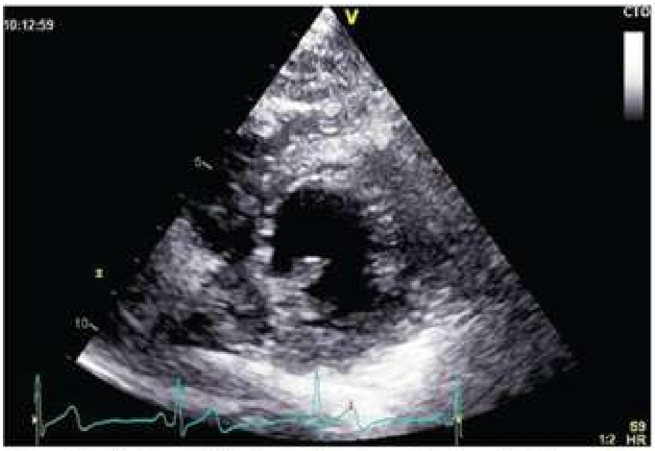

Figure 10: Left ventricle short-axis view at the level of the papillary muscles

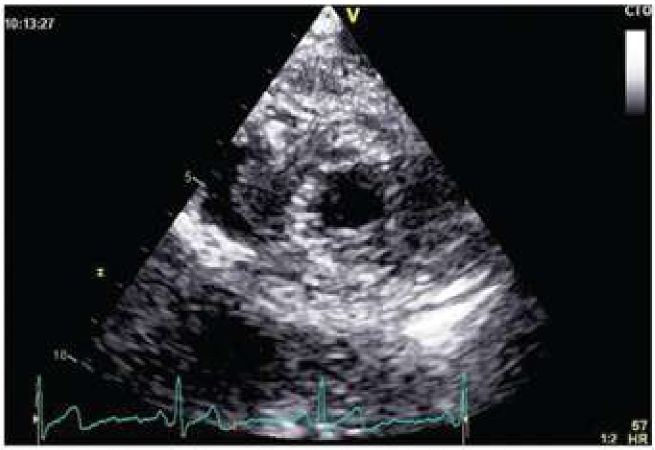

Figure 11: Left ventricle short-axis view at the level of apex

point of insertion of anterior mitral leaflet into the septum in the clockwise direction till the insertion of the posterior leaflet into the lateral wall. The system then calculates a volume based on the summation of 2D-generated discs. These steps are repeated in the end-systolic frame. When both end-diastolic and end-systolic measurements are repeated in the focused 2-chamber view, the system generates an automated biplane 2D EF based on these volumetric measurements.

Focused left ventricle 2-chamber view

Purpose

RWMA in anterior and inferior wall, high frame rate images for 2D strain, etc.

Measurements

- Mandatory - LV volume and EF by Simpson's method
- Optional - 2D longitudinal strain.

Technical description

The focused LV 2-chamber view can be obtained from the focused 4-chamber view by rotating the transducer counterclockwise by approximately 60° [Figure 14 and Video 14]. This view provides a complete visualization of the anterior wall to the right of the display and the inferior wall to the left of the display. Asking the patient to take a shallow inspiration can often help improve visualization of the anterior wall. The LA appendage is seen to the right of the display. The RV should not be visible in this view. Showcasing papillary muscles should be avoided. However, by tilting the transducer, one should be able to image both the papillary muscles from their origins to insertions into the mitral valve. Descending thoracic aorta can be visualized beneath the aria.

Focused left ventricle apical long-axis view

Purpose

RWMA in anterior septum, inferolateral or posterior wall; high frame rate images for 2D strain, etc.

Measurements

- Mandatory - Nil
- Optional - 2D longitudinal strain.

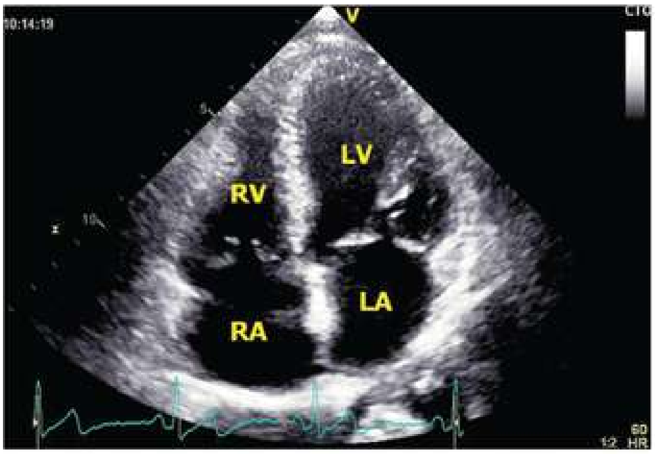

Figure 12: Apical 4-chamber view. LA- left atrium, LV- left ventricle, RA- right atrium, RV- right ventricle

Technical description

A further 60° counterclockwise rotation with a slight anterior angulation reveals the apical long-axis view, also called the apical 3-chamber view [Figure 15 and Video 15]. This view is analogous to the PLAX view, except that distal LV segments and apex are also seen in this view. The inferolateral wall is seen to the left of the display and anterior septum to the right of the display. The apical 3-chamber view is recommended to visualize systolic anterior motion (SAM) of the mitral leaflets, LVOT dynamic obstruction, and AoV stenosis or regurgitation.

Zoomed left ventricle inflow and outflow view two-dimensional and color Doppler

Purpose

- 2D: LVOT dynamic narrowing, SAM of mitral leaflets/ chordae, mitral valve pathology, etc.
- Color Doppler: LVOT dynamic obstruction, MR/AR jet delineation, etc.

Measurements

- 2D: Mandatory - Nil
- Color Doppler: Mandatory - Nil
- Doppler data: Qualitative, quantitative for MR effective regurgitant orifice area by PISA method.

Technical description

A magnified view of the LV inflow and outflow can be obtained by employing the zoom function [Figure 16a and Video 16a]. This view is of particular interest when assessing SAM of the mitral valve, chordal pathology, or dynamic narrowing across the LVOT. Applying a color window across this frame provides qualitative information on flow across the mitral inflow and LV outflow [Figure 16b and Video 16b].

Zoomed left atrium 2-chamber and 4-chamber views two-dimensional

Purpose

LA intra-cavity pathology, LA volume estimation.

Measurements

- Mandatory - LA area for volume estimation
- Optional - 2D LA strain.

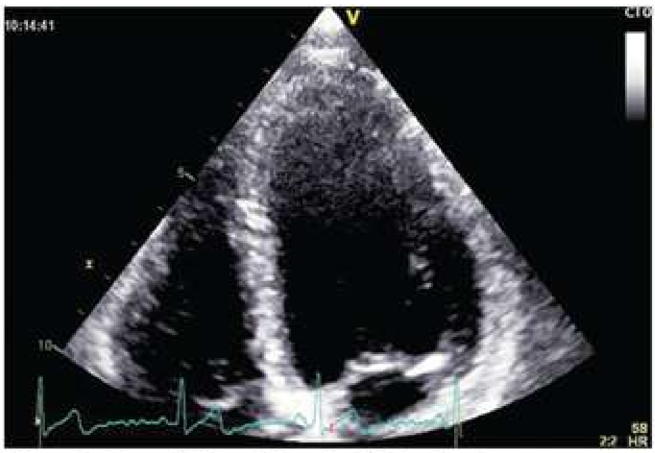

Figure 13: Focused left ventricle apical 4-chamber view

Technical description

The LA is best assessed employing a magnified view of the LA, as seen in the apical 2-chamber [Figure 17 and Video 17] and 4-chamber views [Figure 18 and Video 18]. The zoom function is employed after identifying the LA as the region of interest. For optimal penetration, a lower transmit frequency is recommended, with the focal plane adjusted at the level of the LA cavity. LA area and volume are measured when the LA is maximally dilated during the end-systolic frame. The pulmonary veins and LA appendage are excluded while tracing the LA borders. LA length is measured as the distance between the LA roof and the level of the mitral annulus. The shorter of the two lengths measured in the 4-chamber and 2-chamber views is employed to calculate LA volume by the area-length method. All measurements should be indexed to body surface area.

Pulmonary vein flow pulsed-wave spectral Doppler

Purpose

Assessment of LV diastolic function.

Measurements

- Mandatory - Pulmonary vein flow systolic, diastolic, and atrial reversal velocities
- Optional - Duration of atrial reversal wave
- Doppler data - Qualitative.

Technical description

In the apical 4-chamber view, an assessment of pulmonary venous flow provides complimentary information on LV diastolic function [Figure 19 and Video 19]. Lower transmit frequencies are recommended and the focal point is adjusted at the plane of the LA roof. To obtain an optimal spectral flow pattern, the probe is angled slightly posterior from the apical position to image the right lower pulmonary vein breaking into the LA. A 2–3 mm sample volume is placed >0.5 cm into the vein, and the velocity scale decreased to accommodate low velocity flow. Certain equipment provide a low pulse repetition frequency function that can be activated to profile pulmonary venous flow. Wall filters may need to be adjusted to minimize noise. Sweep speed is adjusted between 50 and 100 mm/s at end expiration, and an average of three consecutive cardiac cycles are obtained.

Focused (left atrium-left ventricle) mitral flow color and pulsed-wave spectral Doppler (optional continuous-wave for mitral regurgitation and mitral stenosis)

Purpose

- Detection and evaluation of MR
- LV diastolic function assessment, MS severity.

Measurements

- Mandatory - Mitral inflow early and late diastolic velocities, deceleration time of early diastolic wave.

Figure 14: Focused left ventricle apical 2-chamber view

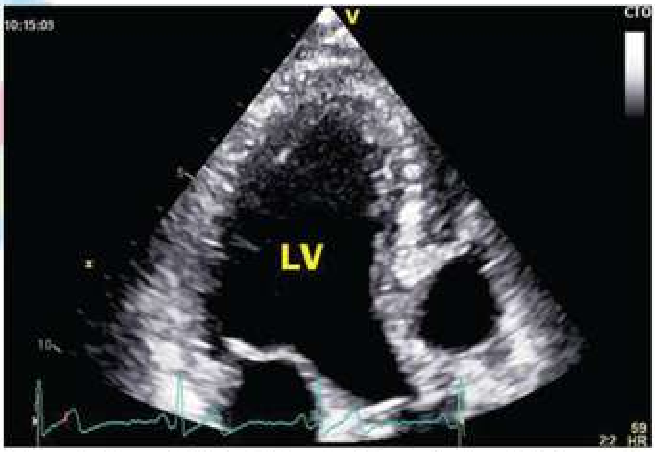

Figure 15: Focused left ventricle apical long-axis view. LV- left ventricle

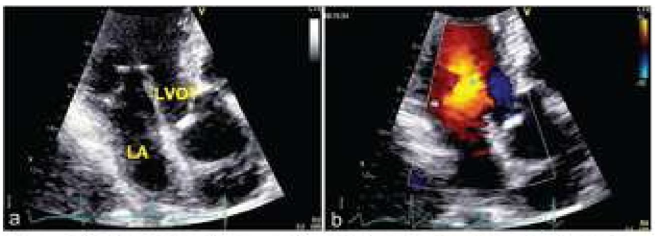

Figure 16: Magnified view of the left ventricle inflow and outflow; (a) two-dimensional image, (b) with color. LV- left ventricle, LVOT- left ventricular outflow tract

Figure 17: Magnified view of the left atrium seen in the apical 2-chamber view. LA- left atrium

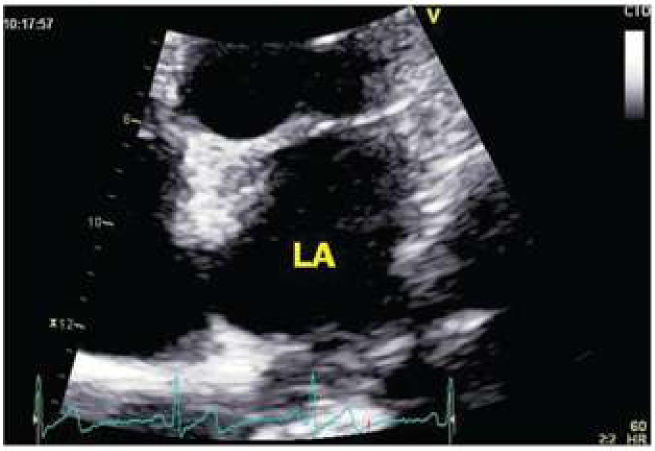

Figure 18: Magnified view of the left atrium seen in the apical 4-chamber view. LA- left atrium

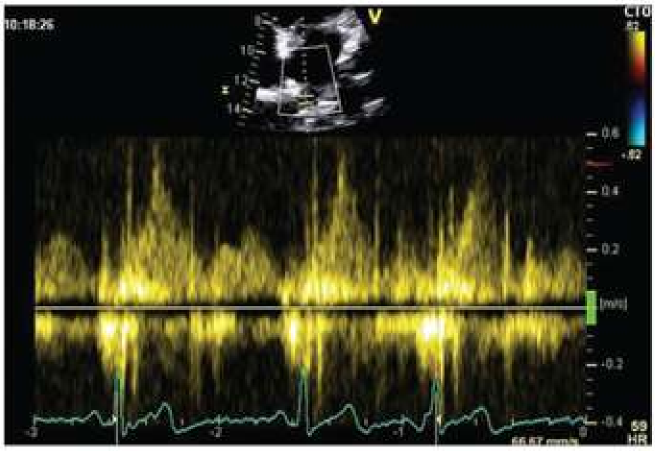

Figure 19: Pulmonary venous flow into the left atrium seen on pulsed-wave Doppler

- Optional - LV inflow propagation velocity, PISA for MR, isovolumic relaxation time, MS severity assessment (pressure gradients, valve area by pressure half-time), MR dP/dt.
- Doppler data - Color image: Qualitative for MR, quantitative for PISA. PW: Quantitative for LV diastolic function, MS and MR, transvalvar diastolic forward flow measured at mitral annulus.

Technical description

Applying color flow across the mitral valve in the focused LA-LV view provides information on the hemodynamic severity of MR, in addition to studying mitral inflow [Figure 20a and Video 20]. Care needs to be taken to ensure a color window as narrow as possible that covers the mitral valve to avoid a drop in frame rate and maintain a Nyquist velocity of approximately 50–60 cm/s.

A PW Doppler interrogation of mitral inflow lends significant information to the assessment of LV filling [Figure 20b]. A 1–3 mm sample volume is placed at the tips of the mitral leaflets in the LV and positioned slightly closer to the lateral wall in keeping with flow direction across the valve. Color flow imaging may assist in the optimal alignment of the Doppler beam. Spectral mitral inflow velocities are initially obtained at a sweep speed of 25–50 mm/s to evaluate respiratory inflow variation. In the setting of no respiratory variation, the sweep speed is adjusted to 100 cm/s, averaged over three cardiac cycles and captured at the end of expiration.

Spectral gain and reject are adjusted to display a crisp diastolic profile across the valve. The resultant spectral pattern should demonstrate a well-defined E-wave generated by early filling and A-wave generated by atrial contraction (in normal sinus rhythm).

Mitral annular tissue Doppler (medial and lateral)

Purpose

LV systolic longitudinal function, diastolic function.

Measurements

- Mandatory - Mitral annular early diastolic velocity (E'), mitral annular systolic velocity (S')
- Optional - Late diastolic velocity (A')
- Doppler data - Quantitative for LV diastolic function.

Technical description

Mitral annular tissue Doppler is obtained from the apical 4-chamber view by placing the PW sample volume on the medial and lateral annular junctions [Figures 21a, b and Video 21]. All tissue Doppler presets on equipment are set to filter out high velocity, low amplitude signals and amplify low velocity, high amplitude signals generated by the myocardium, hence no gross manual adjustments may be required. By narrowing the color tissue Doppler sector to cover the medial annulus and lateral annulus separately, an optimal frame rate of 100–120 frames/s can be acquired.

A 5–10 mm sample volume is placed at or within 1 cm of the insertion sites of the mitral leaflets on septal or lateral walls and adjusted to cover the longitudinal excursion of the annulus in both systole and diastole. Care is to be taken to ensure an angulation of <20° between the ultrasound beam and plane of annular motion. The velocity scale is adjusted to 20 cm/s to profile myocardial velocities above and below the baseline. The tracing is recorded at a sweep speed of 100 cm/s at the end of expiration. 2D reference frame is frozen to improve delineation of the spectral waveform, and an average of three consecutive cardiac cycles is considered. The S', E', and A' are measured in this view. In conjunction with the early mitral inflow velocity (E), acquired using PW Doppler, a noninvasive assessment of LV filling pressures (E/E') is possible. Myocardial performance index can also be measured from these images, considering mitral closure to opening time and ejection time.

Zoomed 5-chamber left ventricular outflow tract-two-dimensional, color, pulsed-wave spectral Doppler

Purpose

- 2D: LVOT dynamic or fixed stenosis, perimembranous VSD, etc.
- Color: LVOT dynamic or fixed stenosis, perimembranous VSD, etc.

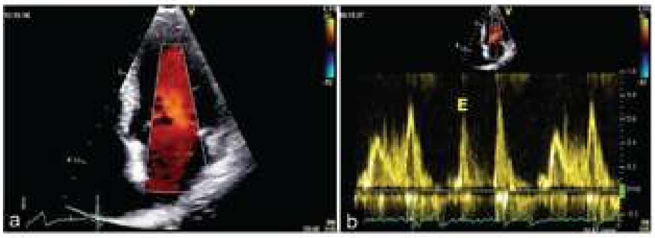

Figure 20: (a) Color flow across the mitral valve in the color left atrium - left ventricle view; (b) mitral inflow pulsed-wave spectral Doppler

- PW: LV stroke volume, LVOT dynamic or fixed stenosis, etc.

Measurements

- 2D: Nil
- Color Doppler: Nil
- PW: Quantitative for stroke volume, continuity equation.

Technical description

A more detailed evaluation of the LVOT is essential to assess dynamic or fixed obstruction, in addition to providing a view for accurate PW/CW measurements [Figure 22a and Video 22a]. Color flow across the LVOT provides a qualitative assessment of AR and localization of the site of obstruction, if present [Figure 22b and Video 22b]. SAM of the mitral valve is well visualized in this view. To assess LVOT flow or measure stroke volume using PW Doppler, a sample volume is placed just proximal to the AoV in the center of the LVOT [Figure 22c and Video 22c]. In calcified, degenerative AS, care should be taken to avoid placing the sample volume too close to the aortic cusps, as this can cause an artifactual increase in LVOT velocities. The sample volume position should also correspond to the location used to assess LVOT cross-section in the 2D PLAX view. In the event of an aliasing spectral pattern, the sample volume can be moved toward the LV to localize the site of obstruction. In a normal heart, the peak velocity should rapidly decline with this maneuver.

Aortic valve flow continuous-wave Doppler

Purpose

Quantification of AS severity.

Measurements

- Mandatory - AS peak and mean gradients, aortic flow VTI
- Doppler data - quantitative for AoV area estimation by continuity equation.

Technical description

Switching to CW Doppler in the previous view provides an assessment of the maximum flow across the AoV [Figure 23 and Video 23]. A peak velocity and VTI obtained from CW can be used in conjunction with the corresponding values obtained in the LVOT to assess AoV area using the continuity equation. All spectral Doppler tracings are to be recorded at 100 mm/s, adjusting baseline and velocity scale to ensure optimal measurement. Like all Doppler evaluations, care is to be taken to ensure the beam is as parallel as possible to blood flow.

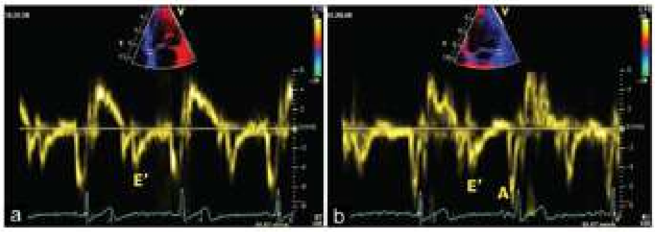

Figure 21: Mitral annular velocities on pulsed-wave tissue Doppler imaging; (a) medial annulus, (b) lateral annulus

Focused right atrium-right ventricle view two-dimensional, tricuspid flow color Doppler, continuous-wave and pulsed-wave

Purpose

- 2D: RV size and function, interventricular septal motion, intracavity clot, mass, etc.
- Color: Detection of TR
- CW: RV/PA systolic pressure
- PW: RV diastolic function, tricuspid stenosis, etc.

Measurements

2D

- Mandatory – RA, RV dimensions
- Optional – Tricuspid annular plane systolic excursion (TAPSE), TV annular size

Color

- Mandatory – Nil
- Optional – TR jet PISA
- Doppler data: Qualitative

CW

- Mandatory – TR jet peak gradient
- Doppler data: Quantitative for PASP, RV dP/dt, etc.

PW

- Mandatory – Tricuspid inflow early diastolic velocity
- Optional – Tricuspid inflow late diastolic velocity, deceleration time of early diastolic wave, pressure half-time
- Doppler data: Quantitative.

Technical description

To perform a focused evaluation of the RV, one would need to begin with the apical 4-chamber view and align the RV with the center of the screen.[4] This view is obtained by moving the transducer slightly medially and reducing the sector width to encompass the RA and RV. In a normal heart, the RV is less than two-thirds the size of the LV [Figure 24a and Video 24]. RV size is assessed by measuring diameters at the base and mid-cavity region at end-diastole, when the chamber size is largest. The length of the RV is assessed from the plane of the TV annulus till the RV apex in this view.

TAPSE is an evaluation of the systolic longitudinal excursion of the TV annulus and is representative of RV systolic function. This is performed by placing an M-mode cursor through the annulus and measuring the displacement at peak systole.

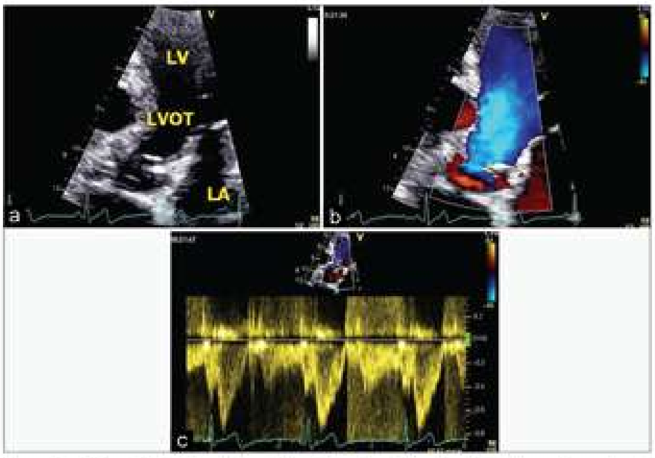

Figure 22: Magnified view of the left ventricular outflow tract; (a) two-dimensional image, (b) with color, (c) left ventricular outflow tract flow on pulsed-wave Doppler. LA- left atrium, LV- left ventricle, LVOT- left ventricular outflow tract

Placing a color Doppler window across the TV in this view allows one to qualitatively assess the severity of TR, or turbulence across the TV [Figure 24b and Video 24]. An approximation of RV systolic pressure can be obtained by assessing the TR jet with CW Doppler [Figure 24c] and adding the resultant peak pressure gradient to RA mean pressure as assessed by IVC size and collapsibility. The cursor is aligned as parallel to the flow as possible. Once the spectral Doppler is obtained, the baseline and velocity scale are adjusted to measure the peak velocity. Spectral gain can be adjusted to provide an optimal delineation of flow pattern. An additional measure of forward flow using PW/CW Doppler across the valve may be useful to study diastolic properties of the RV, or measure TS gradient [Figure 24d]. Tissue Doppler of the lateral tricuspid annulus can also be performed, in a manner analogous to the mitral valve, to measure systolic and diastolic function of the RV.

Subcostal 4-chamber view (right ventricle focused)

Purpose

2D: RV free wall thickness measurement.

Measurements

2D
- Mandatory – Nil
- Optional – RV free wall thickness measurement.

Technical description

To obtain subcostal views, the patient is rolled over to a supine position and knees are bent to relieve muscle strain in the abdominal region. The transducer is placed in the sub-xiphoid region with the orientation marker pointing toward the patient's left, in the 3 o' clock position. Angling the scan plane cephalad brings the subcostal 4-chamber view. Inspiration generally improves the quality of the image by bringing the heart closer to the transducer.

In this view, the LA, RA, interatrial septum, LV, RV, and intact ventricular septum are visualized [Figure 25 and Video 25]. The two ventricles are seen above the atria, with the RV visualized anterior to the LV. A focused view of the right ventricular free wall permits measurements of wall thickness in the setting of elevated RV afterload. Measurements are taken at end-diastole, beyond the TV leaflets at the level of the chordae.

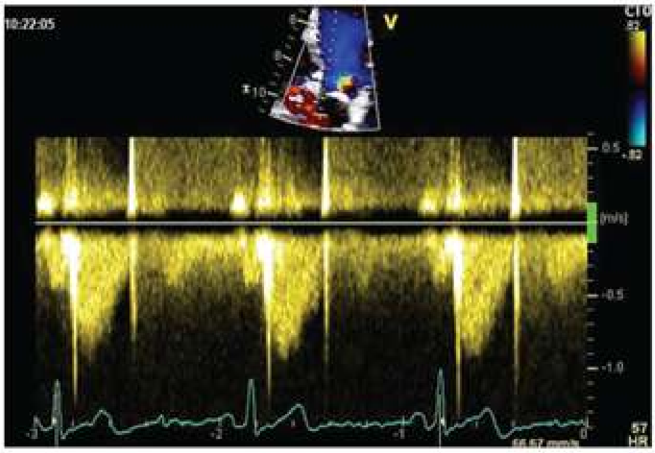

Figure 23: Flow across the aortic valve assessed by continuous-wave Doppler

Subcostal interatrial septal view two-dimensional and color Doppler

Purpose

- 2D: Intactness of interatrial septum; RV free wall thickness measurement (from RV-focused view).
- Color Doppler: To exclude ASD, patent foramen ovale.

Measurements

2D: Mandatory – Nil
- Optional – ASD size
- RV free wall thickness measurement from RV-focused view

Color: Mandatory – Nil
- Optional - ASD size
- Doppler data: Qualitative detection of shunt.

Technical description

From the standard subcostal 4-chamber view, a slight posterior angulation of the transducer stretches out the interatrial septum and brings the two atria into focus. A magnified view of the interatrial septum can be obtained using the zoom function [Figure 26a and Video 26a]. In this view, the interatrial septum is aligned perpendicular to the ultrasound beam, and hence it is the recommended view to profile a patent foramen ovale or ASD. Placing a color Doppler window on this image permits the evaluation of the intactness of the septum [Figure 26b and Video 26b].

Subcostal aorta long axis two-dimensional and color Doppler (pulsed-wave spectral Doppler optional)

Purpose

- 2D: Aortic pulsations, aneurysm, dissection flap, etc.
- Color: Phasic versus continuous flow (to diagnose

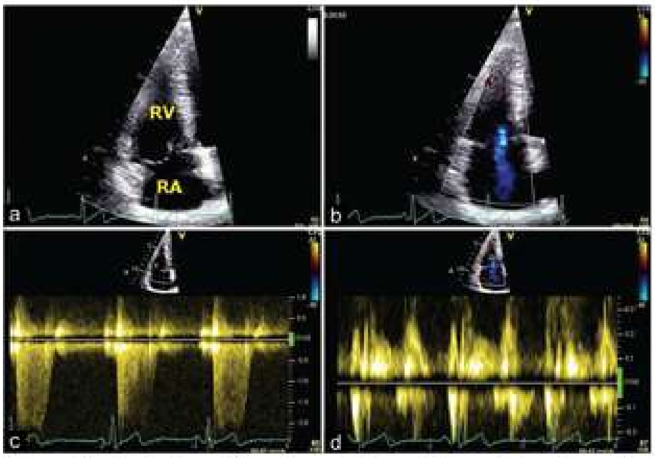

Figure 24: An right ventricle focused view obtained from the apical 4-chamber view; (a) two-dimensional image, (b) with color showing tricuspid regurgitation jet, (c) tricuspid regurgitation jet assessed by continuous-wave Doppler, (d) flow across the tricuspid valve assessed by pulsed-wave Doppler. RA- right atrium, RV- right ventricle

coarctation), flow reversal, differential flow suggestive of aortic dissection.

Measurements

2D

- Mandatory – Nil
- Optional – Aorta size

Color

- Mandatory – Nil
- Doppler data: Qualitative.

Technical description

To obtain the long axis of the aorta, the probe is turned in the counterclockwise direction till the orientation marker faces the patient's head, and the scan plane is tilted inferiorly, or toward the abdomen. A slight leftward angulation profiles the upper abdominal aorta in long axis [Figure 27a]. The upper abdominal aorta can be identified as thick walled and pulsatile. This view is useful to look for an aneurysm or dissection flap. Placing a color Doppler sector in this view [Figure 27b and Video 27] provides qualitative information on flow hemodynamics such as continuous flow in the setting of coarctation and reversal in the setting of significant AR. Optionally, PW Doppler can be used to assess the flow pattern.

Inferior vena cava long axis two-dimensional, inferior vena cava/hepatic vein color, pulsed-wave

Purpose

- 2D: Preload status, respiratory variation in IVC size
- Color: Respiratory variation of IVC/hepatic vein flow
- PW: Estimation of RA pressure.

Measurements

- 2D: IVC size, along with respiratory variability
- Color: Mandatory – Nil

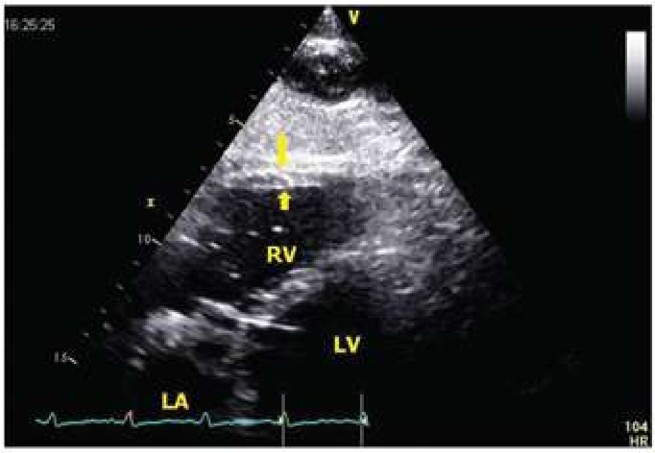

Figure 25: Right ventricle-focused subcostal 4-chamber view for the measurement of right ventricle free wall thickness. LA- left atrium, LV- left ventricle, RV- right ventricle

- Doppler data: Qualitative
- PW: Mandatory – Nil.

Optional - Systolic, diastolic forward and reversal velocities and VTI Respiratory changes in flow reversal.

Technical description

From the subcostal aorta long-axis view, angling the probe to the patient's right will demonstrate the IVC in long axis [Figure 28a and Video 28a]. The IVC is identified as a thin-walled structure that collapses on inspiration in patients with normal RA pressures. With fine angulations, the IVC should be opened to a maximum diameter and clip must be recorded during quiet inspiration. A sniff, or sudden forceful inspiration, demonstrates collapsibility of the IVC and provides information on central venous pressures. The maximal diameter of the IVC must be measured when not collapsed, just proximal to the entry of the hepatic veins.[4]

With fine angulation, the hepatic veins can be demonstrated draining into the IVC [Figure 28b and Video 28b]. A color flow window placed over the hepatic vein provides qualitative information on flow direction. PW Doppler can be employed for additional information on systolic, diastolic, and flow reversal velocities [Figure 28c]. To obtain an optimal spectral waveform, a 3–5 mm PW sample volume is placed in the hepatic vein, taking care to align the Doppler axis parallel to the vessel flow.

Suprasternal long axis of aortic arch two-dimensional, color and pulsed-wave/continuous-wave

Purpose

- 2D: To look for aortic dissection, coarctation, etc.
- Color: Assessment of diastolic flow reversal in AR; differential flow in aortic dissection, turbulence in coarctation, etc.
- PW/CW: Assessment of diastolic flow reversal in AR, coarctation severity.

Measurements

- 2D: Mandatory – Nil

Optional – Linear measurements of aortic arch and isthmus.
- Color: Nil; color M-mode for qualitative assessment of diastolic flow reversal in case of AR
- PW/CW: Mandatory – Nil
  Optional – Descending aorta PW for diastolic flow reversal, CW Doppler for coarctation gradient.

Technical description

The suprasternal long axis of the aortic arch is obtained by placing the transducer in the suprasternal notch with the orientation marker pointing toward the patient's left shoulder. With a slight anterior angulation, the aortic arch and branch vessels are seen [Figure 29a]. Moving from proximal to distal arch, the aortic arch first gives rise to the brachiocephalic artery, followed by the left common carotid and the left subclavian artery, respectively. Applying a color Doppler in this view provides information about blood flow characteristics, turbulence or reversal [Figure 29b and Video 29]. PW or CW Doppler may be applied to measure flow reversal or high gradient forward flow, respectively [Figure 29c].

Pathology-specific additional non-conventional views

Apart from the above-described standard views, additional non-conventional views may need to be obtained to better define specific cardiac pathologies. For example, off-axis views may be required to image eccentric regurgitation jets, or for spatial delineation of cardiac masses or any other structure.

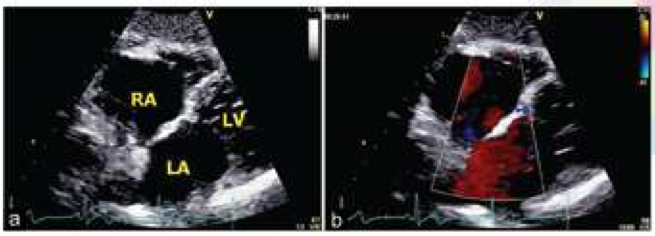

Figure 26: Magnified view of the interatrial septum obtained from the subcostal 4-chamber view; (a) two-dimensional image, (b) with color. LA- left atrium, LV- left ventricle, RA- right atrium

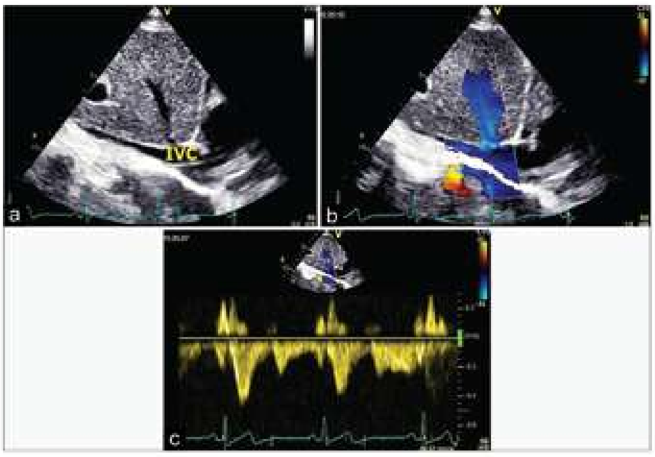

Figure 28: (a) A subcostal view of the inferior vena cava in long axis, (b) color flow across the hepatic vein entering into the inferior vena cava, (c) pulsed-wave Doppler signal across the hepatic vein. IVC-inferior vena cava

Recommended Format for Reporting a Comprehensive Adult Transthoracic Echocardiographic Study

Although as mentioned above, each institution has its own style of reporting echocardiographic findings, it is recommended that the final report should mandatorily include the following details.

Patient data

The patient name, age, gender, blood pressure, heart rate, rhythm, and body surface area.

Overall study impression

The description should include (but not limited to) the following points:

Etiological diagnosis

Etiological diagnosis relevant to the case should include (but not be limited to) the following as applicable: ischemic, infective, degenerative, rheumatic, congenital, idiopathic, etc.

Anatomical/structural diagnosis

Anatomical or structural description relevant to the pathology should include (but not be limited to) the following as applicable: chamber enlargements, hypertrophies, myocardial regional wall abnormalities (thickness, scars, aneurysm), valve/annulus/outflow morphologies, septal defects, IVC size, pericardial/pleural disease, great vessel disease, prosthesis, intracardiac masses (clot/vegetation/tumor), etc.

Functional/hemodynamic diagnosis

Functional or hemodynamic status description relevant to the pathology should include (but not be limited to) the following as applicable (description can be combined with anatomical details for maintaining continuity): LV/RV systolic regional/global function (qualitative or quantitative parameters/indices),

Figure 27: Long-axis view of the abdominal aorta; (a) two-dimensional image, (b) with color

Figure 29: Suprasternal long-axis view showing aortic arch and proximal segment of descending thoracic aorta; (a) two-dimensional image, (b) with color

diastolic function grading, valve gradients, valvular regurgitation grades and mechanism, shunt qualitative estimates, intracardiac pressure quantitative and/or qualitative estimates, prosthesis function, dyssynchrony measurements, etc.

Comment about further management

Therapeutic or management guidance comment relevant to the pathology should include (but not be limited to) the following as applicable: suitability for intervention, future echocardiographic follow-up, need of additional imaging, family screening, etc.

Reporting templates can be created for common pathologies using the above principles [Appendix 1 for ischemic and valvular heart disease templates].

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Nil.

Conflicts of interest

There are no conflicts of interest.

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Appendix

Appendix 1: Illustrative examples of templates for reporting final impressions from an echocardiographic study

(Please note, these templates are only for reporting final impressions. A complete report will also include various measurements and other findings, in addition to the final impressions)

A. Ischemic heart disease report template (strike out whatever is not relevant):

1. Ischemic heart disease
2. Regional wall abnormalities
   - Left ventricular basal/mid/apical segments of anteroseptum, apical lateral wall, apical inferior wall are hypokinetic/akinetic with thinning (…mm)/scarring/preserved thickness
   - Left ventricular basal/mid segments of inferior, posterior wall are hypokinetic/akinetic with thinning (…mm)/scarring/preserved thickness
   - Left ventricular basal/mid segments of lateral wall are hypokinetic/akinetic with thinning (…mm)/scarring/preserved thickness

Graphical representation of regional wall motion abnormality may be added to textual description.

3. Left ventricle shows normal size/dilatation/left ventricular hypertrophy/spherical remodeling/anatomical aneurysm. Left ventricle clot present/absent
4. Left ventricular systolic function is normal/depressed (left ventricular ejection fraction ==.......LVEDV........, LVESV......., GLS.....)
5. Left ventricular diastolic function normal/dysfunction grade =… suggestive of normal/raised LVEDP
6. Left atrium size is normal/increased. Right atrium/right ventricle is normal in size/dilated
7. Aortic and mitral valves: normal/sclerotic. Mitral regurgitation and aortic regurgitation present/absent grade…
8. Pulmonary hypertension present/absent. PASP=......, tricuspid regurgitation grade… inferior vena cava normal/congested
9. Right ventricle function normal/depressed. Tricuspid annular plane systolic excursion =…
10. Any intracardiac clot present/absent. Pericardial effusion none/present (further description ………………)
11. Additional abnormalities………………

B. Valvular heart disease template (strike out nonrelevant):

1. … valvular heart disease with/without evidence of infective endocarditis
2. Mild/moderate/severe aortic stenosis.
   Tricuspid/bicuspid aortic valve. Calcification: nil/mild/severe.
   AVA = ... cm^2 by Doppler/planimetry at stroke volume =… ml/m^2
   Annulus =… mm, aortic root =… mm, Asc Ao = ...mm
   AV gradient peak =… mean =… mmHg at heart rate =… blood pressure =… (imaging window: Apical/right parasternal/suprasternal)
3. Mild/moderate/severe aortic regurgitation. Grade =…
   Aortic regurgitation due to … (mechanism flail leaflet/fibrosed retracted/bicuspid/annular dilatation etc.)
   Aortic valve annulus =… mm, aortic root at sinuses =… mm, STJ = ...mm, Asc Ao = ...mm
4. Mild/moderate/severe mitral stenosis.
   MVA = ... cm^2 by planimetry/pressure half-time.
   Mitral valve gradient peak =… mean =… mmHg at heart rate = sinus/atrial fibrillation rhythm.
   Mitral valve score =…
   Anterior mitral leaflet thickened, pliable/nonpliable, calcification absent/present at …
   Posterior mitral valve leaflet thickened, pliable/nonpliable, calcification absent/present at …
   Medial/lateral commissure fused/open, calcification absent/present at …
   Subvalvular apparatus: chordae thickened/fused, calcification present/absent at …
5. Mild/moderate/severe mitral regurgitation. Grade =…
   Mitral regurgitation due to … (mechanism leaflet tethering, posterior mitral valve leaflet p1/p2/p3 scallop, anterior mitral leaflet A1/A2/A3 segment thickened retracted/myxomatous/prolapsing/flail, chordae shortened/elongated/ruptured/tenting, papillary muscle medial/lateral…)
   Mitral annulus normal/dilated. Anteroposterior =… mediolateral = …mm
6. Left ventricle shows normal size/dilatation/Left ventricular hypertrophy (concentric/eccentric)/spherical remodeling. LVIDd = ...mm, LVIDs = ...mm
   Left ventricular systolic function is normal/depressed. (Left ventricular ejection fraction =… LVEDV = Left ventricular end-diastolic volume LVEDV=........, LVESV=........, GLS=.......)
7. Left atrium/right atrium size normal/dilated. Left atrium appendage clot present/absent.
8. Right ventricular size normal/dilated. Right ventricular function normal/depressed. Tricuspid annular plane systolic excursion =…
9. Tricuspid regurgitation present/absent, functional/organic. Grade =… Tricuspid valve annulus size =… tricuspid valve leaflets noncoaptation/thickened, retracted/fused commissures
10. Pulmonary hypertension present/absent. PASP = ... mmHg, inferior vena cava normal/congested
11. Aortic arch normal/dilated. Coarctation present/absent
12. Additional abnormalities ………………

TRANSESOPHAGEAL ECHOCARDIOGRAPHY IN INTENSIVE CARE UNIT

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Usefulness of Echocardiography in Intensive Care

Echocardiography is an important diagnostic and monitoring bed-side imaging modality which has transformed the care of critical ill patients. Many investigators have reiterated that echocardiography is of immense value in the critical ill patients; this modality of patient management is immediately available, portable, and importantly, relatively noninvasive and provides diagnosis fairly quickly without having to move the patient out of the intensive care unit. The list utility of echocardiography in intensive care unit is listed in the table 1 below.

Table-1: Usefulness of echocardiography in the intensive care unit

- Diagnosis management of haemodynamically unstable patient e.g., hypotension and tachycardia
  - Assess volume status
  - Left ventricular function
  - Regional wall motion abnormality
  - Global myocardial dysfunction
  - Right ventricular function
  - Outflow tract obstruction (LV or RV)
  - Valvular stenosis / insufficiency
  - Pericardial effusion/tamponade
  - Pulmonary embolism
  - Diastolic dysfunction
- Determination of cause of persistent hypoxia
  - Right ventricular pressure
  - Intracardiac shunt
  - Pulmonary embolus
- Diagnosis of aortic dissection / aortic pathology
- Lung scan for e.g.., for pneumothorax
- Haemodynamic calculations
- Diagnosis and management of intracardiac infections
  - Bacterial endocarditis
- Monitoring and surveillance
  - Confirm / exclude pre-existing/current cardiac disease

<u>Focus assessed transthoracic echocardiography (FATE) protocol for rapid diagnosis in ICU</u>

Using the FATE protocol, the cardiac structures are visualized through the chest wall. The FATE protocol is performed using the following four positions of the probe as shown in the diagram below (fig. 1A and 1B):

1) Subcostal view: the transducer is placed in the epigastrium, a little to the right of the midline. The cardiac chambers are visualized as shown in (a); this imaging is easier to obtain in patients with chronic obstructive lung disease and those on positive pressure ventilation.
2) Apical view: this imaging is obtained by placing the transducer at the point of maximal cardiac impulse; please see (b) in the figure below.
3) Parasternal view: the transducer is placed in the left parasternal region either in the third of fourth intercostals space with the marker directed to the right shoulder. The long-axis of the left ventricle is visualized as shown in the figure(c); turning the probe by 90^0 at the same position clockwise will produce short axis of the LV as shown in the figure (d) below.
4) Pleural view; this view is obtained by placing the transducer probe on the lateral side of the chest to look for pleural effusion.

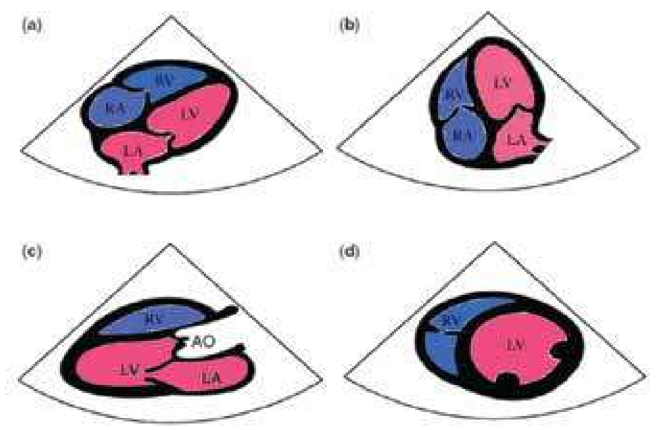


Fig-1(A)
A schematic representation of FATE protocol

(a) Subcostal view (b) Apical view (c) parasternal long axis view (d) parasternal short axis view

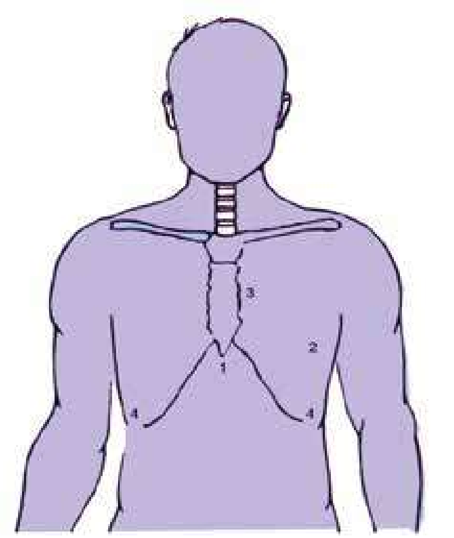


Fig-1(B)
Transducer positions for FATE protocol

(1) subcostal (2) apical (3) parasternal (4) pleural

The FATE protocol is followed for quick identification of

a) Obvious pathology.
b) Assess wall thickness and chamber dimensions.
c) Assess contractility.
d) Image pleura on both sides.
e) Relate findings to the clinical context.

However, the transthoracic echocardiography has significant limitations in the ICU settings especially in situations listed in the table below.

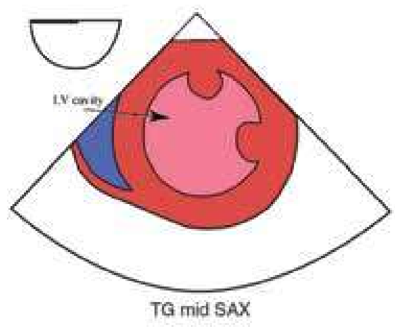
Table – 2: Limitations of Transthoracic Imaging in ICU

- Mechanical ventilation & intermittent positive pressure ventilation(IPPV):
  - -Especially PEEP > 15 cm H_2O
- Inaccessible/unobtainable windows
  - -Surgical dressing and drains
  - -Chest tubes
  - -sternotomy/ Thoracotomy / or upper abdominal incisions
- Surgery – induced fluid collections or edema of chest wall
- inability to position patient optimally
- Obesity
- Severe chronic obstructive pulmonary diseases
- Pnemothorax, pnemopericardium
- Surgical/ subcutaneous emphysema
- Lack of patient cooperation for respiratory maneuvers

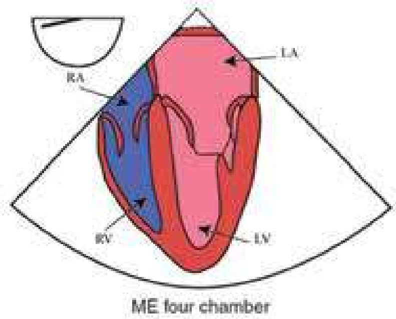
Transesophageal views useful for intensive care units:

In patients with poor acoustic windows using the transthoracic approach, the only alternative is to use the transesophageal approach. The following views are particularly useful in the ICU setting with the transesophageal echocardiography (TEE) approach.

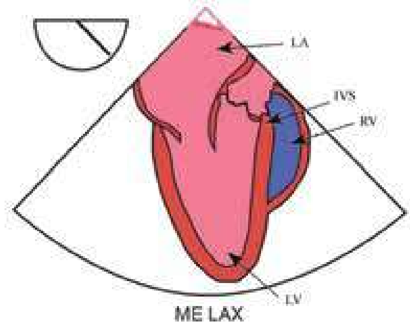
Transgastric midpapillary short axis (SAX) view

Required structures: ● LV cavity ● LV walls (at least 50% of the circumference with visible endocardium) ● Papillary muscles (approximately equal in size and distinct from ventricular wall). Image settings: ● Angle: ~0° ● Sector depth: ~12 cm. Probe adjustments: ● Anteflexed.	Primary diagnostic uses: ● Hemodynamic instability ● LV enlargement ● LV hypertrophy ● LV preload, volume status of the patient ● LV systolic dysfunction ● LV regional wall motion (mid-segments)	

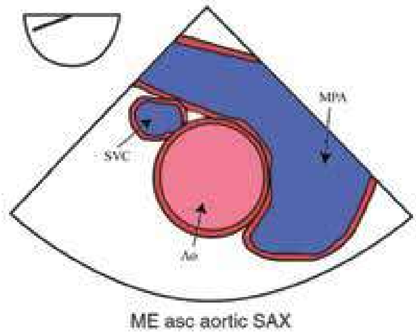
Midesophageal four chamber view

Required structures: ● Left atrium (LA) ● LV ● Right atrium ● Right ventricle (RV) ● Mitral valve ● TV Image settings: ● Angle: ~ 0-10° ● Sector depth: ~12-14 cm. Probe adjustments: ● Neutral – retroflexed.	Primary diagnostic uses: ● Chamber enlargement/dysfunction ● Left ventricular (LV) regional wall motion (inferoseptal and anterolateral walls) ● Mitral valve disease ● Tricuspid valve (TV) disease ● Detection of intracardiac air/mass including thrombus and atrial septal defect.	

Midesophageal left ventricular long axis (LAX) view

Required structures: ● LA ● Mitral valve ● LV ● LV outflow tract ● Aortic valve (AV) and proximal ascending (ASC) aorta. Image settings: ● Angle: ~110-130° ● Sector depth: ~12-14 cm. Probe adjustments: ● Neutral.	Primary diagnostic uses: ● Mitral valve pathology ● LV outflow tract pathology ● LV ventricular wall motion (anteroseptal and inferolateral walls) ● Systolic anterior motion of anterior mitral leaflet.	

Midesophageal ascending aortic SAX view

Required structures: ● Aorta in cross-section in the transverse plane ● PA (main and proximal right). Image settings: ● Angle: ~10-30° ● Sector depth: ~12 cm. Probe adjustments: ● Withdraw probe slowly by 1-2 cm from the AV SAX view.	Primary diagnostic uses: ● Aortic atherosclerosis ● Aortic dissection/aneurysm ● PA pathology (emboli, dilatation, etc.).	

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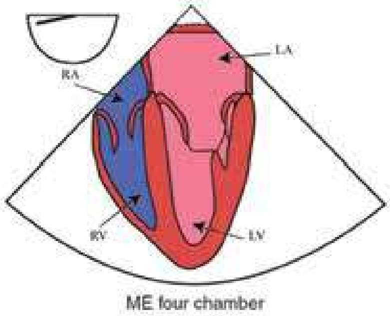
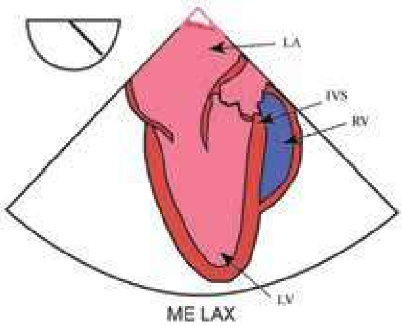
Required structures: ● Left atrium (LA) ● LV ● Right atrium ● Right ventricle (RV) ● Mitral valve ● TV Image settings: ● Angle: ~ 0‑10° ● Sector depth: ~12‑14 cm. Probe adjustments: ● Neutral – retroflexed.	Primary diagnostic uses: ● Chamber enlargement/dysfunction ● Left ventricular (LV) regional wall motion (inferoseptal and anterolateral walls) ● Mitral valve disease ● Tricuspid valve (TV) disease ● Detection of intracardiac air/mass including thrombus and atrial septal defect.	

Midesophageal left ventricular long axis (LAX) view

Required structures: ● LA ● Mitral valve ● LV ● LV outflow tract ● Aortic valve (AV) and proximal ascending (ASC) aorta. Image settings: ● Angle: ~110‑130° ● Sector depth: ~12‑14 cm. Probe adjustments: ● Neutral.	Primary diagnostic uses: ● Mitral valve pathology ● LV outflow tract pathology ● LV ventricular wall motion (anteroseptal and inferolateral walls) ● Systolic anterior motion of anterior mitral leaflet.	

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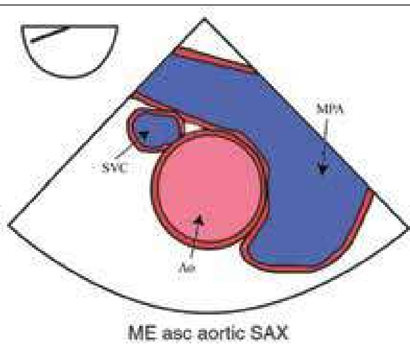
Required structures: ● Aorta in cross‑section in the transverse plane ● PA (main and proximal right). Image settings: ● Angle: ~10‑30° ● Sector depth: ~12 cm. Probe adjustments: ● Withdraw probe slowly by 1‑2 cm from the AV SAX view.	Primary diagnostic uses: ● Aortic atherosclerosis ● Aortic dissection/aneurysm ● PA pathology (emboli, dilatation, etc.).	

Differential diagnosis of hypotension in ICU

Use of TEE is a category I indication in the evaluation of life-threatening haemodynamic disturbances; the following table show the differential diagnosis of hypotension in the ICU setting.

Table – 3: Differential diagnosis of hypotension in ICU

Condition	TEE Findings	Useful Views
Hypovolemia	Decreased EDA Increased FAC “Kissing” papillary muscles	TG SAX of LV TG LAX of LV
Vasodilatation	Normal EDA, Increased FAC	TG SAX of LV ME 4 ch, 2 ch, LAX
Impaired LV systolic function	Increased EDA, decreased FAC Increased ESA, decreased FAC	TG SAX of LV TG LAX of LV
Pericardial Tamponade	Effusion Diastolic collapse of right –sided chambers	ME 4 ch; TG SAX and LAX of LV
Aortic Dissection	Intimal flap , Two lumens in aorta (one true and other false), aortic regurgitation, Pericardial effusion	ME 5 ch; and LAX; ascending / descending Ao
Pulmonary Embolism	Dilated RA & RV TR / PR jets, flow through PFO, Echogenic density in PA	ME 4 ch; RV in / outflow; PA views (upper E)

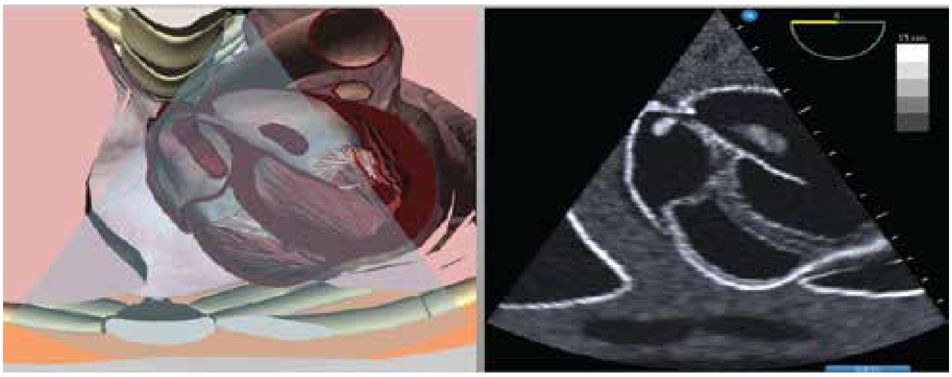
EDA= end diastolic area; ESA= end systolic area; TG SAX= Transgastric short axis; TG LAX = Transgastric long axis; FAC = fractional area change, ME=mid esophageal; 2ch=two chamber, 4ch=four chamber, RA= right atrium, LV= left ventricle, RV right ventricle, AO=aorta, LA =left atrium, PA = pulmonary artery, E= esophageal

Table 4: Measurement of right atrial pressure (RAP)

Inferior vena cava diameter	Change with Negative inspiration (i.e, sniff)	Estimated RAP (mmHg)
Small (< 1.5 cm)	Collapse	0 – 5
Normal (1.5 – 2.5 cm)	Decrease by > 50%	5 – 10
Normal (1.5 – 2.5 cm)	Decrease by < 50%	10 – 15
Dilated (> 2.5 cm)	Decrease by < 50%	15- 20
Dilated (with dilated hepatic veins)	No change	> 20

Diagnosis of cause of persistent hypoxia;

In patients with persistent or refractory hypoxemia, the presence of intracardiac shunt must be excluded by injecting agitated saline through the right side of the heart for e.g., upper limb vein: intracardiac shunt results in saline contrast appearing in the left side of the heart instantaneously where as in case of an intrapulmpnary shunt, for e.g., pulmonary arteriovenous malformation, the contrast appears on the left side after about 3-5 cardiac cycles.



Simulation picture of movement of a thrombus across a patent foramen ovale (PFO) from LA to RA

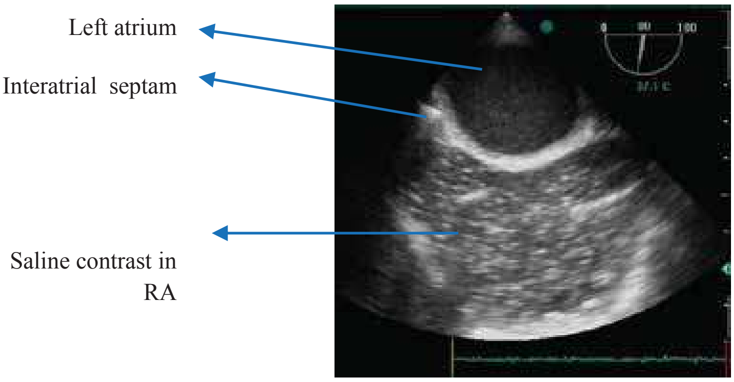


Fig-2: ME bi-caval view showing saline contrast in right atrium (RA) with intact interatrial septum

Evaluation of left ventricular (LV) systolic function

LV global systolic performance is commonly expressed in terms of one or more of the following, all of which can be determined by echocardiography by TTE or TEE. The parameters are (i) fractional shortening (FS) (ii) fractional area change (FAC) (iii) ejection fraction (EF) (iv)cardiac output.

Fractional shortening (FS) is determined by the formula LVIDd - LVIDs / LVIDd x 100 where IDs refers to internal diameter in systole and IDd refers to internal diameter in diastole. Using TEE the LV systolic function is best estimated by using the transgastric-mid papillary short axis. FS is heavily afterload dependent and slightly preload dependent.

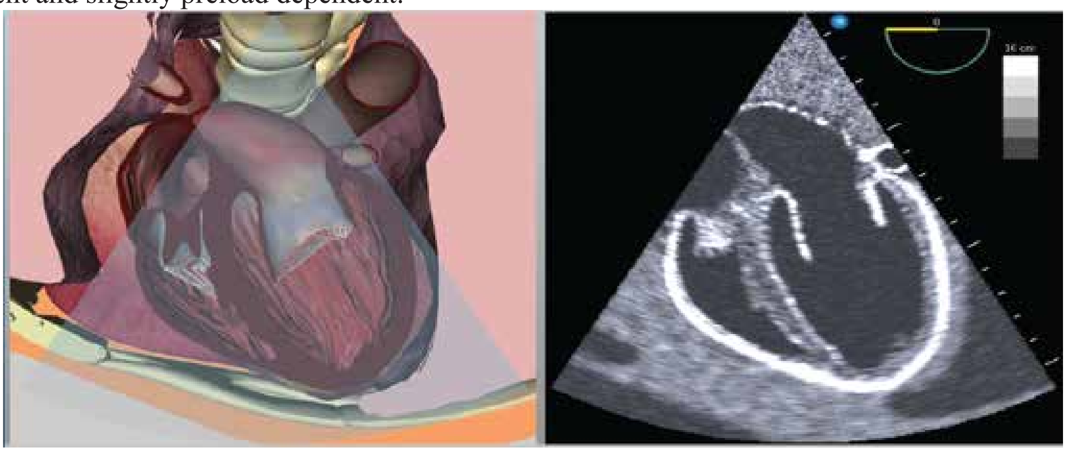


Fig -3: Simulation picture of midesophageal 4-chamber view showing left ventricular dilation

Fractional area change (FAC) is a relatively simple parameter to determine that is obtained from the transgastric mid papillary view. FAC is the relation between LV diastolic area to the systolic area obtained from the following equation: FAC%= end diastolic area- end systolic area/end diastolic area x100.

Ejection Fraction is calculated by using the equation EDV-ESV / EDV x 100, where EDV refers to end-diastolic volume and ESV refers to end-systolic volume. However, please note that all geometric methods make assumptions on shape of ventricle and presence of wall motion abnormality makes the determination of EF untenable.

Estimation of cardiac output:

Flow across a fixed orifice is the product of the cross sectional area (CSA) and the velocity of flow through the orifice. The cardiovascular system is pulsatile and hence the velocity of instantaneous blood flow varies. The integration of the instantaneous flow rate over the entire flow period through a given orifice is called the velocity-time integral (VTI). Stroke volume (SV) is derived as a product of CSA and VTI as shown below. Cardiac output in turn is the product of the SV and the heart rate. The preferred site of measurement of SV and cardiac output is the LV outflow tract (LVOT)

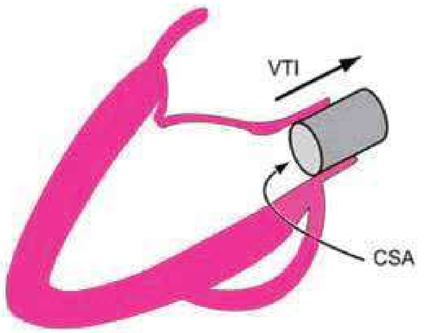


Fig – 4: Use of Doppler echocardiography in calculation of stroke volume (SV); The VTI of the Doppler velocity curve can be conceptualized as the length of a cylinder of blood (stroke distance) ejected through a CSA on one heart-beat. SV is calculated as the product of CSA and VTI; SV (cm^3) =CSA (cm^2)xVTI(cm);SV= stroke volume; CSA= cross sectional area; VTI= velocity time integral

Diagnosis of infective endocarditis.

Echocardiography is necessary for the diagnosis and management of patients suffering from infective endocarditis (IE). The two essential components of echocardiographic features of IE are (i) oscillating intracardiac mass or vegetation (ii) annular abscess, dehiscence of prosthetic valve or acute valvular regurgitation.

ME long axis of aortic valve showing vegetation attached the downstream of aortic value

Detection of myocardial ischemia

Recognition ad identification of regional wall motion abnormality can be readily achieved by two-dimensional echocardiography in the ICU setting. Serial echocardiography is useful in monitoring the success of reperfusion therapy and extent of myocardial viability. The 17 segment model of the LV is shown below.

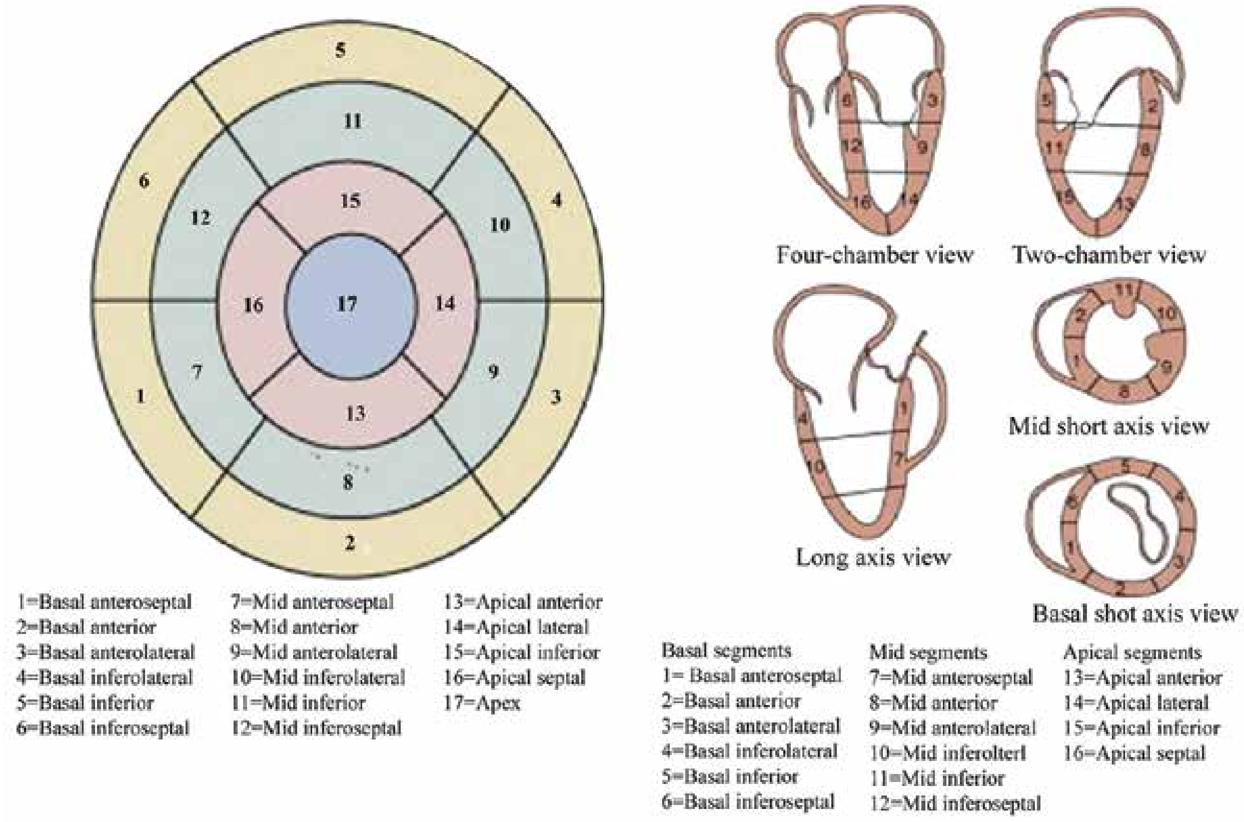
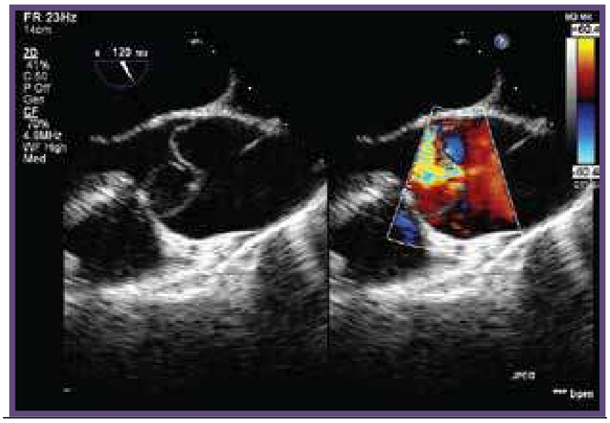


Fig-5: 17-segments model of regional LV assessment; the basal and mid level and divided into six segments and apex into four segments

Diagnosis of aortic pathology

TEE is an extremely useful modality for the diagnosis and classification of thoracic aortic pathology namely aneurysm, dissection and atheromatous lesion. A thoracic aortic aneurysm is a permanent localized dilatation of thoracic aorta that has at least a 50% diameter increase involving all the three layers of the vessel wall. Less than 150% of normal localized dilatation of the thoracic aorta is termed 'ectasis'. Annuloaortic ectasia is defined as isolated dilatation of the ascending aorta, aortic root, and aortic valve annulus. A false aneurysm or a pseudoaneurysm is a localized dilation of the aorta that does not contain all three layers of the vessel wall; instead a false aneurysm consists of connective tissue and clot.

TEE is particularly useful in diagnosis of an aortic dissection with a complete picture of origin/ location of dissection flap, involvement of coronary ostia with an associated risk of myocardial ischaemia, degree of aortic insufficiency and pericardial effusion.



ME long axis of aortic valve showing intimal flap in the aortic lumien

Fig-6: Short axis of descending thoracic aorta showing aortic dissection

<u>Diagnosis of pericardial tamponade</u>

Quick and rapid accumulation of pericardial fluid in the closed pericardial cavity can precipitate haemodynamic instability and cardiovascular collapse. Echocardiographic findings consistent with pericardial effusion and tamponade are listed in the table below.

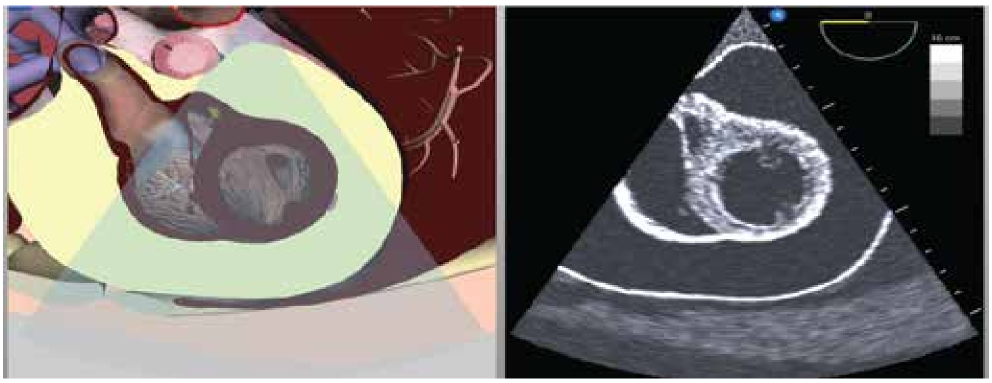


Fig-7: Simulation picture of transgastic short axis showing global pericardial effusion

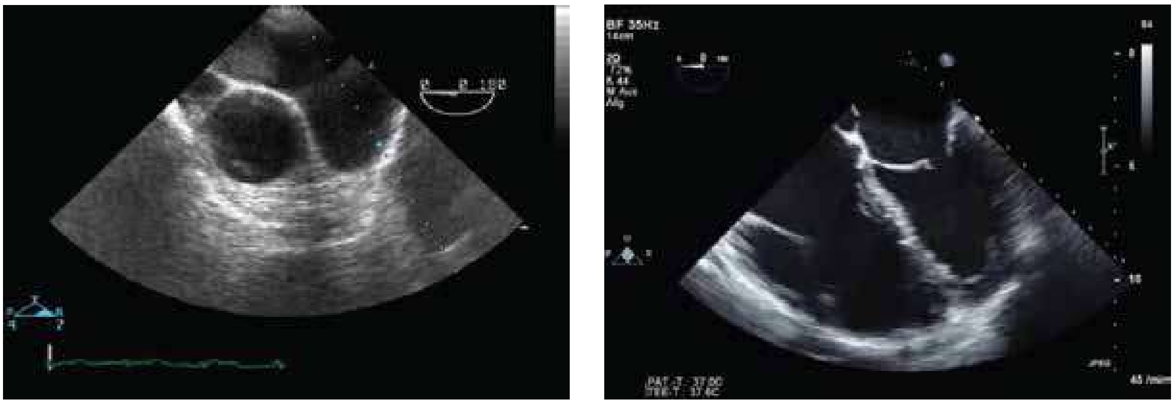
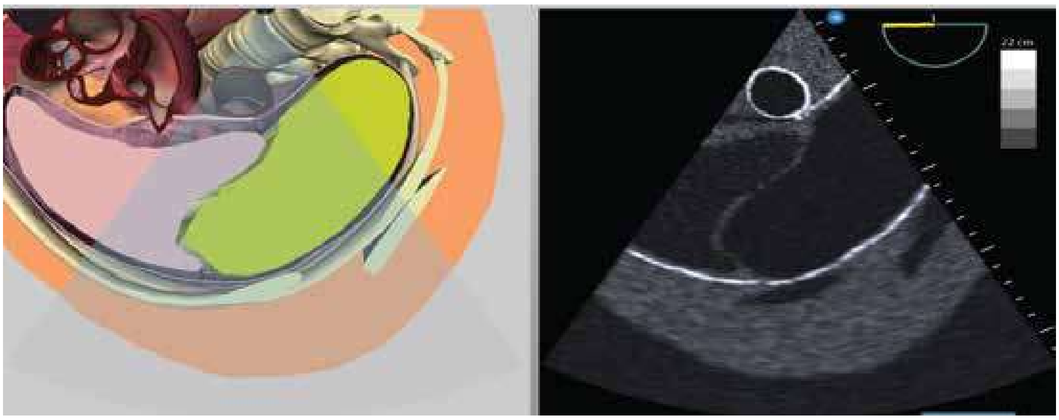


Fig-8 (A): ME ascending aortic short axis showing embolism in right pulmonary artery
Fig-8(B): ME 4- chamber view showing RV dilation in pulmonary embolism



Left sided pleural effusion with collapsed left lung

Conclusions:

Hemodynamic instability associated with hypotension in the ICU is a class I indication for performing TEE. The advantage of TEE is that it provides better acoustic windows than that with TTE in almost all mechanically ventilated patients. It has been demonstrated that TEE leads to a change in management in more than 50% of ICU patients when performed for hemodynamic instability .TEE is especially of proven value for assessment of suspected infective endocarditis and diagnosis of aortic dissection.

Review Article

Practice guidelines for perioperative transesophageal echocardiography: Recommendations of the Indian association of cardiovascular thoracic anesthesiologists

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The IACTA guideline committee acknowledges that it followed the international guidelines, especially the ASE and SCA principles wherever necessary and modified the strategy to suit local requirements.

ABSTRACT

Transoesophageal Echocardiography (TEE) is now an integral part of practice of cardiac anaesthesiology. Advances in instrumentation and the information that can be obtained from the TEE examination has proceeded at a breath-taking pace since the introduction of this technology in the early 1980s. Recognizing the importance of TEE in the management of surgical patients, the American Societies of Anesthesiologists (ASA) and the Society of Cardiac Anesthesiologists, USA (SCA) published practice guidelines for the clinical application of perioperative TEE in 1996. On a similar pattern, Indian Association of Cardiac Anaesthesiologists (IACTA) has taken the task of putting forth guidelines for transesophageal echocardiography (TEE) to standardize practice across the country. This review assesses the risks and benefits of TEE for several indications or clinical scenarios. The indications for this review were drawn from common applications or anticipated uses as well as current clinical practice guidelines published by various society practicing Cardiac Anaesthesia and cardiology . Based on the input received, it was determined that the most important parts of the TEE examination could be displayed in a set of 20 cross sectional imaging planes. These 20 cross sections would provide also the format for digital acquisition and storage of a comprehensive TEE examination. Because variability exists in the precise anatomic orientation between the heart and the esophagus in individual patients, an attempt was made to provide specific criteria based on identifiable anatomic landmarks to improve the reproducibility and consistency of image acquisition for each of the standard cross sections.

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INTRODUCTION

Perioperative transesophageal echocardiography (TEE) is a diagnostic and monitoring imaging tool with widespread applications in the operating rooms and intensive care settings.[1] This modality is being used in both government institutions and private hospitals all across India. In view of increasing application of TEE in Indian context, it has become imperative to establish protocol/guidelines for the practice of TEE. This document is expected to assist physicians to help appropriate application of TEE and improve the perioperative management

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of surgical patients. These recommendations may be adapted and modified according to the local institutional policies, circumstances and expertise; and are not intended to be absolute regulatory requirements. Further, these recommendations are subject to the availability of TEE facility in a given hospital and its availability is not binding for carrying out surgical procedures [Table 1]. The guidelines do not address training, certification, establishing credentials and quality assurance.

INDICATIONS FOR PERIOPERATIVE TEE

The American Society of Anesthesiologists and Society for Cardiovascular Anesthesiologists in its updated report on TEE recommends the use of TEE for all adult open-heart and thoracic aortic procedures and transcatheter intracardiac procedures.[2] However, the Indian Association of Cardiovascular Thoracic Anesthesiologists recommendations are categorized as follows:

Technique for insertion of a TEE probe in an anesthetized individual: The following steps are followed for insertion of TEE probe in anesthetized and intubated patients:

1. Mouth is examined for abnormalities and loose teeth
2. An informed consent from the patient is obtained prior to the procedure
3. A suitable general anesthesia is administered
4. A nasogastric/orogastric tube is inserted to decompress the stomach and is removed prior to the passage of the TEE probe
5. A bite-guard is inserted to prevent injury to the probe by the patient's teeth
6. The probe is lubricated generously with jelly
7. The probe is inserted by displacing the mandible anteriorly and advancing the probe gently in the midline; manipulation of the neck by flexion of the neck will help in some cases; if blind insertion of the probe is not easy, a laryngoscope may be used to expose the posterior pharynx and permit direct passage of the probe into the esophagus; undue force should never be applied at any stage during insertion of the probe;[4] once in the esophagus, the transducer should never be forced through a resistance
8. The tip of the transducer is allowed to return to the neutral position before advancing or withdrawing the probe and undue force is never applied when flexing the tip with the control wheels
9. Cleaning and decontamination of the probe should be performed after each use based on hospital practice
10. It is recommended to have an electrocardiogram trace on the echocardiographic imaging screen.

Table 1: Perioperative TEE guidelines

Category-I	Category-II
Conditions for which there is evidence and/or general agreement that a given procedure or treatment is useful and effective	Conditions for which there is conflicting evidence and/or a divergence of opinion about the usefulness/efficacy of a procedure or treatment
Mitral valve repair	
Aortic valve repair	Myocardial ischemia and coronary artery disease (off-pump CABG inclusive)
Acute aortic dissection	Heart valve replacement
Acute unstable aortic aneurysm	Intracardiac mass/foreign body
Thoracic aortic trauma	Pulmonary embolism
Before balloon mitral valvuloplasty[3]	Aortic atherosclerotic disease
LA thrombus	Air embolism
Endocarditis/vegetation	Interventional procedure in cardiology
Complex congenital heart disease	Cardiomyopathy
Hemodynamic instability	Pericarditis
Minimally invasive cardiac surgery	Placement of IABP, PA catheter
LVAD insertion	Administration of cardioplegia especially retrograde
Critical care: Persistent hypotension, unexplained hypoxemia	Orthopedic surgery

LVAD: Left ventricular assist device, CABG: Coronary artery bypass graft, LA: Left atrium, IABP: Intra-aortic balloon pump, PA: Pulmonary artery

Complications associated with TEE (rare)[5]

1. Esophageal ulceration/injury/bleeding
2. Esophageal perforation
3. Esophageal hematoma
4. Laryngeal palsy
5. Dysphagia
6. Dental injury
7. Accidental tracheal extubation
8. Cardiac arrhythmia (especially supraventricular tachycardia in children)
9. Airway obstruction and increased ventilatory pressure
10. Hypoxia/unintentional endobronchial intubation
11. Distraction from anesthetic care
12. Death.

Contraindications to TEE:[6]

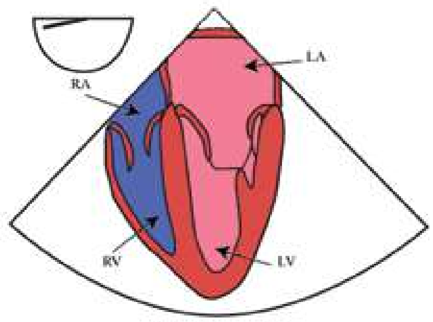
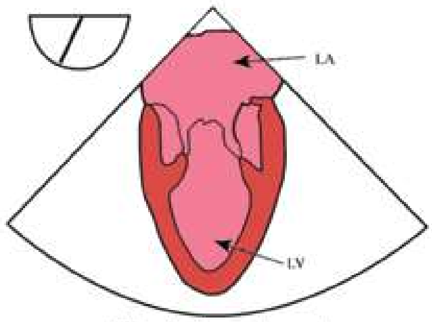
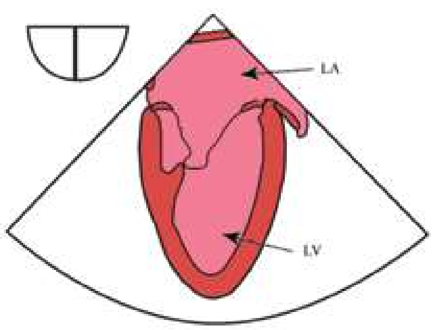
Absolute	Relative
Refusal of patient consent	Esophageal stricture
Previous esophagectomy	Esophageal diverticulum
Previous esophagogastrectomy	Tracheoesophageal fistula
Previous bariatric surgery	Hiatus hernia
Suspected/actual neck injury	Large descending thoracic aortic aneurysm
	Unilateral vocal cord paralysis
	Esophageal varices
	Post-radiation therapy

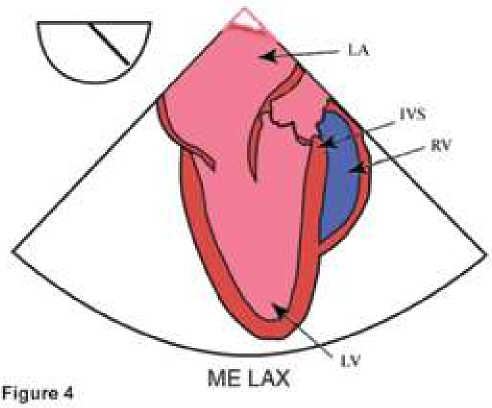
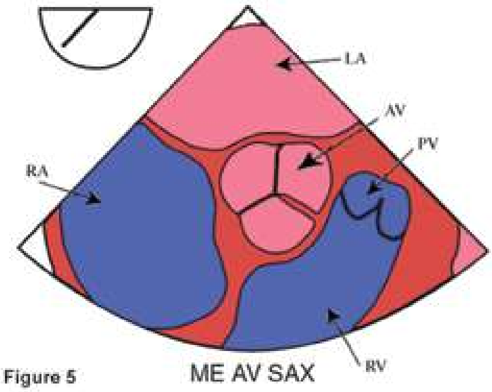
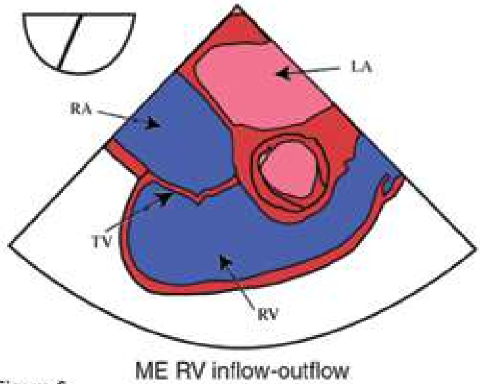
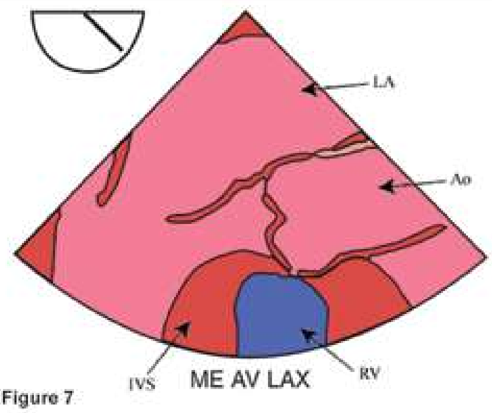
TERMINOLOGY FOR MANIPULATION OF PROBE

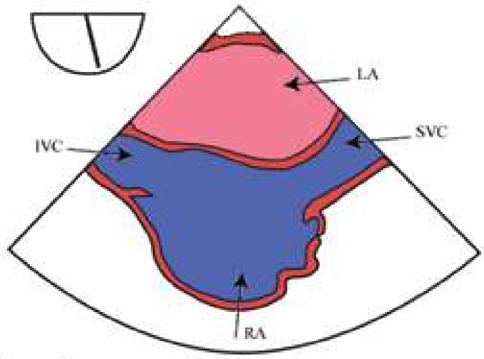
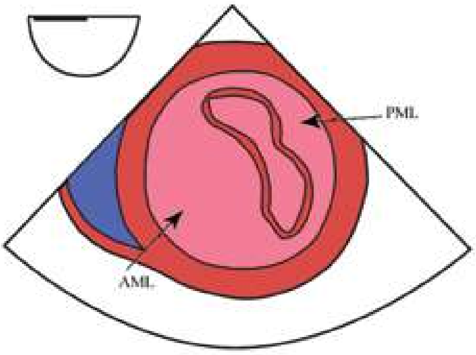
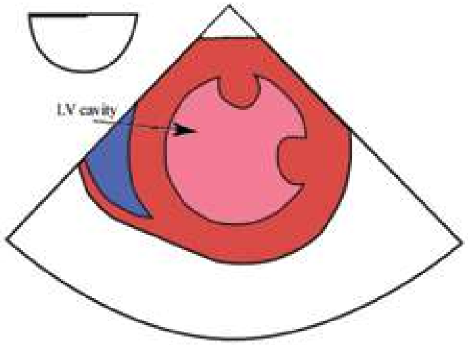
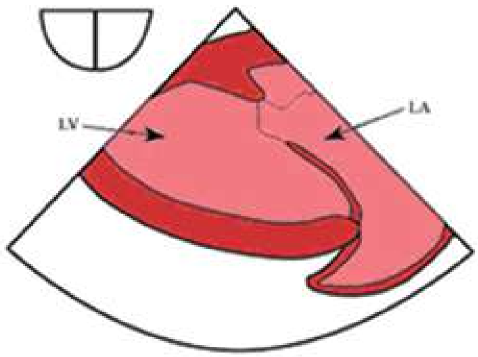
The terminology used to describe manipulation of the probe and transducer during image acquisition is described here.[7] With the patient supine, the imaging plane is directed anteriorly from the esophagus through the heart. With reference to the heart, superior means toward the head, inferior means toward the feet, posterior means toward the spine and anterior means toward the sternum. The terms right and left denote the patient's right and left sides, except when the text refers to the image display.

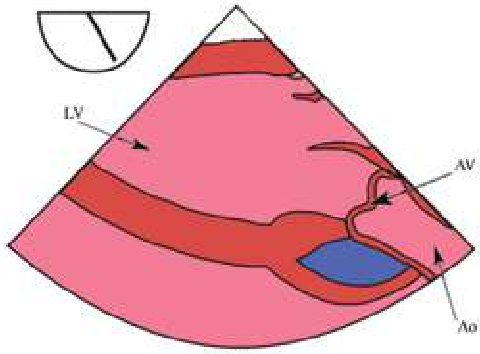
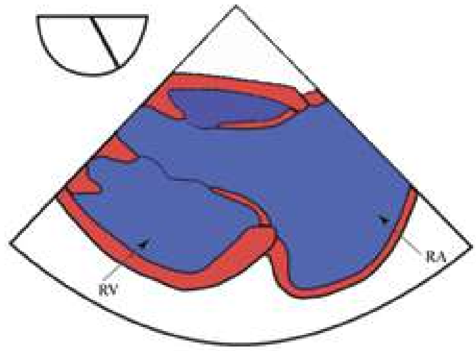
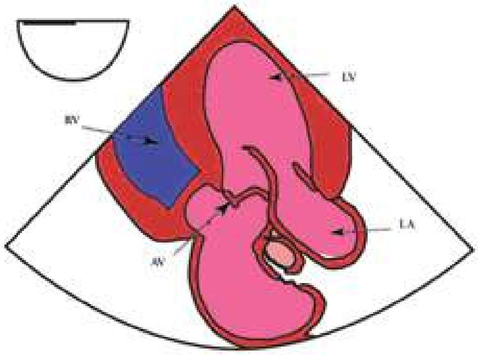
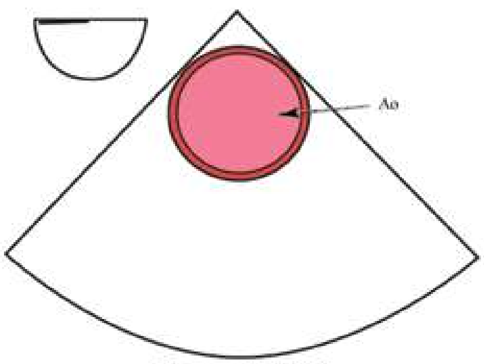
"Advancing:" pushing the tip of the probe distally into the esophagus or the stomach; "withdrawing:" pulling the tip in the opposite direction proximally; "turning to the right;" rotating the anterior aspect of the probe clockwise within the esophagus toward the patient's right; "turning to the left:" rotating the probe counterclockwise. Flexing the tip of the probe anteriorly with the large control wheel is called "anteflexing" and flexing it posteriorly is called "retroflexing." Flexing the tip of the probe to the patient's right with the small control wheel is called "flexing to the right," and flexing it to the patient's left is called "flexing to the left." Finally, axial rotation of the

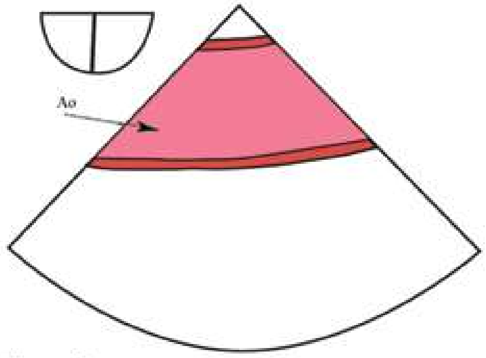
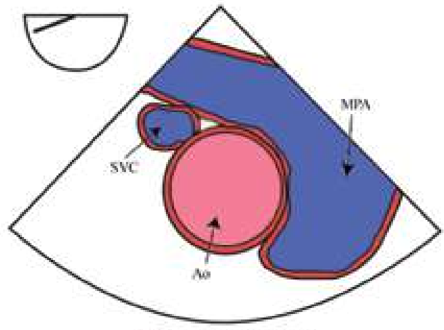
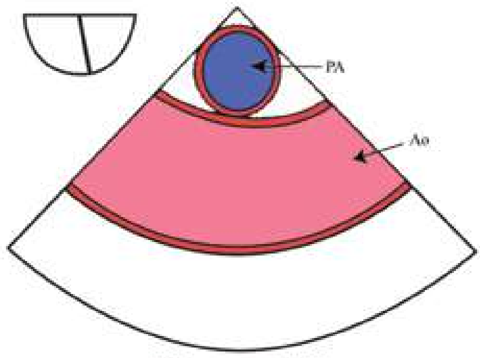
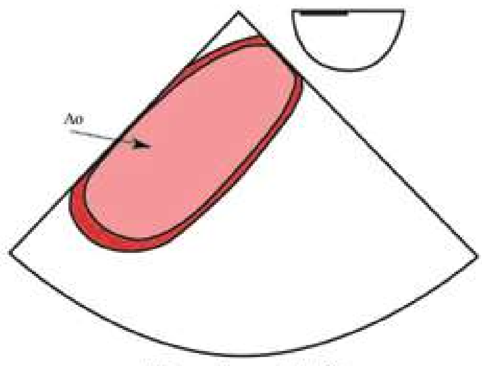
TWENTY STANDARD VIEWS + ADDITIONAL VIEWS [FIGURES 1-26]

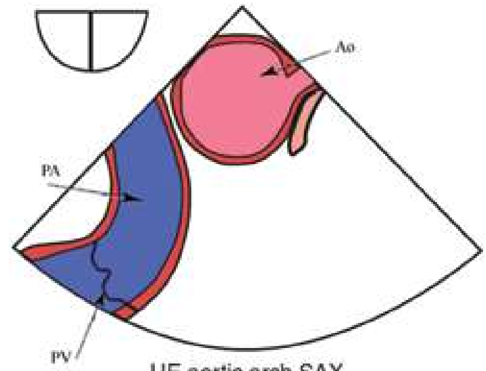
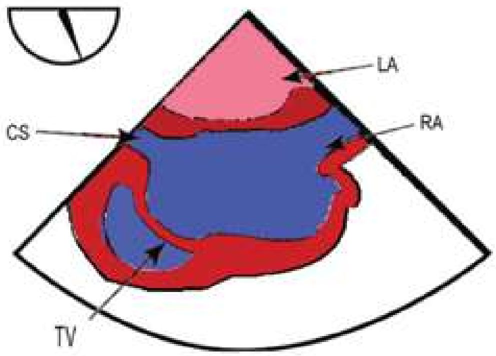
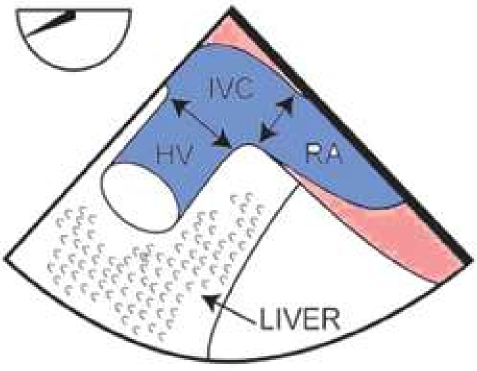
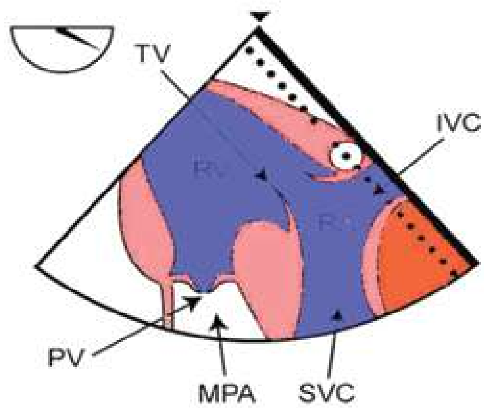
ME four-chamber view Image settings: • Angle: ~ 0-10° • Sector depth: ~12-14 cm. Probe adjustments: • Neutral – retroflexed. Required structures: • Left atrium (LA) • LV • Right atrium • Right ventricle (RV) • Mitral valve • TV	Primary diagnostic uses: • Chamber enlargement/dysfunction • Left ventricular (LV) regional wall motion (inferoseptal and anterolateral walls) • Mitral valve disease • Tricuspid valve (TV) disease • Detection of intracardiac air/mass including thrombus and atrial septal defect.	 Figure 1 ME four chamber
ME mitral commissural view Required structures: • LA • LV • Mitral valve • Papillary muscles. Image settings: • Angle: ~60-75° • Sector depth: ~12 cm. Probe adjustments: • Neutral.	Primary diagnostic uses: • LV regional wall motion • Mitral valve disease.	 Figure 2 ME mitral commissural
ME two-chamber view Required structures: • Left atrial appendage • Mitral valve • LV apex (maximum LV length). Image settings: • Angle: ~80-100° • Sector depth: ~12-14 cm. Probe adjustments: • Neutral.	Primary diagnostic uses: • Left atrial appendage mass or thrombus • LV apex pathology • LV systolic dysfunction • LV regional wall motion (anterior and inferior walls).	 Figure 3 ME two chamber

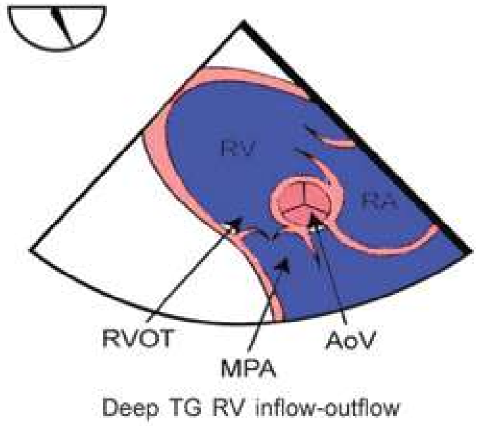
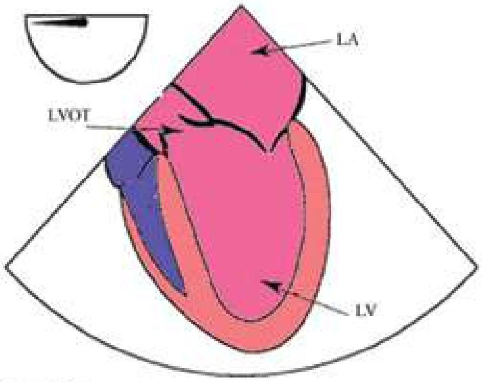
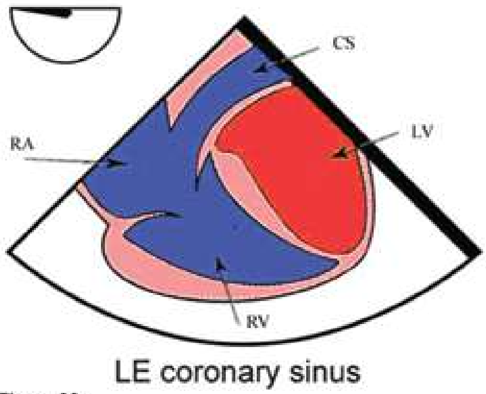
ME LV long axis (LAX) view Required structures: • LA • Mitral valve • LV • LV outflow tract • Aortic valve (AV) and proximal ascending (ASC) aorta. Image settings: • Angle: ~110-130° • Sector depth: ~12-14 cm. Probe adjustments: • Neutral.	Primary diagnostic uses: • Mitral valve pathology • LV outflow tract pathology • LV ventricular wall motion (anteroseptal and inferolateral walls) • Systolic anterior motion of anterior mitral leaflet.	 Figure 4
ME AV short-axis (SAX) view Required structures: • AV leaflets • Commissures • Coaptation point. Image settings: • Angle: ~25-45° • Sector depth: ~10-12 cm. Probe adjustments: • Neutral.	Primary diagnostic uses: • AV morphology • Aortic stenosis/regurgitation • Coronary arteries • Air in the roof of LA.	 Figure 5
ME RV inflow-outflow Required structures: • PV • TV • Main PA (atleast 1cm distal to the PV) • RV wall from TV to PV. Image settings: • Angle: ~50-70° • Sector depth: ~10-12 cm. Probe adjustments: • Neutral.	Primary diagnostic uses: • Pulmonic valve (PV) disease • Pulmonary artery (PA) pathology • Right ventricular outflow tract (RVOT) pathology (e.g., subvalvular stenosis).	 Figure 6
ME AV LAX view Required structures: • LVOT (at least 1 cm proximal to the AV) • AV (visualized cusps approximately equal in size) • ASC aorta (at least 1 cm distal to the sinotubular junction). Image settings: • Angle: ~115-130° • Sector depth: ~8-10 cm. Probe adjustments: • Neutral.	Primary diagnostic uses: • AV pathology • Aortic pathology (ASC and root) • Left ventricular outflow tract (LVOT) pathology.	 Figure 7

ME bicaval view Required structures: • Right atrial free wall and appendage • Superior vena cava • Interatrial septum • Inferior vena cava (IVC) • LA. Image settings: • Angle: ~100-110° • Sector depth: ~8-10 cm. Probe adjustments: Probe rotated toward right.	Primary diagnostic uses: • Atrial septal defect • patent foramen ovale • Right atrial tumor.	 Figure 8 ME bicaval
TG basal SAX view Required structures: • Mitral leaflets • LV (basal segments). Image settings: • Angle: ~0° • Sector depth: ~12 cm. Probe adjustments: • Neutral and anteflexed.	Primary diagnostic uses: • LV systolic dysfunction (basal segments) • Mitral valve pathology	 Figure 9 TG basal SAX
TG midpapillary SAX view Required structures: • LV cavity • LV walls (at least 50% of the circumference with visible endocardium) • Papillary muscles (approximately equal in size and distinct from ventricular wall). Image settings: • Angle: ~0° • Sector depth: ~12 cm. Probe adjustments: • Anteflexed.	Primary diagnostic uses: • Hemodynamic instability • LV enlargement • LV hypertrophy • LV preload, volume status of the patient • LV systolic dysfunction • LV regional wall motion (mid-segments).	 Figure 10 TG mid SAX
TG two-chamber view Required structures: • Mitral leaflets • Mitral subvalvular apparatus • LV (anterior and inferior walls: Basal and mid segment). Image settings: • Angle: ~90° • Sector depth: ~12 cm. Probe adjustments: • Neutral.	Primary diagnostic uses: • LV systolic dysfunction (anterior and inferior walls). • Mitral subvalvular pathology	 Figure 11 TG two chamber

TG LAX view Required structures: • Mitral leaflets • Mitral subvalvular apparatus • LV (anteroseptal and inferolateral wall) • LV outflow tract • AV and proximal ASC aorta. Image settings: • Angle: ~110-130 cm. • Sector depth: ~12 cm. Probe adjustments: • Neutral to leftward.	Primary diagnostic uses: • LV systolic dysfunction (anteroseptal and inferolateral walls) • Doppler interrogation of AV.	 TG LAX **Figure 12**
TG RV inflow view Required structures: • Right atrium • TV • Tricuspid subvalvular apparatus • RV. Image settings: • Angle: ~110-130° • Sector depth: ~12 cm. Probe adjustments: • Neutral-rightward.	Primary diagnostic uses: • RV systolic dysfunction • TV pathology.	 TG RV inflow **Figure 13**
Deep TG LAX view Required structures: • LV • AV • ASC aorta. Image settings: • Angle: ~0° • Sector depth: ~16 cm. Probe adjustments: • Anteflexed.	Primary diagnostic uses: • AV pathology • LVOT pathology • Doppler interrogation of aortic outflow.	 **Figure 14** Deep TG LAX
Descending (DESC) aorta SAX view Required structures: • DESC aorta in cross-section in the transverse plane (0°). Image settings: • Angle: ~0° • Sector depth: ~6 cm. Probe adjustments: • Probe turned toward left until DESC aorta is seen in SAX.	Primary diagnostic uses: • Aortic atherosclerosis • Aortic dissection.	 **Figure 15** Desc aortic SAX

DESC aorta LAX view Required structures: • DESC aorta in LAX in the longitudinal plane (90°). Image settings: • Angle: ~90° • Sector depth: ~6 cm. Probe adjustments: • Neutral.	Primary diagnostic uses: • Aortic atherosclerosis • Aortic dissection • Intra-aortic balloon pump placement.	 Figure 16 Desc aortic LAX
ME ASC aortic SAX view Required structures: • Aorta in cross-section in the transverse plane • PA (main and proximal right). Image settings: • Angle: ~10-30° • Sector depth: ~12 cm. Probe adjustments: • Withdraw probe slowly by 1-2 cm from the AV SAX view.	Primary diagnostic uses: • Aortic atherosclerosis • Aortic dissection/aneurysm • PA pathology (emboli, dilatation, etc.).	 ME asc aortic SAX **Figure 17:** Nomenclature of 17 segments of left ventricle for transesophageal echocardiography (modified from Corqueria *et al.* Circulation 2002; 105:539-42)
ME ASC aortic LAX view Required structures: • ASC aorta in LAX • Right PA in cross-section. Image settings: • Angle: ~100° • Sector depth: ~10-12 cm. Probe adjustments: • Neutral.	Primary diagnostic uses: • Aortic atherosclerosis • Aortic dissection • ASC aortic aneurysm.	 Figure 18 ME asc aortic LAX
UE aortic arch LAX view Required structures: • Distal ASC aorta/aortic arch. Image settings: • Angle: ~0° • Sector depth: ~10 cm. Probe adjustments: • Withdraw probe slowly from the DESC aorta SAX view until aorta becomes oblong, slight manipulation of the transducer toward the right and lowering the probe handle help.	Primary diagnostic uses: • Aortic athrerosclerosis • Aortic dissection • Aortic regurgitation • Measurement of distal ASC aortic diameter • Visualization of aortic cannulation site.	 Figure 19 UE aortic arch LAX

UE aortic SAX view (Looking down view) Required structures: • Aortic arch in cross-section • Main PA. Image settings: • Angle: ~90° • Sector depth: ~10 cm. Probe adjustments: • Neutral.	Primary diagnostic uses: • Aortic atherosclerosis • Aortic dissection • Diagnosis of patent ductus arteriosus • Measurement of gradient across the pulmonary valve.	 Figure 20 UE aortic arch SAX
ADDITIONAL VIEWS ME modified bicaval view Primary diagnostic uses: • TV pathology • Doppler interrogation of TV. Image settings: • Angle: ~110° • Sector depth: ~8-10 cm. Probe adjustments: • Probe rotated toward right as in bicaval view.	Required structures: • Right atrium • LA • Interatrial septum • Coronary sinus • TV.	 Figure 21 ME modified Bicaval view
Lower esophageal (LE) hepatic view Primary diagnostic uses: • Inferior venacava collapsibility and diameter • Hepatic venous flow velocity. Image settings: • Angle: ~20° Probe adjustments: • Rightward.	Required structures: • Right atrium • Hepatic vein • IVC.	 Figure 22 LE hepatic vein
Deep TG RV LAX Primary diagnostic uses: • Doppler assessment across RVOT • RVOT. Image settings: • Angle: ~110-130° • Sector depth: ~16 cm. Probe adjustments: • Rightward.	Required structures: • RV • Pulmonary valve • PA.	 Figure 23 Deep TG in/outflow

Deep TG RV inflow-outflow view Primary diagnostic uses: • Doppler assessment of PA flow. Image settings: • Angle: ~120-140° • Sector depth: ~16 cm. Probe adjustments: • Rightward.	Required structures: • RV • Pulmonary valve • PA.	 **Figure 24**
ME 5-Chamber view Primary diagnostic uses: • LVOT • Aortic regurgitation/stenosis by color flow Doppler. Image settings: • Angle: ~0-10° • Sector depth: ~12-14 cm. Probe adjustments: • Neutral – retroflexed.	Required structures: • LA • LV outflow tract • LV • Right atrium • RV • Mitral valve • TV.	 **Figure 25**
Lower esophageal coronary sinus view Primary diagnostic uses: • Placement of retrograde cardioplegia cannula. Image settings: • Angle: ~0-10° • Sector depth: ~12-14 cm. Probe adjustments: • Retroflexed.	Required structures: • Coronary sinus in LAX. • TV (septal and posterior leaflets)	 **Figure 26**

multiplane angle from 0° toward 180° is called "rotating forward," and rotating in the opposite direction toward 0° is called "rotating back."

The images displayed at the top of the screen are in the near field and structures in the far field are at the bottom of the screen. At a multiplane angle of 0° (the horizontal or transverse plane), with the imaging plane directed anteriorly from the esophagus through the heart, the patient's right side appears in the left of the image display and vice versa. Rotating the multiplane angle forward from 0° to 90° moves the left side of the display inferiorly (caudad) and right side of the display superiorly (cephalad). Rotating the multiplane angle to 180° places the patient's right side to the right of the display, will be a mirror image of 0°. Approximately distance of the probe tip from lips is 20-25 cm for upper esophageal (UE) views, 30-40 cm for midesophageal (ME) views and 40-45 cm for transgastric (TG) view in an average sized adult male; however, placement of the transducer into desired location is primarily accomplished by waiting the image to develop as the probe is manipulated rather than depth markers on the probe.

THE 17-SEGMENT MODEL FOR REGIONAL LV ASSESSMENT AND CORONARY ARTERIAL DISTRIBUTION

From base to the apex, the LV is divided into basal, mid and apical thirds corresponding to the proximal, middle and apical segments of the coronary arteries. The scheme divides the ventricle into 17 segments [Figure 27], six segments both in the basal and mid portions (anteroseptal, inferoseptal, anterior, anterolateral, inferolateral and inferior walls) and five at the apex (septal, anterior, lateral, inferior and apical).[8] As these segments can be recorded from three SAX and several longitudinal views, it is possible (and useful) to evaluate a segment from more than one view [Figure 27].

The ME four-chamber view (transducer at 0°, posterior to the LA) allows simultaneous imaging of the LV and RV. It is advisable to retroflex the probe to avoid foreshortening of the left and RV cavities. In this view, the segmental function of the infero septal, antero-lateral walls and apex can be assessed. With the transducer at 90°, the ME two-chamber view allows visualization of the inferior and anterior walls and adjacent portions of the apex. Further transducer rotation up to 120-150° will result in a LAX view and visualization of the anterior septum and inferolateral wall on the right and left respectively. Using the trans-gastric approach, a series of SAX views can be obtained at 0-20° by modifying probe depth and anteflexion. For example, maximal anteflexion will generally allow visualization of the basal ventricular segments and the mitral valve. A lesser degree of ante-flexion or slight probe advancement will result in SAX views at the high and low papillary muscle levels. In these SAX views, the inferior wall is seen at the top of the screen, the anterior wall at the bottom, the inferolateral and anterolateral walls to the right and the anterior and inferior septal walls to the lower left and upper left of the screen. Further probe advancement will often result in a SAX view of the LV apical segments. Because ventricular segments perfused by each of the three major coronary arteries are represented in the SAX view at the mid-papillary muscle level, it is commonly used intraoperatively to evaluate global and segmental function.[9] Transducer rotation to 90° yields a two-chamber view, with the inferior and anterior walls at the top and bottom of the screen, respectively. Further rotation to 120-150° will result in a LAX view, with the inferolateral wall on top and the anterior septum at the bottom of the screen [Figure 28].

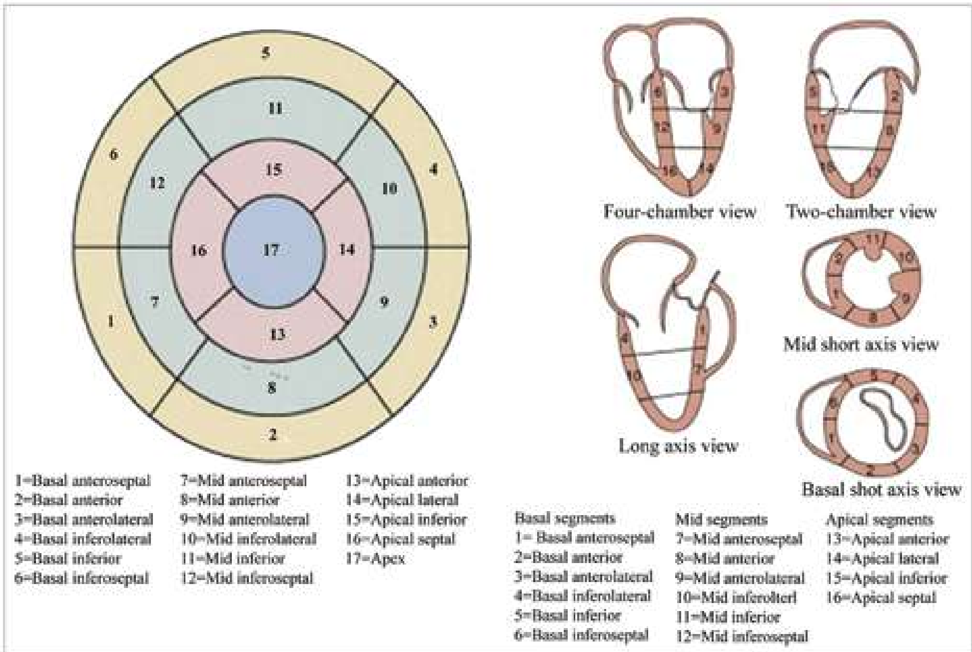


Figure 27: Nomenclature of 17 segments of the left ventricle for transesophageal echocardiography (modified from Corqueria *et al.* Circulation 2002; 105:539-42)

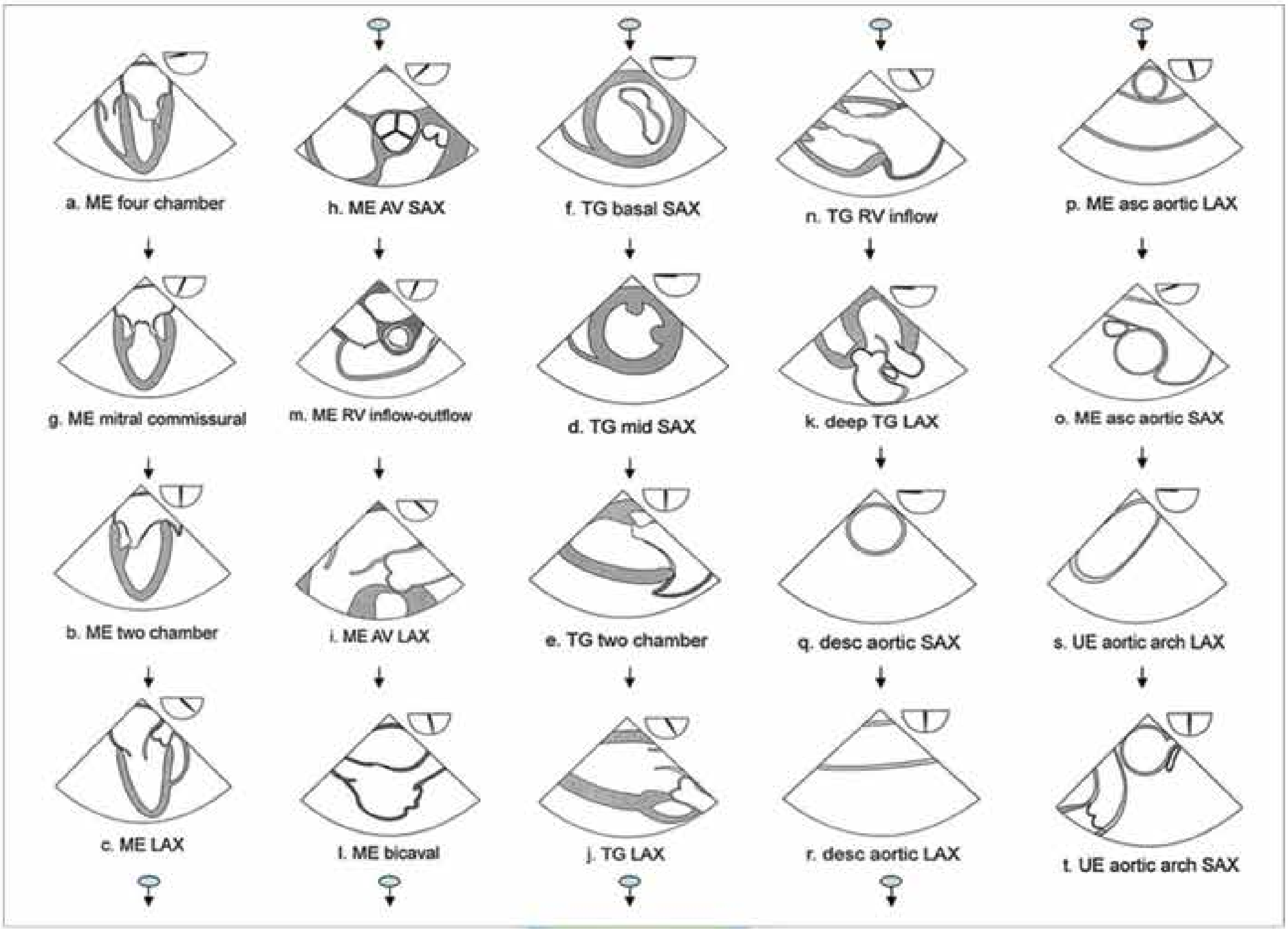


Figure 28: Recommended sequence of transesophageal echocardiography (TEE) examination. Cross-sectional views of the recommended comprehensive TEE examination: Approximate multiplane angle is indicated by the icon adjacent to each view. ME = Mid esophageal, LAX = Long axis, TG = Transgastric, SAX = Short-axis, AV = Aortic valve, RV = Right ventricle, ASC = Ascending, DESC = Descending, UE = Upper esophagea

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TEE workshop schedule

25th August 2017			
Time	Topic (s)	Speaker(s)	Moderator(s)
08:00-09:00	Ganesha Vandana		
09:00 - 09:20	Comprehensive views; an update	Dr. Ravi Hebballi	Dr. Pradeep Madhivathanan Dr. Anil Kumar H Dr. Prashanth M B
09:20 - 09:40	Artifacts and pitfalls	Dr. Sandeep Markan	
09:40 – 09:50	Discussion		
09:50 – 10:00	Coffee break		
10:00 – 10:20	LV systolic function assessment by echocardiography	Dr. Suresh Chengode	Dr Suresh G Nair Dr. Raghu B Dr. Shriman Narayan
10:20 – 10:40	RV function assessment by echocardiography	Dr. Prabhat Tewari	
10:40 – 10:50	Discussion		
10:50 – 11:20	Echocardiographic anatomy of Mitral valve and assessment	Dr. Satish Govind	Dr. Amarja Nagre Dr. Manjunath N Dr. Manjunath R
11:20 – 11:40	Mitral stenosis and Mitral regurgitation (case-based TEE evaluation)	Dr. Joel Devasi	
11:40 – 11:50	Discussion		
11:50 – 12:10	Echocardiographic anatomy of Aortic valve and assessment	Dr. Satyajeet Misra	Dr. TA Patil Dr. Lakshmi R Patil
12:10 – 12:30	Aortic stenosis and Aortic regurgitation (case-based TEE evaluation)	Dr. Sudarshan Shetty	
12:30 – 12:40	Discussion		
12:40 – 13:30	Lunch break		
13:30 – 13:50	Assessment of mitral valve repair by 2D and 3D	Dr. Jorg Ender	Dr. Ravi varma Patil Dr. Parimala Prasanna Shimha Dr. Sucharita Das
13:50 – 14:10	Prosthetic valves	Dr. Thomas Koshy	
14:10 – 14:20	Discussion		
14:20 – 14:40	Echocardiography for Aorta	Dr. Sanjay O P	Dr. Deepa Sarkar Dr. Jagadeesh A M Dr. Jyothi Mallikarjuna
	Diastolic dysfunction by echocardiography	Dr. Deepak Tempe	
15:00 – 15:10	Discussion		
15:10 – 15:20	Coffee break		
15:20 onwards	IACTA-TEE fellowship exams		
15:20 – 15:40	Tissue Doppler, Strain & speckle in TEE	Dr. Annette Vegas	Dr. Dheeraj Arora Dr. Murali Chakravarthy Dr Murugesan C
15:40 – 16:00	TEE for aortic dissection	Dr. Rajesh C Arya	
16:00 – 16:10	Discussion		
16:10 – 16:30	Patient-Prosthesis Mismatch	Dr. Srikanth Sola	Dr. Sanjeevani Inamdar Dr. Umesh S Dr. Hema C Nair
16:30 – 16:50	Echocardiogram in percutaneous transmitral commissurotomy	Dr B K Mahala	
16:50 – 17:00	Discussion		
17:00 – 17:20	Hemodynamic monitoring with echocardiogram in ICU	Dr. James Harmon	Dr. Abhijeet Paul Dr. Jayaprakash K Dr. Sanjay Banakal
17:20 – 17:40	Echocardiography for ASD device closure	Dr. Vijayalakshmi I B	
17:40 – 17:50	Discussion		

26th August 2017			
08:30 – 08:50	Echocardiographic evaluation of Tricuspid and Pulmonary valves	Dr. Sheila Cole Pai	Dr. Jigisha J. Sachde Dr. Suresh G Nair
08:50 – 09:10	TEE in pulmonary embolism	Dr. Salaunkey Kiran	
09:10 – 09:20	**Discussion**		
09:20 – 09:40	Echo for HOCM and cardiomyopathy	Dr. Sameer Srivatsava	Dr. Manjula Sarkar Dr. Shivananda NV Dr. Suresh P V
09:40 – 10:00	Beating heart mitral valve interventions	Dr. Chirojit Mukherjee	
10:00 – 10:10	**Discussion**		
10:10 – 10:20	**Coffee break**		
10:20 – 10:40	Introduction to focused intensive care echocardiography (FICE)	Dr.Pradeep Madhivathanan	Dr. Muralidhar K Dr. Rupa Sreedhar Dr. Ratan Gupta
10:40 – 11:00	Interesting cases in ICU	Dr. Priya Menon	
11:00 – 11:10	**Discussion**		
11:10 – 11:30	Simulation in echocardiography	Dr Poonam Malhotra	Dr. Vishwas Malik Dr. Abhijeet Shitole
11:30 – 11:50	Haemodynamic calculations	Dr. Ranjith Karthekeyan	
11:00 – 12:00	**Discussion**		
12:00 – 12:20	Echocardiography in non cardiac surgery	Dr. Govind Rajan	Dr. Unnikrishnan KP Dr. Harish B R Dr. Keshava Murthy S
12:20 – 12:40	Lung Ultrasound	Dr Vivek Kumar	
12:40 – 12:50	**Discussion**		
12:50 – 13:40	**Lunch break**		
13:40 – 14:00	Introduction to endobronchial and esophageal ultrasound	Dr. Madhuri Rao	Dr. Kumar Belani Dr. Neeti Makhija Dr. Sandeep Koti
14:00 – 14:20	Basics in 3D	Dr. Shrinivas G	
14:20 – 14:30	**Discussion**		
14:30 – 14:50	LV function with 3D	Dr. Naman Shastri	Dr. Nilesh Juvekar Dr. Shio Priya Dr. Mandar V G
14:50 – 15:10	3D for Mitral valve	Dr. K K Kapur	
15:10 – 15:20	**Discussion**		
15:20 – 15:30	**Coffee break**		
15:30 – 16:30	Echo jeopardy (Buzzer First Round) **Team 1** Dr. Chirojit Mukherjee, Dr. Poonam Malhotra **Team 2** Dr Rajesh Arya, Dr. Minati Choudhury **Team 3** Dr. Rupa Shreedhar, Dr. Unnikrishnan KP **Team 4** Dr. Neeti Makhija, Dr. Satyajeet Misra		**Quiz Master** Dr. Mahala B K
Valediction			
16:30 – 16:40	**Presidential address 1**		**Dr. Rajeev Lochan Tiwari**
16:40 – 16:50	**Presidential address 2**		**Dr. B B Mishra**
16:50 – 17:00	**Message from UOM**		**Dr. Kumar Belani**
17:00 – 17:20	**Symbolism of Ganesha**		**Dr. Thimappa Hegde**
17:20 – 18:00	**Ganesha Haarati**		

27th August 2017			
8:00 - 9:30	WET LAB		
9:30 – 10:00	COFFEE / TEA - BREAK		
Special Lectures			
10:00 – 10:25	Echocardiography in heart failure	Dr. Yatin Mehta	Dr Poonam Malhotra Dr. Aruna Ramesh
10:25 – 10:50	Radiation induced valvular heart disease- case reviews	Dr Suma Konety	
11:00 – 16:00	PBLD / Hands-on-session / Lecture Demonstration / FTEE - practical exam		

Echo for Vascular access	Ultrasound for lung	TTE (FATE)	Haemodynamic Management with Echocardiography	Simulation Station	PBLD Session
10 participants	10 participants	10 participants	10 participants	10 participants	50 participants
Dr. Sunil Chhajwani Dr Sushma G L	Dr J Ender Dr Vivek Kumar Dr Rajesh Shetty Dr Madhuri Rao	Dr. Nilesh Juvekar Dr. Sanjeevini Inamdar Dr. Mahala B K Dr. James Harmon Dr.Pradeep Madhivathanan	Dr. Ravi Hebbali Dr. Sandeep Markan Dr. Rupa Sreedhar Dr Neeti Makhija	Dr. Aruna C Ramesh Dr. Keshavamurthy M R Dr Harish K S Dr Roopa K P Dr Suprith C Dr Ravikumar R	Dr Priya Menon Dr. Unnikrishnan KP Dr. Minati Choudhury Dr. Sudhakar Subramani Dr. Vishwas Malik
Facilitators Dr Antara Dr Tejas	**Facilitators** Dr Rohit Dr Ambika	**Facilitators** Dr Medha Dr Nilesh	**Facilitators** Dr Savitri Dr Myomin	**Facilitators** Dr Anuradha Dr Dipesh Dr Kassa	**Facilitators** Dr Karthikeyan Dr Neeta Dr Senait

SCOPE OF SERVICES

1. Anesthesia
2. Cardio Thoracic Surgery - Adult
3. Cardiac Thoracic Surgery - Pediatric
4. Cardiac Thoracic Surgery -Neonates
5. Heart Transplantation
6. Intensive Therapy Care Unit - Adult (AITU)
7. Intensive Therapy Care Unit - Pediatric (PITU)
8. Cardiology – Adult
9. Cardiology –Pediatric
10. Coronary Care Unit
11. Heart Failure Clinic
12. Arrhythmia Clinic
13. Aneurysm Clinic
14. Warfarin Clinic
15. Preventive Cardiac Health Screening Clinic
16. Cardiac Catheterization Laboratory

DIAGNOSTIC SERVICES

1. **Non Invasive Cardiology Services**
    - Echocardiography - Adult
    - Echocardiography - Pediatric
    - Fetal Echocardiography
    - Transesophagial Echocardiography
    - Treadmill Test
    - ECG and Holter
2. **Radiology Services**
    - X-ray
    - Cardiac MRI
    - MRI Scan Pediatric
    - 64 slice CT scan
    - Ultrasound
3. **Nuclear Medicine- PET CT Imaging**
4. **Laboratory Medicine**
5. **Blood Bank**

SUPPORT SERVICES

1. Cardiac Rehabilitation
2. Yoga therapy and counseling
3. Ambulance services
4. Telemedicine
5. Clinical Research
6. Homograft and Valve banking

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