Clinical Skill Development in 2D- Color Doppler Echocardiography

Echocardiogram (Echo)- the use of ultrasound to examine the heart is **Safe, powerful, noninvasive and painless technique.** In recent years the echo has become one of the most important tool in the diagnosis and evaluation of many cardiac condition. In districts and secondary care practice one third of all cases comprises of cardiovascular diseases. M.D. physician with clinical cardiology background can develop skill to perform echo, interpret echo studies, and derive information compared with other diagnostic technique.

For those who decided to learn echocardiography this is good starting point. The causes diagnosis and evaluation has been approached by using all echo mode – M mode, 2-dimensional, Doppler, colorflow mapping and TEE where applicable.

The basic aim of this skill development is for equipping physician with one more effective tool in understanding primary cardiac disease and its involvement in other systemic diseases. The period of this journey and experience will be at times confusing and frustrating, to get a clear image or holding the transducer and finding good view of heart.
Outline of Programme

Duration - 6 Days
Participants - up to 6
Sessions and their durations - 2 sessions each 60 minutes –
4 sessions each 60 minutes –
Evaluation - Day 2 to Day 6

Method of Teaching

a) Lecture Method
b) Teaching Aids – OHP Presentation, black board presentation and chalk.
   c) Video Demonstration
d) Hands on experience (on patients in echo cardiograph laboratory)

Reading Material –
Training Module for skill development of Echocardiography with clinical cardiology.
Handbook Echo Made Easy to be supplied 2 months in advance to participants in the training.

References - Reading Material
1. Echo made easy - Sam Kaddoura Churchil Livingstone, 2002
4. Text Book of echocardiography- Fiegenbaum

Exercise / Evaluation
Session 1
Basic notions – about ultrasound, transmission & machine
WHO NEEDS AN ECHO STUDY

Session 2
Live demonstration of echocardiography machine control panel and different transducers.

Session 3
Standard views
Sequence of examination

Session 4
To learn various echo techniques

Session 5
The Normal echo
PARASTERNAL WINDOW (PLA)

Session 6
The Normal echo
PARASTERNAL WINDOW (SAX)

Session 7
The normal echo
APICAL WINDOW
Chamber function (systolic / diastolic)

Session 8
The normal echo
SUBCOASTAL WINDOW
SUPRASTERNAL WINDOW

Session 9
MVD

Session 10
AVD

Session 11
TVD
Session 12
PVD

Session 13
LV FUNCTION, HEART FAILURE

Session 14
PULMONARY HEART DISEASE

Session 15
CORONARY HEART DISEASE

Session 16
CARDIOMYOPATHY AND MYOCARDITIS

Session 17
PERICARDIAL DISEASE

Session 18
Cardiac masses
Infections
Artificial valve

Session 19
Congenital heart disease

Session 20
Special procedure-TEE and Stress echo

Session 21
Special situation-Pregnancy, stroke, TIA

Session 22
Special situation-Hypertension and hypertrophy
Systemic diseases

Session 23
Revision
Valve disease and need for various surgical intervention

Session 24
Revision
CAD-need for further invasive intervention
Day 1

Session – 1
Basic notions – about ultrasound, machine & transmission

WHO NEEDS AN ECHO STUDY

Objective
To introduce ultrasound production, Propagation of ultrasound waves and production of images.

Content-Text

Basic Notions

- Echocardiography is the technique of examining the heart by the use of ultrasound. To appreciate and fully understand this technique, a brief explanation of the basic physics and some technical aspects is necessary.

- Sound is form of energy created by mechanical vibrations. It is transmitted through different media in the same format of sound waves.

The units used when examining these sound waves are:

  - The hertz (Hz)- this is used to express the number of cycles per second – 1 Hz = 1 cycles/s;
  - The kilohertz (kHz) – 1kHz = 1000 Hz;
  - The megahertz (MHz) –1 MHz = 1000000 Hz.

The range of sound frequency audible to human ear is 20 Hz to 20 kHz. Ultrasound is a term used to describe sound waves whose frequency is above the normal audible range, i.e. over 20kHz.

When ultrasound transmission travel through human tissue, the part of waves is absorbed, some passes through the tissues and others reflected i.e. echoed back. An echographic examination of the heart is based on the detection and examination of this reflected echo.

The frequency of ultrasound wave for echo is between 2.5 and 3.5 MHz.

The reflected ultrasound is displayed as

- Amplitude modulation (A-mode)
- Brightness modulation (B-mode)
- Motion modulation (M-mode)
WHO NEEDS AN ECHO STUDY

For understanding cardiac involvement we should have

- Adequate clinical information
- The reason an echo is being requested
- The specific question being asked

The following is the list of indication for an echo study:

- Assessment of valve function, e.g. systolic or diastolic murmur
- Assessment of left ventricular function - systolic, diastolic and regional wall motion, e.g. suspected heart failure in a subject with breathlessness or oedema, or pre-operative assessment
- Suspected endocarditis
- Suspected myocarditis
- Cardiac tamponade
- Pericardial disease (e.g. pericarditis) or pericardial effusion, especially if clinical evidence of tamponade
- Complications of myocardial infarction (MI), e.g. VSD, MR, effusion
- Suspicion of intracardiac masses - tumor, thrombus
- Cardiac chamber size, e.g. LA in atrial fibrillation (AF), cardiomegaly on chest x-ray.
- Assessment of artificial (prosthetic) valve function
- Arrhythmias, e.g. AF, ventricular tachycardia (VT)
- Assessment of RV and right heart
- Estimation of intracardiac and vascular pressures, e.g. pulmonary artery systolic pressure (PASP) in lung disease and suspected pulmonary hypertension (PHT)
- Stroke and transient ischaemic attack (TIA) - cardiac source of embolism?
- Exclusion of left ventricular hypertrophy (LVH) in hypertension
- Assessment of congenital heart disease.
**Causes of genesis of Murmurs**

- High velocity or volume across a normal valve
- Forward flow across a diseased valve
- Leakage across a valve
- Flow through a shunt (an abnormal communication between chambers or vessels)
- Flow across a narrowed blood vessel

1. **Possible causes of a systolic murmur**
   - Benign flow murmur -
   - Aortic - sclerosis or stenosis
   - HCM
   - Mitral - regurgitation, prolapse
   - Pulmonary - stenosis
   - Tricuspid - regurgitation
   - Shunts -
   - Coarctation of the aorta

2. **Conditions associated with a benign systolic murmur**
   - Pulmonary flow - common, especially in young children (30%)
   - Venous hum - continuous, reduced by neck vein compression, turning head laterally, bending elbows or lying down. loudest in neck and around clavicles
   - Mammary souffle - particularly in pregnancy
   - High-flow states - pregnancy, anaemia, fever, anxiety, thyrotoxicosis...

3. **Possible Causes of a diastolic murmur**
   - Aortic - regurgitation
   - Mitral - stenosis
   - Pulmonary - regurgitation
   - Tricuspid - stenosis (rare)
   - Congenital shunts - e.g. PDA
5. Who with a murmur should have an echo?

- Features suggesting a murmur is pathological/organic
- Symptoms - chest pain, breathlessness, oedema, syncope, dizziness, palpitations.
- Cyanosis
- Thrill (palpable murmur)
- Diastolic murmur
- Pansystolic
- Very loud murmur (but remember the loudness of a murmur often bears no relation to the severity of the valve lesion)
- Added/abnormal heart sounds - abnormal S2 ejection clicks, opening snaps, S4 (not S3 which can be normal, particularly if age <30 years)
- Physical signs of heart failure
- Wide pulse pressure and displaced apex
- Suspected endocarditis
- Suspected aortic dissection
- Cardiomegaly (e.g. on chest x-ray)
- Associated ECG abnormalities, e.g. LVH (exceptions are venous hum or mammary souffle as above)
Day 1

Session 2
Live demonstration of echocardiography machine control panel and different transducers.

Objective
To provide basic information of various part of echocardiography machine:
Handling of machine, information regarding functioning of machine & choosing of an appropriate transducer.

Contents: Text
Begin with a new patient
Enter name (ID)
Menu Selection
Selection of transducer
Gain
Depth gain compensation
Track ball for positioning the dot or range markers
Freeze
Measurements
Annotation
Image recording

- Two dimensional (2-D) or cross-sectional
- Motion or M-Mode
- Doppler - continuous wave, pulsed wave and colour flow.
Day 1

Session 3

Standard views
Sequence of examination

Objective

About various transducer and their images
Obtaining standard views.
Sequences of an echocardiography examination

Contents: Text

Transducers and scanners-The transducer contain piezoelectric element.
M-Mode imaging-single beam of ultrasound transmits and receives.

2-D imaging-Multiple ultrasound beam is required. They can be Mechanical or electronic phased array transducers.

Doppler effect-Measures mean blood velocity. It also distinguishes Laminar from turbulent flow.

Examination technique- B right hand technique and Left hand technique.

Echo windows and obtaining standard views.
**Parasternal view-**

PLA- (Base of the heart to apex) 2\textsuperscript{nd} to 4\textsuperscript{th} intercostals space, left sternal edge and

PSA Same space and rotating the transducer to 90-degree heart is seen cut in transverse section at level of MV, AV, LV papillary muscle and LV apex.

**Apical view-Over the apex four views**

4-chamber heart shape view
5-chamber (including aortic outflow)
2 chamber long axis

**Sub coastal view-under the xiphisternum**

Suprasternal view for imaging aorta in coarctation
Rt parasternal view-for AV or ascending aorta

**Sequences of an echocardiography examination-**

Routine examination follows-
Parasternal window
Apical window
Subcostal window
suprasternal window
Rt Parasternal window
Day 1

Session 4

To learn various echo techniques

Objective

Viewing various echo windows and views with standard position
To learn various echo techniques

- Two dimensional (2-D) or cross-sectional
- Motion or M-Mode
- Doppler - continuous wave, pulsed wave and colour flow

Contents: Text

Echo techniques

Three echo methods are in common clinical usage:

- Two-dimensional (2D) or “cross-sectional “
- Motion or M-mode
- Doppler-continuous wave, pulsed wave and colour flow

Motion or M –Mode echo-is produce by transmission and reception of ultrasound beam along only one line. It produces a graph of depth and strength of reflection with time. Changes in movement, valve opening and closing, ventricular wall movement can be displayed. Size of chambers and thickness of wall can be measured.

To create a 2-D image, the ultrasound beam must be swept across the area of interest. The transducer rotates the beam it produces through a certain angle, either mechanically or electronically.
2D echo gives a snapshot in time of a cross-section of tissue. If these sections are produced in quick succession and displayed on a TV screen, they can show: real-time imaging of the heart chambers, valves and blood vessels.

Doppler echo uses the reflection of ultrasound by moving red blood cells. The Doppler principle is used to derive velocity information. The reflected ultrasound has a frequency shift relative to the transmitted ultrasound, determined by the velocity and direction of blood flow. This gives haemodynamic information regarding the heart and blood vessels. It can be used to measure the severity of valvular narrowing (stenosis), to detect valvular leakage (regurgitation) and can show intracardiac shunts such as ventricular septal defects (VSDs) and atrial defects (ASDs).

The 3 commonly used Doppler echo techniques are:

1. **Continuous wave Doppler**:

   Two crystals are used—one transmitting continuously and one receiving continuously. This technique is useful for measuring high velocities but its ability to localize precisely a flow signal is limited since the signal can originate at any point along the length or width of the ultrasound beam.

2. **Pulsed wave Doppler**:

   This allows a flow disturbance to be localized or blood velocity from a small region to be measured. A single crystal is used to transmit an ultrasound signal and then to receive after a pre-set time delay. Reflected signals are only recorded from a depth corresponding to half the product of the time delay and the speed of sound in tissues (1540m/s). By combining this technique with 2-D imaging, a small “sample volume” can be identified on the screen showing the region where velocities are being measured. The operator can move the sample volume. Because the time delay limits the rate at which sampling can
occur, there is a limit to the maximum velocity that can be accurately detected, before a phenomenon known as “aliasing” occurs, usually at velocities in excess of 2m/s.

Continuous wave and pulsed wave Doppler allow a graphical representation of velocity against time and are also referred to as “spectral Doppler”

3. Colour flow Mapping:

This is an automated 2-D version of pulsed wave Doppler. It calculates and directions at points along a number of scan lines superimposed on a 2-D echo image. The velocities and directions of blood flow are colour-encoded. Velocities away from the transducer are in blue, those towards it in red. This is known as the BART convention (Blue Away, Red Towards). Higher velocities are shown in progressively lighter shades of colour. Above a threshold velocity, “colour reversal occurs (explained again by the phenomenon of aliasing). Areas of high turbulence or regions of high flow acceleration are often indicated in green.
Day 2

Session 5

The Normal echo

PARASTERNAL WINDOW

Objective

To look for structures in PLA

Contents: Text

Parsternal view-
PLA (Base of the heart to apex) 2nd to 4th intercostals space, left sternal edge and

PSA Same space and rotating the transducer to 90 degree heart is seen cut in transverse section at level of MV,AV,LV papillary muscle and LV apex.

Long Axis View

M-Mode Study

There are three standard positions in this view:

- Position 1 – the cursor is placed at the tips of the MV leaflets (MV tracing);
- Position 2 – the cursor is placed across the AV (a tracing of the valve, aortic root and left atrium is obtained);
- Position 3 – the cursor is placed beyond the tips of the MV in the left and right ventricular cavities. (A tracing of the LV cavity, IVS and RV is obtained).

Two – dimensional

The structures and examined in this view are:

- The mitral valve (MV)
- The left ventricular outflow tract
- The basal and the mid part of the interventricular septum (IVS)
- The left ventricle (LV)
- The right ventricle (RV)
- The left atrium (LA)
- The pericardium
- A cross-section of the descending aorta.

**Colour flow Mapping**

Colour flow mapping can be used in the PLA view to detect:
- Abnormal eccentric jets in mitral and aortic valve disease (stenosis and regurgitation). This view can be used with other standard views to obtain an overall assessment of valvular disease;
- Abnormal blood flow through abnormalities in ventricular septum as seen in VSD;
- Other abnormalities, such as sinus of Valsalva aneurysm.

**Doppler**

Mitral and aortic valves
- When making velocity measurements it is necessary for the Doppler beam to be parallel to blood flow. In the parasternal long axis view, the Doppler beam is perpendicular to flow across the mitral and aortic valves, therefore it is not possible to make accurate measurements of velocity. However, Doppler echocardiography can be used for detecting high velocity flow, for example in mitral and aortic stenosis and regurgitation. In other words, the only possible use for Doppler in this window when examining the mitral and aortic valves is to detect the presence of (to diagnose), and not to quantify, the severity of these disorders.
Day – 2

Session – 6
The Normal echo

PARASTERNAL WINDOW

Objective
To look for structures in PSA

Contents: Text
Parsternal view-

PLA (Base of the heart to apex) 2\textsuperscript{nd} to 4\textsuperscript{th} intercostals space, left sternal edge and

PSA Same space and rotating the transducer to 90-degree heart is seen cut in transverse section at level of MV, AV, LV papillary muscle and LV apex.

Parasternal short axis views

A group of different views are obtained in the short axis configuration by manipulating the transducer to transect the heart at different levels. The standard levels for echocardiographic examination in these planes are:

- The mitral valve
- The aortic valve
- The papillary muscle
- The apex.

Two – dimensional
The structures that can be examined at this level are:

- The mitral valve
- Regions of the left ventricular wall at the MV level
- The right ventricular cavity.
Mitral valve

- Normal – both leaflets can be seen in this view with:
- The anterior leaflet (above) and the posterior (below);
- The anterior leaflet is larger than the posterior;
- The two leaflets separate in diastole giving the classic ‘fish mouth’ appearance and coapt in systole;
- Planimetry of the MV area can be made from a frozen diastolic frame to measure the MV orifice.

PSA: Aortic Valve Level at the Base of the Heart

This is a cross-sectional cut at the base of the heart. Different modes are used for examination.

Two – dimensional

Three valves (aortic, pulmonary and tricuspid) can be visualized in this view. The left and right atria, interatrial septum and pulmonary artery can also be visualized.

Aortic valve leaflets

The size, shape and number of the aortic valve leaflets can be seen in this particular view.

- Normal – the valve normally consists of three leaflets which can be visualized in diastole when they come together giving a shape that resembles the Mercedes-Benz symbol. In normal conditions the leaflets will separate in systole to a dimension similar to that of the actual aortic root.
RV Outflow Tract, Pulmonary Valve And Pulmonary Artery.

The RV outflow tract, pulmonary valve and pulmonary artery can be seen to the right of the aorta in this view.

- Normal – the RV outflow tract appears superiorly and to the right in this view where it tracks down to the pulmonary valve (PV) location. In most cases the PV can be visualized but it may be difficult on occasions. One or two of the three leaflets can be seen to the left of the aortic valve in this view.

The main pulmonary artery is seen distal to the pulmonary valve and bifurcates into two branches (the right and left pulmonary arteries) giving what is called the ‘pair of trousers’ sign.

PSA: Papillary Muscle Level

This is a cross-sectional cut of LV at the papillary muscle level.

Two – dimensional

Normal

- Morphology
  - LV wall – circular, cross-sectional representation of the LV cavity at the PML is seen. This cut demonstrates the regional wall motion of the LV at this level.
  - Papillary muscles – muscles are seen attached to the LV walls inside the cavity.

- Contractility and motion
  - In systole – the LV walls become thicker and they move towards each other, resulting in a smaller cavity.
  - The associated papillary muscles become thicker and move in a similar way to the LV motion.
In diastole – thinning of the LV walls is a feature of diastole caused by the movements of LV walls in different directions.

Regional wall motion abnormalities at the level of the papillary muscles can be easily seen in this view and used to help evaluate overall ventricular function.

**PSA: Apical Level**

Two – dimensional

This can be used in LV regional wall motion assessment.

It can also help in estimating the extent of:

- LV hypertrophy
- LV dilatation
- LV wall scars
- The presence of thrombus
- Apical aneurysm.

**Doppler**

Colour flow mapping

Colour flow mapping can help to detect the less common presence of a ventricular septal defect at this level.
Day 2

Session 7
The normal echo
APICAL WINDOW

Objective
Looking of echo from apical area of heart
Chamber function (systolic / diastolic)

Contents: Text
Three echo modes 2-D, Doppler and color flow mapping are used for this view

APICAL 4 CHAMBERS
The structures visualized are
LV
RV
IVS
LA
RA
IAS
MV
TV
Doppler blood flow is seen across MV & TV and abnormal intracardiac communication.

LV Cavity
The LV cavity can be seen with the apex at the top of the screen and, depending on preferred technique the cavity may be seen either to the left of the screen or to the right.

Right ventricle Cavity
The RV cavity appears in the same orientation as the LV cavity and is the smaller of the two. The RV can be also identified by the presence of the moderator band near the apex.
IVS
Thickness
Motion (real time)
Continuity with anterior aortic wall

LA atrium
RA atrium
Interatrial septum is seen as the structure separating the two atria.

Mital Valve/ Tricuspid valve
Normal
- In systole – the MV is closed with the leaflets coapted at the same level of the MV annulus
- In diastole – opening of the MV can be seen as the leaflets move freely into the LV cavity

APICAL 5 CHAMBERS
The structures visualized by angulation of transducer is aortic valve and ascending aorta. This is a good view for aortic stenosis and AR.

APICAL 2 CHAMBERS
The structures visualized by rotating the transducer on the cardiac apex are 2 chamber view can show different segment of the LV.
Day 2
Session 8
The normal echo
SUBCOSTAL WINDOW
SUPRASTERNAL WINDOW
Objective
To view various structure from these site.
Direction of blood flow and hemodynamic
Contents: Text
Subcostal window
The subcostal window is an additional window in the echocardiographic examination and it is particularly useful in the following situations.

- When it is difficult to use other windows, for example, in patients with emphysema or barrel chest.
- In the detection of congenital abnormalities in newborn and young infants.
- In visualizing the IAS; it is the best window to examine this structure. (The ultrasound beam is perpendicular to the IAS in this view.).

There are two main groups of views in this window:

- The four – chamber view
- The short axis views.

Suprasternal window
With the transducer placed in the suprasternal notch and titled superiorly.
A longitudinal and a transverse cross sectional can be obtained.

- Aorta (ascending, arch and descending)
- Aortic pulmonary artery relationship
- Left atrial appendage.

The views obtained in this window are:

- Longitudinal cross section (Parallel to the aortic arch);
- Transverse cross – section (Perpendicular to the aortic arch.).
Day 3
Session 9
Normal MV and its apparatus
MV disease
Objective
To look at MV and its apparatus for rheumatic, degenerative, calcification in different windows and mode in disease and health

Contents: Text
Mitral stenosis- The MV is located between the LV and LA. The MV opens during ventricular diastole when blood flows from LA into LV. During ventricular systole, the MV closes as blood is ejected through the AV.

The MV has 3 main components:
- Leaflets (2) – anterior and posterior
- Chordae attached to papillary muscles (subvalvular apparatus)
- Annulus (valve ring)

1. Passive flow of blood begins Closed leaflets (thickened and more echogenic) begin to open
2. Thickened leaflets drift apart slowly and less completely due to fusion at leaflet tips. Because of the fusion the posterior leaflet moves towards anterior leaflet.
3. Thickened leaflets move back together more slowly

Changes in MV area with severity of MS
* Normal valve 4-6cm²
* Mild MS 2-4cm²
* Moderate MS 1-2cm²
* Severe MS < 1cm²

Criteria for diagnosis of severe MS (many derived from Doppler)
- Measured valve orifice area < 1cm²
- Mean pressure gradient > 10mmHg
- Pressure half-time > 200ms
- Pulmonary artery systolic Pressure > 35mmHg.
**Mitral regurgitation [MR]**

This is leakage of blood through the MV from LV into LA during ventricular systole. M-mode shows LV dimensions are increased, as is velocity of motion of the posterior wall and interventricular septum (IVS). The LA is enlarged.

**2-D Echo may show-**
An underlying MV abnormality e.g. flail MV leaflet with chaotic movement, MV prolapse, vegetation
Rapid diastolic MV closure due to rapid filling
Dilated LV with rapid filling
Septal and posterior wall becomes more vigorous
Increased circumferential fiber shortening with good LV function
LA size increased
Doppler shows size and site of regurgitant jet

**Chronic MR**
1. Leaflet abnormalities
2. Annulus abnormalities
3. Abnormalities of the chordae tendinae
4. Papillary muscle abnormalities

**Doppler feature of MR**
1. Wide jet
2. Jet filling the area of left atrium
3. Systolic flow reversal in pulmonary veins
4. Dense signal on continuous Doppler
5. Raised pulmonary artery pressure

D/D of acute versus chronic MR?
Day 3

Session 10
Aortic valve disease

Objective
Evaluate LVOT, aortic valve at junction of LV outflow and ascending aorta.

Contents: Text
Valvular
Sub valvular
Supra valvular

Aortic valve (AV)
Bicuspid AV. This congenital abnormality affects 1-2% of the population and results in cusps, which separate normally but usually have an **eccentric closure line**, which may lie anteriorly or posteriorly. (Note that in up to 15% of cases the closure line is central.) An eccentric closure line may alternatively be caused in a tricuspid AV when there is a subaortic VSD and prolapse of the right coronary cusp. 2-D echo (especially the parasternal short-axis view at AV level) can help to differentiate between a bicuspid and a tricuspid AV, but this can be difficult if the valve is heavily calcified. Bicuspid AV is an important cause of AS and may co-exist with other congenital abnormalities such as coarctation of the aorta.

- Calcific AS. There are dense echoes usually throughout systole and diastole, which may make cusp movement hard to see.
- Vegetations. These can usually be seen by echo if 2mm of more in diameter (transoesophageal echocardiography (TOE) may visualize smaller vegetations. These usually give multiple echoes in diastole, but if large can also be seen during systole. Distinction from calcific aortic stenosis can be difficult on M-mode.
- Fibromuscular ring (subaortic stenosis).
Abnormal pattern of Aortic valve leaflet is seen in
Bicuspid aortic valve
Cacic
Vegetation
Fibromuscular ring (subaortic stenosis).
HOCM
Prosthetic artificial valve
Echo feature of AS

**Echo features of AS**

The M-mode features of S have been mentioned. On 2-D echo using parasternal long-and short-axis views and apical 5-chamber views:

1. The cusps may be seen to be thickened, calcified, have reduced motion or may, ‘dome’ (the latter is usually diagnostic of AS)
2. There may be LVH due to pressure overload
3. LV dilatation occurs if heart failure has developed (usually a poor prognostic feature)
4. post-stenotic dilatation of the aorta may be seen.

**Doppler** is most useful in determining the severity of AS by estimating the pressure gradient across the AV. Valve area can be calculated by use of the continuity equation. Severity of AS correlates with valve area, peak velocity, peak pressure gradient and mean pressure gradient (often more accurate than peak).
Doppler features of varying degrees of AS

<table>
<thead>
<tr>
<th>Valve area (cm²)</th>
<th>Peakl velocity (m / s)</th>
<th>peak gradient (mmHg)</th>
<th>Mean gradient (mmHg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>2.5—3.5</td>
<td>&lt;10</td>
<td>&lt;10</td>
</tr>
<tr>
<td>Mild</td>
<td>1.5—2.5</td>
<td>&lt;20</td>
<td>&lt;20</td>
</tr>
<tr>
<td>Moderate</td>
<td>0.75—1.5</td>
<td>20—64</td>
<td>20—40</td>
</tr>
<tr>
<td>Severe</td>
<td>&lt;0.75</td>
<td>&gt;64</td>
<td>&gt;40</td>
</tr>
</tbody>
</table>

Echo diagnosis of AR

All the echo modalities are useful in diagnosis and evaluation. Doppler and colour flow mapping are especially helpful. M-mode and 2-D echo cannot directly diagnose AR but may indicate underlying causes (e.g. dilated aortic root, bicuspid AV) and aid in the assessment of the effects of AR (e.g. LV dilatation).

M-mode may show:
- Vegetations on AV
- Fluttering of AV cusps in diastole *(e.g. rupture due to endocarditis or degeneration)*
- Eccentric closure line of bicuspid valve
- Dilatation of aortic root.
- Fluttering of anterior MV leaflet
- Premature opening of AV because of raised left ventricular end-diastolic pressure (LVEDP) and premature closure of MV. Both suggest severe AR
- Dilatation of LV cavity due to volume overload
- Exaggerated septal and posterior wall of LV wall motion (exaggerated septal early dip strongly suggests AR).

2-D echo may show:

- LV dilatation – correlates with severity of AR
- Abnormal leaflets (bicuspid, rheumatic)
- Vegetations
- Dilated aortic root
- Proximal aortic dissection
- Abnormal indentation of the anterior MV leaflet
- Abnormal intraventricular septal motion.

Doppler
This is useful both for detecting AR and assessing its severity. Colour flow mapping is helpful. The jet of AR can be seen entering the LV cavity on a number of views such as parasternal long axis and apical 5-chamber. Pulsed Doppler can be used in the apical 5-chamber view with the sample volume just proximal to the AV. AR can be detected as a signal above the baseline (towards the transducer) but since AR velocity is usually high (>2 m/s) aliasing will occur. Continuous wave Doppler is then useful and the signal seen only above the baseline.

Assessing the severity of AR
As with MR, assessing severity of AR is not straightforward. A number of echo criteria are used:
1. Effects on the LV
2. The volume of blood regurgitating across the valve
3. The rate of fall of the pressure gradient between the aorta and LV
Day 3

Session 11

Normal Tricuspid valve
Tricuspid valve disease

Objective
To see tricuspid valve look and functions like MV but has three leaflets.

Contents: Text
Echo finding are analogous to MV
Tricuspid stenosis
Tricuspid regurgitation

M-mode and 2-D echo findings are analogous to MS:
- Thick and / or calcified leaflets
- Restricted leaflet motion
- Doming of one or more leaflets in diastole (especially the anterior leaflet).

Doppler findings are similar to MS. There is increased flow velocity in diastole. Severe TS is usually associated with a gradient of 3-10 mmHg.

Virtually every TV shows some TR during its normal function.

Echo assessment of TR severity is best achieved by Doppler as with MR. More severe TR is associated with a broad, high-intensity jet filling the RA. There is associated retrograde systolic flow in the vena cava and hepatic vein.
Day 3

Session 12

Normal pulmonary valve
Pulmonary valve disease

Objective
Observe the PV has three leaflet is seen at RVOT and Pulmonary artery

Contents: Text -
Pulmonary stenosis

Valvular PS 2-D echo may show thickened, calcified, calcified leaflets, doming of valve leaflets in systole and restricted motion. There may be post-stenotic dilatation of the PA or its branches and RV hypertrophy or dilatation due to pressure overload.

<table>
<thead>
<tr>
<th>Severity of PS</th>
<th>Peak gradient (mmHg)</th>
<th>Valve area (cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild</td>
<td>&lt;25</td>
<td>&lt;1.0</td>
</tr>
<tr>
<td>Moderate</td>
<td>25-40</td>
<td>0.5-1.0</td>
</tr>
<tr>
<td>Severe</td>
<td>40</td>
<td>&lt;0.5</td>
</tr>
</tbody>
</table>

Supravalvular PS The increase in Doppler velocity detected by pulsed wave Doppler is distal to and not at the level of the PV.

Subvalvular PS A muscular band and/or narrowing of subvalvular area seen. There is not usually post-stenotic dilatation. Using pulsed wave Doppler, it can seen that the increase in velocity occurs in the RVOT below the level of the PV.
Pulmonary regurgitation [PR]

M-mode and 2-D echo cannot detect PR directly but can show some evidence of the underlying cause and the effect. There may be evidence of:

- PHT- dilated RV, dilated PA, abnormal IVS motion (behaves as though it ‘belongs’ to the RV rather than LV –‘right ventriculazation’ of IVS)
- Dilated PA- the diameter can be measured usually in parasternal short-axis view at AV level
- Vegetation on the valve in endocarditics
- Thick immobile PV leaflets in rheumatic heart disease or carcinoid
- Absent valve leaflets (congenital)
- PA aneurysm.

Doppler techniques show PR and help to assess severity, as with AR. Doppler indicators of severe PR are:

- Colour flow – the regurgitant jet is visualized directly. Severity is indicated by the width of the jet at valve, how far into RV it extends and the area of the jet by planimetry
- Pulsed wave Doppler –the distance between the PV and level at which PR is detected can be determined. A jet at the lower infundibular region is severe
- Increased intensity of the Doppler signal
- Increased slope of the Doppler signal (deceleration time).
Day 4
Session 13
Assessment of LV function (systolic and diastolic)

Objective
Systemic cardiac output is maintained by the left ventricle pumping the blood in systemic circulation. To understand the relaxing and contractile function of each chamber & assess the heart failure.

Contents: Text –
Normal function & Heart failure
One definition is of a clinical syndrome caused by an abnormality of the heart which leads to a characteristic pattern of haemodynamic, renal, neural and hormonal responses. A shorter definition is ventricular dysfunction with symptoms.
Echo plays a crucial role when heart failure is suspected (e.g. unexplained breathlessness, clinical signs such as raised venous pressure, basal crackles, third heart sound) to help establish the diagnosis, assess ventricular function and institute correct treatment.
An underlying cause of heart failure should always be sought and echo plays an essential role here also. The most common cause in Western populations is coronary artery disease. Echo may also reveal a surgically treatable underlying cause, e.g. valvular disease or LV aneurysm. Severe AS may cause heart failure (which affects 3% of those aged over 75 years) and the murmur at this stage may be absent.
LV systolic function is a major prognostic factor in cardiac disease and has important implications for treatment.
LV systolic function can be assessed by M-mode, 2D and Doppler techniques. M-mode gives excellent resolution and allows measurement of LV dimensions and wall thickness. 2-D techniques are often used to provide a visual assessment of LV systolic function, both regional and global. The general validity of this has been shown but there are inter-observer variations. Visual estimation is clinically useful but unreliable in those who have poor echo images, can be limited in value in serial evaluation and inadequate where LV volumes critically
influence the timing of intervention. Computer software on the echo machine may be used to provide a quantitative assessment of LV function. Certain geometrical assumptions are made about LV shape, which are not always valid, particularly in the diseased heart.

**M-mode** can be used to assess LV cavity dimensions, wall motion and thickness. The phrase, ‘a big heart is a bad heart’, carries an important element of truth – poor LV systolic function is usually associated with increased LV dimensions. This is not always the case, e.g. if there is a large akinetic segment of LV wall or an apical LV aneurysm following MI, systolic function may be impaired due to regional wall motion abnormalities but M-mode measurements of LV dimensions may be within the normal range.

LV internal dimension measurements in end-systole (LVESD) and end-diastole (LVEDD) are made at the level of the MV leaflet tips in the parasternal long-axis view. Measurements are taken from the endocardium of the left surface of the interventricular septum (IVS) to the endocardium of the LV posterior wall (LVPW). The ultrasound beam should be as perpendicular as possible to the IVS. Care must be taken to distinguish between the endocardial surfaces and the chordae tendinae on the M-mode tracing.

LVESD is at the end of systole, which occurs at the peak downward motion of the IVS (which usually slightly precedes the peak upward motion of the LVPW) and coincides with the T wave on the ECG. The normal range is 2.0-4.0 cm.

LVEDD is at the end of diastole (R wave of ECG). The normal range is 3.5-5.6 cm.

Remember that the normal range for LVEDD and LVESD varies with a number of factors, including height, sex and age.

M-mode measurements can be converted to estimates of volume but this is inaccurate in regional LV dysfunction and spherical ventricles. The LVEDD and LVESD measurements can be used to calculate LV fractional shortening, LV ejection fraction and LV volume, which give some further indication of LV systolic function.

**Fractional shortening (FS)** is a commonly used measure and is the % change in LV internal dimensions (not volumes) between systole and diastole:
KVEDD – KVSD

\[ \text{FS} = \frac{\text{KVEDD}}{\text{KVSD}} \times 100\% \]

**Normal range 30-45%**

The LV volume is derived from the ‘cubed equation’ (i.e. volume, \( V = D^3 \), where D is the ventricular dimension measured by M-mode). This assumes that the LV cavity is an ellipse shape, which is not always correct. There are some equations which attempt to improve the accuracy of this technique. The volume in end-diastole is estimated as \((\text{LVEDD})^3\) and in end-systole as \((\text{LVESD})^3\). The **ejection fraction (EF)** is the % change in LV volume between systole and diastole and is:

\[ \text{EF} = \frac{(\text{LVEDD})^3 - (\text{LVESD})^3}{(\text{LVEDD})^3} \times 100\% \]

**Normal range 50-85%**.

LV wall motion and changes in thickness during systole can be measured. The IVS moves towards the LVPW and the amplitude of this motion can be used as an indicator of LV function.

Wall thickness can also be measured. The walls thicken during systole. The normal range of thickness is 6 – 12 mm. Walls thinner than 6 mm may be stretched as in dilated cardiomyopathy or scarred and damaged by previous MI. Walls of thickness over 12 mm may indicate LV hypertrophy, an important independent prognostic factor in cardiovascular outcome risk.

**2-D echo** can be used qualitatively to assess LV systolic function by viewing the LV in a number of different planes and views. An experienced echo operator can be often give reasonably good visual assessment of LV systolic function as being normal, mildly, moderately or severely impaired, and whether abnormalities are global or regional.
2-D echo can also be used to estimate LV volumes and EF. Multiple algorithms may be used to estimate LV volumes from 2-D images but all make some geometrical assumptions, which may be invalid. The area – length method (symmetrical ventricles) and the apical biplane summation of discs method (asymmetrical ventricles) are validated and normal values available.

**Simpsons method**

A number of techniques are available. Simpson’s method divides the LV cavity into multiple slices of known thickness and diameter D (by taking multiple short-axis views at different levels along the LV long axis) and then calculating the volume of each slice (area x thickness). The area is $\pi \left( \frac{D}{2} \right)^2$. The thinner the slices, the more accurate the estimate of LV volume is. Calculations can be made by computer of most echo machines. The endocardial border must be traced accurately and this is often the major technical difficulty. Endocardial definition has improved with some newer echo technology (e.g. harmonic imaging) and automated endocardial border detection systems are available on some echo machines. The computer calculates LV volume by dividing the apical view into 20 sections along the LV long axis.

The LV ejection fraction can be obtained form LV volumes in systole and diastole (as above). Alternatively, computer-derived data can be obtained by taking and tracing the LV endocardial borders of a systolic and a diastolic LV frame.

An estimate of cardiac output can be obtained using LV volumes:

Cardiac output = stroke volume x heart rate

Stroke volume is LV diastolic volume – LV systolic volume.

Measurement of LV shape are an important and underutilized aspect of LV remodeling e.g. after MI. increasing LV sphericity has prognostic importance and loss of the normal LV shape may be an early indicator of LV dysfunction. 2-D echo allows a simple assessment of LV shape (measuring the ratio of long axis length to mid-cavity diameter). The location and extent of wall motion abnormality following MI correlates with LV EF and is prognostically useful.
Regional LV wall motion
The LV can be divided up on 2-D imaging of apical 4-chamber and parasternal short-axis views into segments (9 or 16) and an assessment can be made of these segments. This can be useful at rest and in stress echo to determine the location of coronary artery disease.
A segment’s systolic movement may be classified as:
- Normal
- Hypokinetic (reduced movement)
- Akinetic (absent movement)
- Dyskinetic (movement in the wrong direction, e.g. outwards movement of the LV free wall during LV systole)
- Aneurysmal (out-pouching of all layers of the wall).

Echo Findings in patients with heart failure.
Left ventricle
- Dimensions – systolic and diastolic
- Systolic function and an indication of fractional shortening and ejection fraction.
- Regional or global wall motion abnormalities – evidence of previous infarction, ischemia or aneurysm.
- Wall thickness – concentric hypertrophy (e.g. hypertension or amyloid) or asymmetrical hypertrophy (e.g. HCM).
- Evidence of diastolic heart failure.

Valves
- AS & AR
- MR (as a cause or secondary to ventricular dilatation)
- MS

Pericardium
- Effusion
- Constriction
- Echo suggestion of cardiac tamponade (e.g. RV diastolic collapse).
Right heart
- Right Ventricular dimensions
- PHT (estimation of PASP by Doppler assessment of TR)

Left atrium
- Dimensions (particularly if AF and planned cardioversion)

Intracardiac thrombus

Changes in heart size and function in response to therapy.

LV Diastolic dysfunction

Left heart failure can occur due to diastolic dysfunction. This function relates to chamber stiffness and relaxation of ventricle after contraction.

Diastole has four periods

Isovolumic relaxation, early rapid filling, late filling and atrial systole. Abnormalities in any of these may contribute of diastolic heart failure.

Doppler study of mitral valve can provide useful information of diastolic dysfunction

1. Slow – relaxation pattern E-wave is small, A-wave is large, AT is prolonged, IVRT is prolonged.

2. Restrictive pattern E-wave is very tall, A-wave is small, DT is short, IVRT is short.
Day 4

Session 14
Pulmonary heart disease

Objective
To determine clinical importance RV function

Contents: Text -

Clinical importance of RV function in
1. Myocardial infarction
2. Valvular heart disease (e.g. MS, PS)
3. Chronic lung disease causing PHT
4. Septicaemic shock and post cardiotomy shock
5. CHD-before and after surgery
6. Pericardial effusion

Echo Assessment of RV function
1. The RV has greater geometrical complexity
2. The RV free wall is heavily trabeculated making edge recognition difficult.
3. Overlap between RV and other cardiac chambers in some imaging modulaties make reliable volume measurement difficult.
4. The location of the RV directly under the sternum poses specific problems for echo (the ultrasound beam will not penetrate bone)
5. The assessment of the RV is especially difficult in subject eho have had previous thoracic surgery or have chronic lung disease. RV function studies are often vital for them.

The best echo views for the RV are usually
- Subcostal 4-chamber
- Apical 4-chamber
- Parasternal short-axis at MV and papillary muscle levels.

Estimates can be made of RV internal dimensions, wall thickness and ejection fraction. RV function is sensitiveto myocardial contractility, preload and afterload but also to LV contractility, the contribution of the septum, and to intrapericardial
pressure. An analysis of RV function should take all these factors into account and EF per se may not be sensitive enough to these factors.

Right-side failure is associated with a dilated, hypokinetic RV. If the RV is the same size or larger than the LV in all views, it is abnormal.

Note that even in the most experienced hands, adequate echo examination of the RV may be obtained in only approximately 50% of subjects.

**Echo features of Pulmonary hypertension**

**M-mode**
- Abnormal M-mode of the pulmonary valve leaflets with absent A-wave or mid-systolic notch
- Dilated RV with normal LA
- Abnormal IVS motion (right ventricularization of IVS)
- Underlying cause, e.g. MS (PA systolic pressure is an index of severity).

**2D echo**
- Dilated PA (e.g. parasternal short-axis view at aortic level). The PA diameter should normally not be greater than aortic diameter
- RV dilatation and/ or hypertrophy
- RA dilatation
- Abnormal IVS motion
- Underlying cause, e.g. MV or AV disease, ASD, VSD, LV dysfunction.

**Doppler**
This is best method to assess PA systolic pressure using TR velocity or short PA acceleration time as a surrogate of PHT.
Day 4

Session 15
Coronary heart disease

Objective
To assess myocardial ischaemia and predicting the artery involved.
To assess myocardial infarction and look for complication
Myocardial hibernation & stunning

Contents: Text -
Assessment of ischaemia
Ischaemia results in immediate changes, which can be detected by echo:

- Abnormalities of wall motion (hypokinetic, akinetic, dyskinetic)
- Abnormalities of wall thickening (reduced or absent systolic thickening or systolic thinning – this is more sensitive and specific for ischaemia)
- Abnormalities of overall LV function (e.g. ejection fraction) (also known as asynergy).

These can be detected by 2-D echo but M-mode is also extremely good because is high sampling rate makes it very sensitive to wall motion and thickening abnormalities. It is essential that the beam is at $90^\circ$ to the wall. There are limited regions of the LV myocardium that can be examined by M-mode – most usefully, the posterior wall and IVS.

Prediction of artery involves
Dividing the LV into segments as described does this. Stress echo is also based on this.
Assessment of myocardial infarction
Echo can help in detecting the extent of LV infarction, assessing RV involvement and detecting complications.
Complications of myocardial infarction

Many of the complications of acute MI can be detected by echo.

- Acute heart failure due to extensive MI.
- Acute MR. Acute VSD.
- Mural thrombus
- LV aneurysm.
- Pseudoaneurysm (false aneurysm).
- Pericardial effusion
- Myocardial function after MI.

Myocardial ‘hibernation’ and ‘stunning’

The heart is critically dependent upon its blood supply. Occlusion of a coronary artery results in the cessation of myocardial contraction within 1 min. Myocardial cell death usually occurs after 15 min of ischaemia.

An impairment of contractile function may remain even after restoration of the blood supply without MI. This effect has been termed myocardial stunning (stunned heart). It may cause reversible systolic or diastolic dysfunction. Although stunned myocardium is viable, normal function may not be regained for up to 2 weeks. Recurrent episodes of ischaemia may result in the loss of normal function of the heart, and the term hibernating myocardium (hibernation) has been applied to a similar condition.
Day 4

Session 16
Cardiomyopathies and myocarditis

Objective
To look for degenerative and inflammatory diseases of myocardium.

Contents: Text –
The most important idiopathic cardiomyopathies are:
- Hypertrophic increased ventricular wall thickness
- Dilated (increased ventricular volume)
- Restrictive (increased ventricular stiffness).

Echo is diagnostic of HOCM. The important echo features are seen using both M-mode and 2-D imaging:
1. Asymmetrical septal hypertrophy (ASH).
2. Systolic anterior motion (SAM) of the MV apparatus which may abut the IVS. This may not be seen at rest but may occur following provocation by the Valsalva manoeuvre or isovolumic exercise.
3. Mid-systolic AV closure and fluttering.

The definition of asymmetrical hypertrophy varies but a septal to posterior wall ratio of 1.5 or more is unequivocal evidence of asymmetry. Neither ASH nor SAM is specific for HCM. ASH may occur in AS and SAM may occur in MV prolapse. Their occurrence together is strongly suggestive of HCM.

Continuous wave Doppler shows increased peak flow through the LVOT. Pulsed wave Doppler with the sample volume in the LVOT proximal to the AV shows that the increase in velocity occurs below the level of the valve, distinguishing the obstruction from valvular aortic stenosis. The peak in maximal velocity across the AV is often bifid in HCM. There may also be features of LV diastolic dysfunction due to LVH (e.g. abnormal transmitral flow pattern with E-wave smaller than A-wave)
Dilated cardiomyopathy

M-mode and 2-D echo show:

- Dialation of all the cardiac chambers (left and right ventricles and atria) – increased LVESD and LVEDD.
- Reduced wall thickness and motion (ranging from mild to severe impairment) – reduced ejection fraction and fractional shortening, reduced motion of IVS and LVPW.
- Intracardiac thrombus (LV and LA.)

Doppler studies may show functional MR and TR.

Doxorubicin induced cardiomyopathy

Echo features of restrictive cardiomyopathy

- LV and RV cavity sizes are usually normal or only mildly increased, but there is impaired contractility of the ventricular walls seen on M-mode and 2-D echo. There may be dilatation of the LA and RA.
- Impaired LV and RV diastolic function. This is best assessed by Doppler echo. There is often a characteristic abnormal ‘restrictive pattern’ of MV flow with a very large E-wave and small A-wave.
Day 5

Session 17

Pericardial disease

Objective
To look pericardial area for fluid, thickening, calcification cyst.

Contents: Text

Causes of Pericardial Effusion
- Infection – viral, bacterial including tuberculosis, fungal
- Malignancy
- Heart failure
- Post MI
- Cardiac trauma or surgery
- Uremia
- Autoimmune – rheumatoid arthritis, SLE, scleroderma
- Inflammation – amyloid, sarcoid
- Hyperthyroidism
- Drugs – phenylbutazone, penicillin, procainamide, hydralazine, isoniazid
- Radiation
- Idiopathic

M mode and 2-D echo are the most important methods to assess pericardial effusion. On M-mode, using a parasternal long-axis view, the echo-free pericardial effusion may be seen below the posterior wall of the LV or above the anterior wall of the RV. On 2D imaging, the effusion can be as an echo-free space surrounding, the heart. The effusion may be through the pericardial space or loculated in certain regions only.
**Echo features of tamponade**

- Large volume pericardial effusion
- RA and/or RV diastolic collapse. Both are sensitive to tamponade. After relief of tamponade by drainage of the effusion, RV diastolic collapse soon reverses. Diastolic RA collapse does not do so as quickly and may be the more sensitive indicator of tamponade.
- Doppler features are of exaggerated changes in transmitral and transtricuspid flows normally seen with inspiration and expiration and changes in flow patterns of the superior vena cava (SVC)

Echo may aid in safely performing therapeutic echo-guided needle aspiration of pericardial fluid (pericardiocentesis) to relieve the tamponade, which may be life saving. Echo can help to locate the site and extent of fluid collection and assess the success of the procedure.

**Echo features of constrictive pericarditis.**

M-mode and 2-D echo

- Thickened pericardium. This is difficult to quantify and often tends to be overestimated. The normal pericardium is highly echogenic and appears bright. The degree of this depends upon the gain settings on the echo machine. On M-mode, the thickened pericardium appears as a dark thick echo line or as multiple separated parallel lines.
- Calcified pericardium – localized or generalized
- Abnormal septal motion, especially end-diastolic (exaggerated anterior motion).
- Dilated IVC due to raised systemic venous pressure
- Abnormal LV filling pattern – LV only expands in early diastole. Difficult to recognized in real-time. On M-mode this appears as mid- and late-diastolic flattening of LVPW motion
- Premature diastolic opening of the PV with increased RV end-diastolic pressure.
Doppler

Abnormal MV flow pattern reflecting abnormal diastolic LV filling of a ‘restrictive pattern.’

Increase in early diastolic velocity (E-wave large)

Rapid deceleration

Very small A-wave compared with E

Short pressure half-time of mitral and tricuspid valve flow

Exaggerated respiratory variation of MV flow (decreased E-wave by>25% on inspiration) or TV flow (decreased E-wave by>25% on expiration).

There is also prominent systolic ‘X’ descent of SVC flow.
Day 5

Session 18

Cardiac masses
Infections
Artificial valve

Objective

To look for abnormal masses seen in heart

Contents: Text

Myxoma –

Myxomas may be readily detected by M-mode or 2-D echo. The myxoma can be seen as a mass in the LA cavity and may prolapse through the MV into the LV cavity during diastole obstructing flow. It may be so large as to fill the LA. Doppler can show the haemodynamic effects.

Thrombus

2-D imaging is the best echo technique to identify thrombus, which is usually echo-bright. However, this is not always the case and it can be difficult to distinguish from myocardium if they have similar echogenicity. TOE can be helpful, especially, for LA and LA appendage thrombus.
**Infections**

Use of echo is SBE

Remember that many vegetations are not seen on TTE until they are >2mm in size. Colour Doppler may identify AR or MR, acquired VSD or a septal abscess. TOE is very useful in SBE, particularly for:

- Visualizing small vegetations.
- MV
- Prosthetic valve endocarditis
- Leaflets perforation
- Aortic root abscess
- Sinus of Valsalva aneurysm
- LVOT aneurysm
- LVOT to RA fistula.

**Artificial valve**

Echo features of valve malfunction

1. Findings should be compared with baseline values where possible.
   - Loose part of valve, e.g. ruptured bioprosthesis leaflet.
   - Loose sutures
   - Abnormal motion – reduced or exaggerated motion of any part of prosthesis
   - Associated findings, e.g. calcification, thrombus, vegetation, abscess, increased chamber size (LV, LA)

2. Haemodynamic abnormalities of prosthesis (by Doppler and colour flow)
   - Obstruction may be suggested by increased flow velocity or reduced orifice area
   - Regurgitation – increased severity of jet or new jet.
Day 5

Session 19
Congenital heart disease

Objective
To detect anatomical defect presentation and producing symptoms.

Contents: Text –

Echo is essential in the diagnosis of congenital heart disease and has reduced the need for cardiac catheterization in such conditions. Echo allows anatomical and haemodynamic assessment (e.g. the location and size of shunts, cardiac chamber anatomy and connections, and pressure such as pulmonary artery pressure.

Shunts

VSD ASD PFO PDA
Eisenmengers reaction

Coarctation of aorta

Congenital valve abnormality–

Bicuspid aortic valve,pulmonary stenosis
Ebstein anamoly

Complex cyanotic congenital defects –
Tetralogy of Fallots
Day 5

Session 20
Special procedure- TEE and Stress echo

Objective
Trans oesophageal visualization by ultrasound.
Stress induced changes in heart.

Contents: Text –
TTE- Ultrasound directed from chest wall is transthoracic echo
TEE/TOE-The oesophagus lies posterior to heart and anterior to descending aortas. Examining- the heart by transducer in the oesophagus is transoesophageal echo (TEE). This provides us improved image quality.

Advantages of TOE

- Improved image quality and resolution – the transducer is very close to the heart and there is less interference with the ultrasound beam. Higher ultrasound frequencies can be used since tissue attenuation of ultrasound is small and penetration depth required less than TTE (e.g. 5 MHz rather than 2-4 MHz).
- Some aspects of the heart can be examined which cannot be seen by TTE, e.g. posterior parts such as LA appendage, descending, aorta, and pulmonary veins.

Disadvantages of TOE

- Invasive technique – uncomfortable with potential small risk
- New views have to be learnt.

Use of TOE

- Mitral valve disease
- Endocarditis
- Posthetic valves
- Aortic disease
- Aortic valve disease
- Thromboembolic vascular disease
- Left atrial appendage
- Intracardiac masses
- Septal defects
- Intraoperative monitoring
- Congenital heart disease
- Critically ill individuals on ITU
- Air or fat embolism.

**Stress echo**

Stress transthoracic echo aids in the diagnosis of ischaemic heart disease. It helps to localize the site and quantifies the extent of ischaemia by the demonstration of regional wall motion and thickness abnormalities with stress which are not present at rest. This technique may be used as an alternative to exercise stress ECG testing or stress radionuclide myocardial perfusion scanning (e.g. stress thallium) in certain circumstances.

**Indications for stress echo**

**Ischaemic heart disease**

1. Uncertain diagnosis, equivocal exercise stress ECG test
2. Inability to exercise on treadmill
3. Resting ECG abnormality prevents interpretation of changes with exercise (e.g. LBBB, LVH with strain, digoxin)
4. Following acute MI
5. Localization of site of ischaemia
6. Assessment of myocardial viability – hibernation or stunning.
Day 6

Session 21
Special situation-

Objective
Cardiac assessment -Pregnancy, stroke, TIA

Contents: Text –

Pregnancy
Echo in pregnancy is safe. Many pregnant women develop systolic murmurs due to increased cardiac output (which rises by 30-50% in pregnancy). Many murmurs are benign (e.g. mammary soufflé) but some may not be. Cardiac disease can present and be diagnosed for the first time during pregnancy, or those with pre-existing heart disease may become pregnant and may suffer deterioration in their cardiac state. Echo is essential in both situations. Some may suffer troublesome palpitations and whilst this is a less clear-cut indication for echo, the finding of normal LV function, chamber size and valve function can be very reassuring.

Stroke, TIA and thromboembolism
This is a fairly common question asked when an echo is requested. It can be quite difficult to answer, particularly by TTE. TOE may provide more information. The main purposes of echo are:

- To make a diagnosis associated with risk of thromboembolism (e.g. MS, LV dilatation)
- To detect a direct source of embolism from an intracardiac mass – thrombus, tumour, vegetation.

TOE may be indicated (with a normal or inconclusive TTE) if:
High suspicion of embolism (e.g. endocarditis)
Young patient (many centers arbitrarily say age < 50 years).
Contents: Text

Hypertension and LVH

Hypertension is the most important cause of LVH, which is an independent predictive factor for cardiovascular mortality and morbidity.

Main indications for echo in hypertension.

- Assessment of LV systolic and diastolic function
- Detection of LVH and response to treatment
- Detection / effects of co-existing coronary disease (e.g. by stress echo)
- Possible underlying cause of hypertension (e.g. aortic coarctation).

LVH is often considered present if the IVS or LVPWE thickness is above ‘normal limits’ (often >12mm in diastole). Strictly speaking, one should measure LV mass to diagnose LVH. This can be calculated from M-mode or 2D measurements of IVS and LVPW thickness in diastole and LVEDD, all in cm, by an equation suggested by Devereux and Reichek (Circulation 1977; 55:7613-618)

\[
LV \text{ mass (g)} = 1.04 \left( LVEDD + LVPW \right)^3 - LVEDD^3 - 4
\]

This should be corrected for height or BSA (which gives ‘LV mass index’). The ‘normal values’ are:

<table>
<thead>
<tr>
<th></th>
<th>Women</th>
<th>Men</th>
</tr>
</thead>
<tbody>
<tr>
<td>LV mass corrected for height (g / m)</td>
<td>89 ± 25</td>
<td>114 ± 35</td>
</tr>
<tr>
<td>LV mass corrected for BSA</td>
<td>112</td>
<td>136</td>
</tr>
<tr>
<td>('LV mass index') (g / m²)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Systemic disease**

Echo abnormalities in some systemic diseases

**Infection**
- HIV infection and AIDS
- Chagas’ disease
- Lyme disease

**Inflammatory, rheumatic and connective tissue disease**
- Marfan’s syndrome
- SLE
- Rheumatoid arthritis
- Ankylosing heart disease
- Rheumatic heart disease

**Endocrine**
- Diabetes
- Acromegaly
- Hypothyroidism
- Hyperparathyroidism

**Infiltrations**
- Amyloid
- Sarcoid
- Chronic anaemia
- Hypertension
- Renal failure
- Malignancies.
Day 6

Session 23

Revision

Objective

Valve disease and need for various surgical intervention

Day 6

Session 24

Revision

Objective

CAD-need for further invasive intervention.
The normal echo

- Heart chamber size
- Chamber function (systolic and diastolic)
- Valvular motion and function
- Intracardiac and extracardiac masses and fluid collections
- Direction of blood flow and haemodynamic information (e.g. valvular stenosis and pressure gradients) by doppler echo.
- Height, Sex, Age, Physical training (athletes)

M-mode Echo Cardiography

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Normal Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mitral anterior leaflet EF Slope</td>
<td>80 – 150 mm/sec.</td>
</tr>
<tr>
<td>EPSS</td>
<td>2 – 7 mm</td>
</tr>
<tr>
<td>Aortic Cusp Opening</td>
<td>15 – 26 mm.</td>
</tr>
<tr>
<td>Aortic Root</td>
<td>20 – 37 mm</td>
</tr>
<tr>
<td>Left Atrium</td>
<td>19 – 40 mm</td>
</tr>
<tr>
<td>LVID (Diastolic)</td>
<td>37 – 56 mm (flat)</td>
</tr>
<tr>
<td></td>
<td>35 – 57 mm (left lateral)</td>
</tr>
<tr>
<td>LVID (Systolic)</td>
<td>24 – 42 MM</td>
</tr>
<tr>
<td>RVID (Diastolic)</td>
<td>7 – 23 mm (flat)</td>
</tr>
<tr>
<td></td>
<td>9 – 26 mm (left lateral)</td>
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<tr>
<td>IVST (Diastolic)</td>
<td>6 – 11 mm</td>
</tr>
<tr>
<td>LVPWT (Diastolic)</td>
<td>6 – 11 mm</td>
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<tr>
<td>IVST / LVPWT Ratio</td>
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</tr>
<tr>
<td>Motion</td>
<td></td>
</tr>
<tr>
<td>IVS</td>
<td>3.8 mm</td>
</tr>
<tr>
<td>LVPW</td>
<td>9 – 14 mm</td>
</tr>
</tbody>
</table>

LEFT Ventricular function

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Normal Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>LVEDV</td>
<td>LVAd--------cm</td>
</tr>
<tr>
<td>LVESV</td>
<td>LVLd--------cm</td>
</tr>
<tr>
<td>EF</td>
<td>LVAs--------cm</td>
</tr>
<tr>
<td>CO</td>
<td>LVLs--------cm</td>
</tr>
<tr>
<td>FS</td>
<td>LVVd--------ml</td>
</tr>
<tr>
<td></td>
<td>LVVs--------ml</td>
</tr>
<tr>
<td></td>
<td>EF----------%</td>
</tr>
<tr>
<td></td>
<td>SV----------ml</td>
</tr>
</tbody>
</table>

LV area length method
Pre and post evaluation of clinical skill development of echocardiography

Echocardiogram (Echo)- the use of ultrasound to examine the heart noninvasive or invasive technique?

Name some indication of echocardiographic study.

Describe the windows in which echo study are done routinely

Name various echo technique.

Name the structures of heart seen in 2D parasternal long axis.

What are the constituent of mitral valve apparatus?

Name the structures of heart seen in Apical 4 chamber view.

Describe the Doppler criterion of Mitra stenosis.

Discuss the causes of mitral regurgitation as assessed by anatomical defects.

What is LVOT.

Echo feature of Aortic stenosis.

Name LV function assessed by echo.

LV systolic function
LV diastolic dysfunction.

Methods can be useful for assessing myocardial ischaemia.

What is hypertrophic cardiomyopathy

Echo feature of congestive cardiomyopathy.

Discuss the causes of LVH.

Training Module
Clinical Skill Development Of
Echocardiography For Physician (Internal Medical Specialist) In Public Service/Private Service

Congenital shunts can be seen in which condition It will be long before you can perform echo but discuss its usefulness in your practice