Paediatric Cardiology

Paediatric Echocardiography Guideline

Staff relevant to:	Medical & Nursing staff working within EMCHC & Cardiac PICU
Written by: Reviewed by:	Dr Suhair Shebani Guideline Lead Clinical Practice Group 5th of May 2023
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1. Introduction and who this guideline applies to

BACKGROUND:
Echocardiography is an indispensable tool in the diagnosis and management of cardiac disease in fetal, newborns, infants, children and young adults.

INDICATIONS AND CONTRAINDICATIONS: to delineate the anatomy in suspected congenital heart disease, and the function in suspected cardiomyopathy, or cardiac involvement in a more generalised genetic, and systemic abnormality. It is a safe imaging modality with no radiation risk.

A full routine scan will be performed on all new patients as described, with the following exceptions:

a) Post radio-frequency ablation, to rule out pericardial effusion.
b) Immediately post cardiac surgery on PICU and post cardiac catheter.
c) Oncology patients for LV Function.
d) On consultant cardiologist discretion

In addition if distraction techniques are unsuccessful and the patient is un-cooperative, it may be necessary to perform a detailed scan under sedation (see sedation guidelines Sedation For Painless Imaging UHL Childrens Guideline UHL C96/2016).

2 . Guideline Standards and Procedures

1) Before patient enters the room, ensure correct patient details are entered onto the echo machine i.e. hospital number including the S, date of birth, Weight, Height, SA outpatient or inpatient, consultant and person performing the scan.

2) If scanning an Inpatient, ring relevant ward to check patient is fit enough to come to department, ensuring infection status is clarified, pre warning about mobility and behavioural issues.

3) Have accessible distraction toys and video if necessary relevant to patients age.

4) Collect patient from outpatients waiting area.

5) Introduce yourself to the patient and parent/guardian, explaining the test and what you are going to do, thereby gaining verbal consent.

6) Ensure appropriate exposure respecting patient's privacy, religious, and cultural beliefs at all time, and that all patients will be treated equally.

7) Place three electrodes onto the patient and connect to the echo ECG cable (place an ECG on where able to do so, i.e. if co-operative).

8) Ensure patient is comfortable.

9) Ensure you are comfortable by adjusting height of couch and your position.

10) If the patient is a small child who may be upset, it may be appropriate to ask the parent or guardian to lie on the couch with them, follow health and safety guidelines at all times.

Follow the echo machine handbook for use and recommended set up for the machine.

Selecting the correct frequency transducer **-**

In paediatric echocardiography, patient's range from new-borns to teens/adults, therefore a variety of transducer sizes are needed to meet all imaging requirements.
For optimal resolution the highest frequency transducer should be tried first and if penetration is inadequate, transducers with progressively lower frequency should be tried until the transducer with the best resolution and most adequate penetration is found.

- For premature and new-born infants use S12 for Phillips, 10S or the 6S for the Vivid E9.
- Older infants and children use S8 for Phillips or M5S for the Vivid E9.
- Older children and teens/adults use S5-1 for Phillips Matrix, X5-1 for Phillips Epic, and the M5S for the Vivid E9.

Place jelly, onto selected transducer (please use sterile gel if the patient is post-op).

Post processing and reporting:

When all images have been obtained, detach patient from ECG and remove electrodes, wiping off any gel.

End study on echo machine and attend the patient on CRIS (Technicians)

All scans are to be reviewed by a specialist Paediatric registrar or Consultant Paediatric Cardiologist, who will tell the patient the results at the time in clinic or later on the ward.

Where possible, reports are to written on to the XCELERA system immediately after review. If unable to do so, place top copy of report in notes. For inpatients, a copy of the report should be placed in the patients notes on the ward.

Leave transducers clean, using Trigene wipes, clean bed and leave room tidy for next patient. Ensure couch is wiped with chlorclean at the end of each session.

At the end of each session, ensure all studies have been exported to the XCELERA reporting system.

Once reported a copy will be copied and pasted onto Cris.

Studies performed on Phillips machines will be automatically deleted after 28 days. Studies performed on the GE need to be manually deleted.

Reporting

1. All Scans done by technicians are reported straight away on Xcelera unless the system is down, an echo bar code has to be put to ensure appearance on the EDRM system in the correct investigation folder

2. Cardiologists and Cardiology SpRs
    a) All new cardiac diagnosis should be reported on Xcelera, printed and correct barcode put on
    b) Pre-discharge scans: same as (a)
    c) Any hand written reports for (non a,b) especially PICU scans, have to be on the correct A4 purple edge paper with ECHO bar code.

Imaging Guidance:

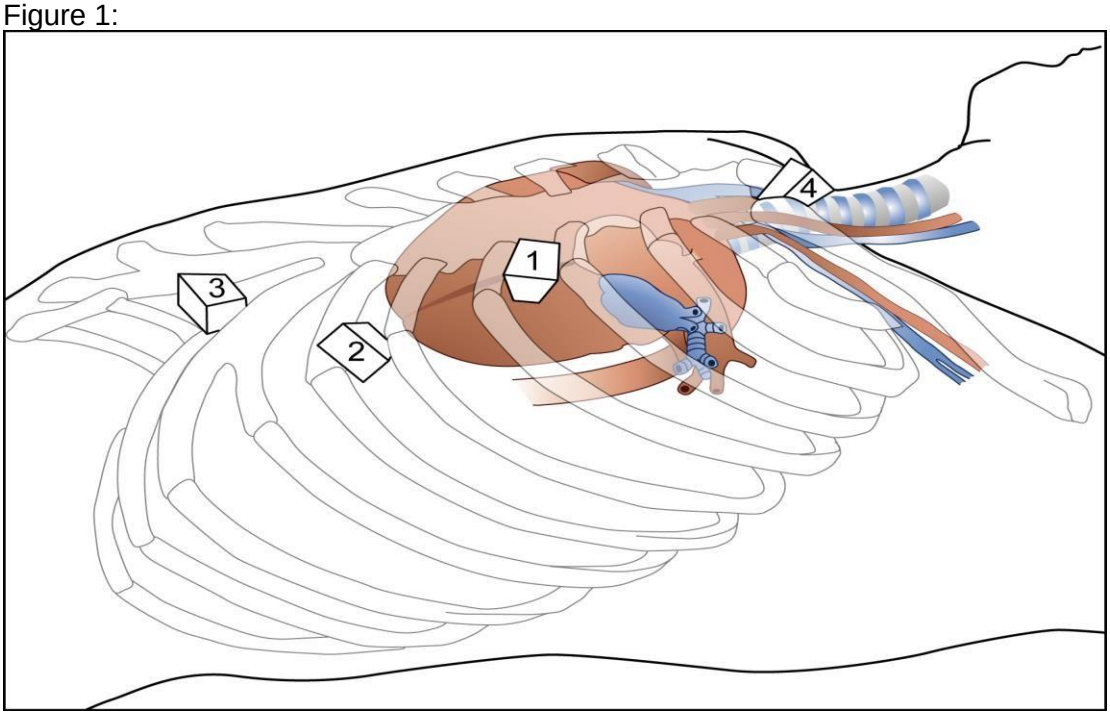
SEQUENTIAL ANALYSIS DURING 2-D ECHO CARDIOGRAPGY TO ENSURE ACCURATE ANATOMICAL DIAGNOSIS

1. Abdominal situs
2. Atrio-ventricular concordance.
3. Ventriculo-arterial concordance.
4. Shunts: ASD, VSD, PDA
5. Aortic arch , head and neck vessels, and descending aorta
6. Pulmonary venous drainage.
7. Systemic venous drainage
8. Global function.
9. Pericardial collection

2- DIMENSIONAL ECHOCARDIOGRAPHY: 2-D

2-D echocardiography demonstrates the spatial relationship of structures and therefore provides an accurate anatomic diagnosis of abnormalities in the heart and great vessels. It provides tomographic images of the heart by directing the transducer beam along selected cross-sectional planes. Once this skill is mastered with clear understanding of the normal sequential anatomy, abnormalities in anatomy or function could be easily diagnosed at least to start the emergency management until a more experienced cardiac input is available.

Figure 1:



Imaging sequence and planes:
Main 4 standard positions 1 longitudinal parasternal views, 2. apical 4-chamber view, 3. subcostal view, 4. suprasternal view. [Figure 1].

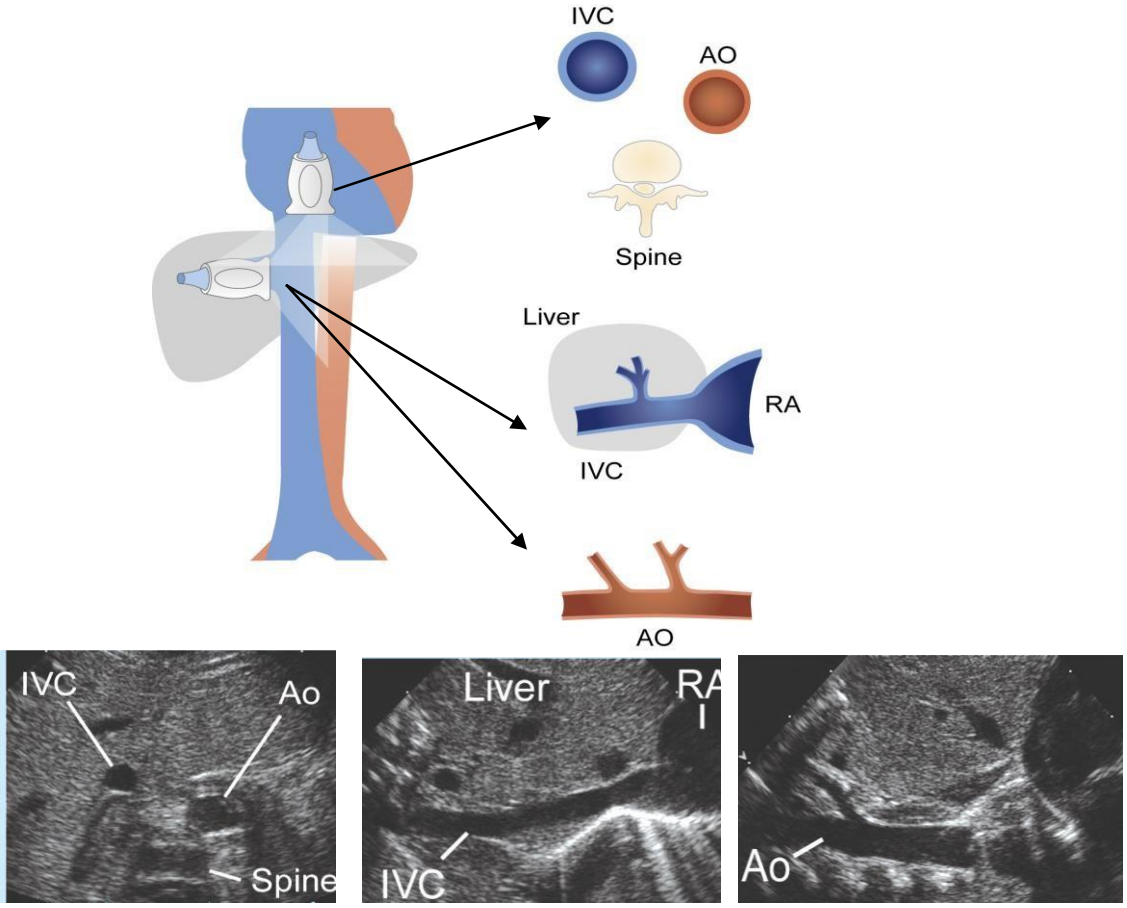
In Paediatric Cardiology we use the above standard views and additional views in a different sequence:
1. Abdominal sagittal and transverse views [Figure 2]: unlike adults, in paediatrics we start with this view to determine the situs and pulsation of the abdominal aorta. They are obtained from the subxyphoid region, and are useful to demonstrate the inferior vena cava (IVC), hepatic veins (HV), and abdominal aorta (Abd AO).

- The transverse abdominal plane [Figure2a] shows the liver on the right side and the stomach on the left, cross section of the spine is seen posteriorly with the aorta left and posterior and IVC right and anterior.

- In the sagittal plane [Figure 2b], slight rightward angulation of the transducer demonstrates, IVC passing through the liver and entering the right atrium (RA), minor angulation will demonstrate the HV joining the IVC just below the RA.

- Leftward angulation provides a longitudinal view of the Abd AO often the celiac and superior mesenteric arteries could be visualised from the anterior wall of the aorta. [Figure 2c]

Figure 2:



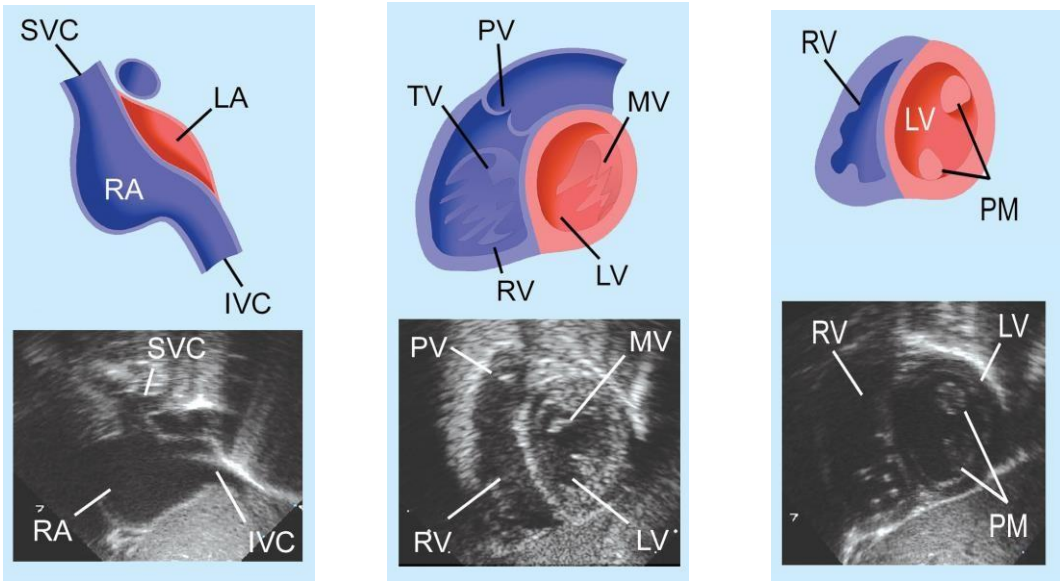
2a 2b 2c

2.

Subcostal views [Figure 3]: they are perpendicular to the 4-chamber views, the transducer is in the subxyphiod region and is rotated about 90 degrees clockwise from the 4-C view and are visualised as if looking from the patients left side.

- The most rightward plane [Figure 3a] transects the superior and inferior vena cavae and their connection to the right atrium
- Leftward angulation: the ultrasound beam passes through the body of the RV and outflow tract to the pulmonary valve [Figure 3b]
- More angulation to the left provides short axis view of the left ventricle and mitral valve [Figure 3c]
- Leftward rotation by 90 degrees and upwards, the entire interatrial septum can be visualised as well as the pulmonary veins
- Further upward angulation the right ventricular outflow tract, pulmonary artery and branch pulmonary arteries can be visualised.

Figure 3:



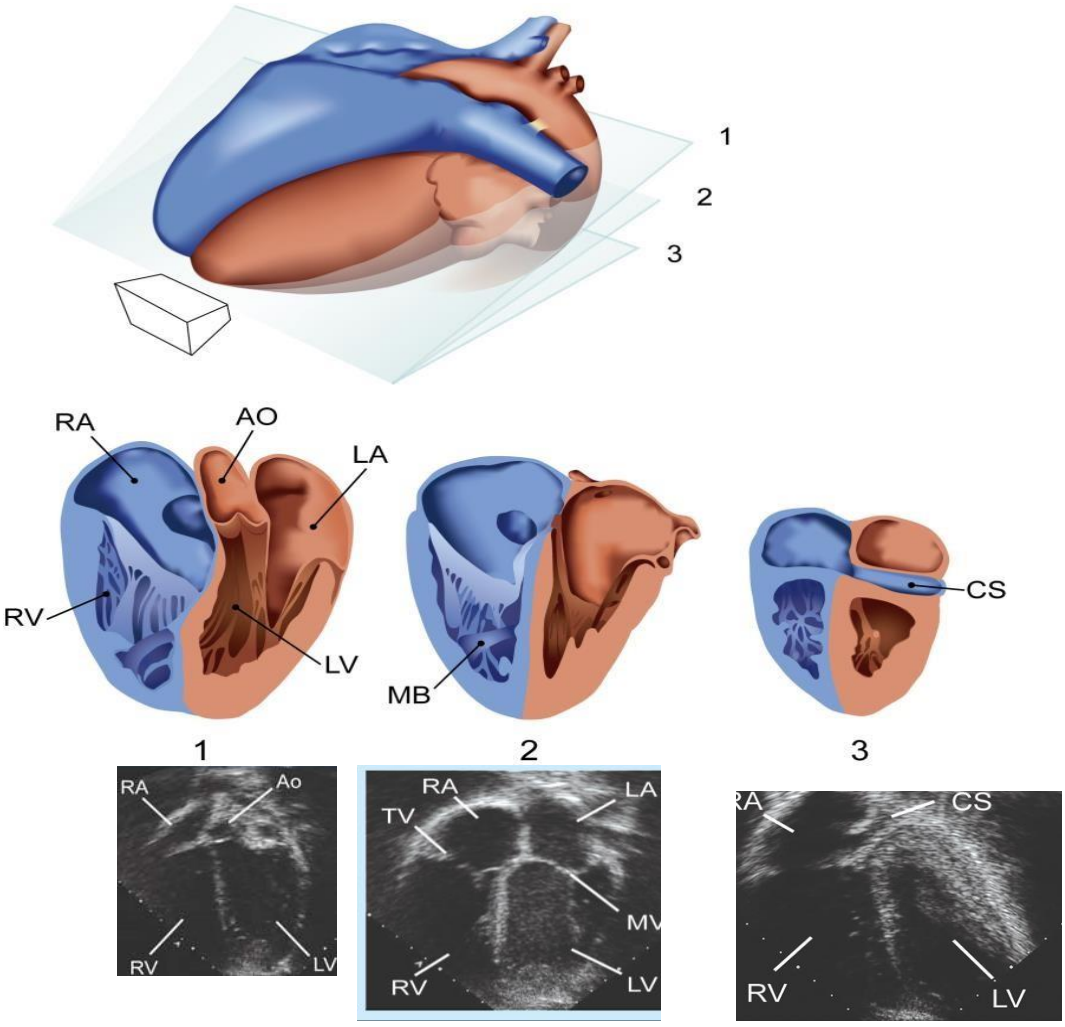
3a 3b 3c

3.

Four-chamber views: Obtained by placing the transducer on the cardiac apex, from there angulation anterior and posterior will give 3 standard imaging planes [Figure 4].

- Anterior angulation provides the 5-chamber (outlet) view: the 4-chambers plus the aortic valve, subaortic area, proximal part of the ascending aorta, sometimes the left coronary artery, and outlet part of the IVS [Figure 4a]. Some echocardiographers can visualise the pulmonary artey arising from the right ventricle by further anterior angulation of the transducer but this is not a standard view.
- Anterior tilting demonstrates the standard 4-chamber (inlet) view, which in which you should be able to visualise the 4 cardiac chambers; 2 atria and two balanced ventricles, the two AV-valves tricuspid and mitral with normal offsetting, the inlet part of inter ventricular septum (IVS), and the pulmonary veins [Figure 4b].
- Posterior angulation provides the coronary sinus view, RA and tricuspid valve [Figure 4c]

Figure 4:



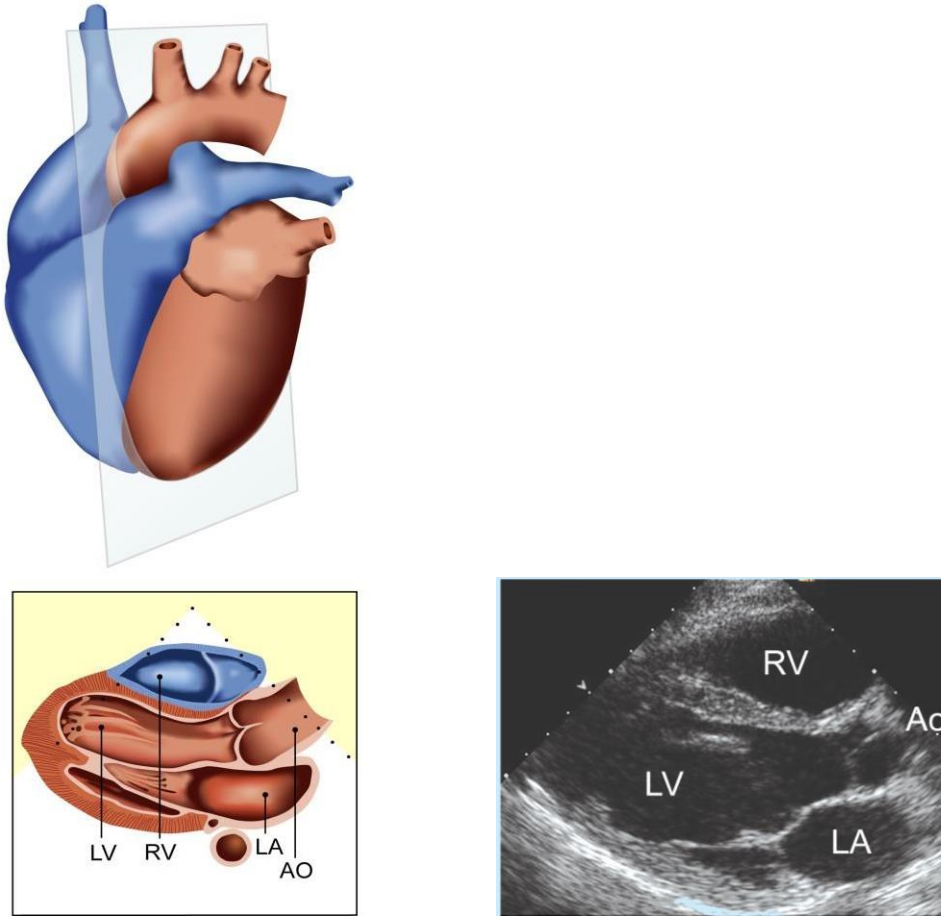
4a 4b 4c

4.

Left parasternal long axis view: The transducer is placed in the 3rd or 4th intercostals spaces angulating at 11:00 o'clock position with the aorta to the right and the left ventricular cavity is to the left of the screen with both mitral and aortic valves clearly seen, the left ventricular cavity is not foreshortened, the left atrium behind ascending aorta and right ventricular cavity and outflow tract is most anterior at 12:00 o'clock position [Figure 5].

- Motion of the aortic and mitral valve leaflets is apparent
- Normal continuity of the anterior mitral valve leaflet with the posterior aortic root.
- M-mode analysis of LV function and dimensions and aortic to LA ratio can be done from this view.

Figure 5:



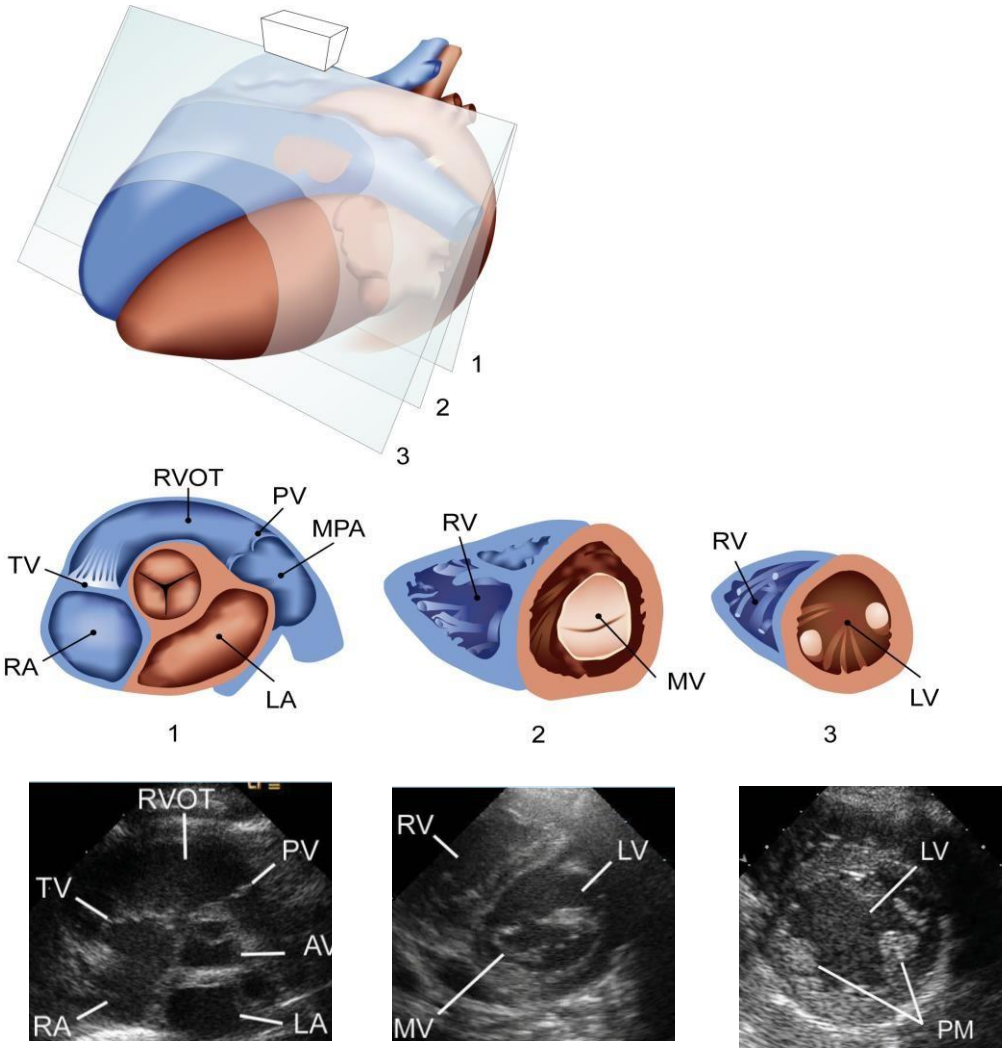
5.

Left parasternal short axis views: with the transducer in the same 3rd or 4th intercostals spaces, where optimum long axis view was obtained, rotate the transducer by 90 degrees, the images are shown as if looking superiorly from the apex of the heart [Figure 6].

- Most superior plane: the aortic valve in cross section in the middle of the screen with it is typical 3 cusps, the right ventricular outflow tract anteriorly leading to the pulmonary valve to the left of the aortic valve and the main pulmonary artery in it is longitudinal plane giving rise to the right and left branch pulmonary arteries. The tricuspid valve to the right and the interatrial septum at 7:00 o'clock position separating the right and left atriums. Ductal flow could be demonstrated there but a higher cut towards the aortic arch is better. Coronary arteries can be easily visualised in this section bearing in mind that the right coronary artery arises at a higher level than the left. [Figure 6a].
- Midlevel plane transects the left ventricle and the mitral valve which has a characteristic fish-mouth appearance surrounded by the left ventricular endocardium. This is a good position to assess wall motion abnormalities and m-mode analysis, mitral valve abnormalities [Figure 6b].
- Inferior plane: further inferior angulation: papillary muscles of the left ventricle, medial angulation from there permits visualisation of the anterior

and or septal leaflets of the tricuspid valve [Figure 6c].

Figure 6:



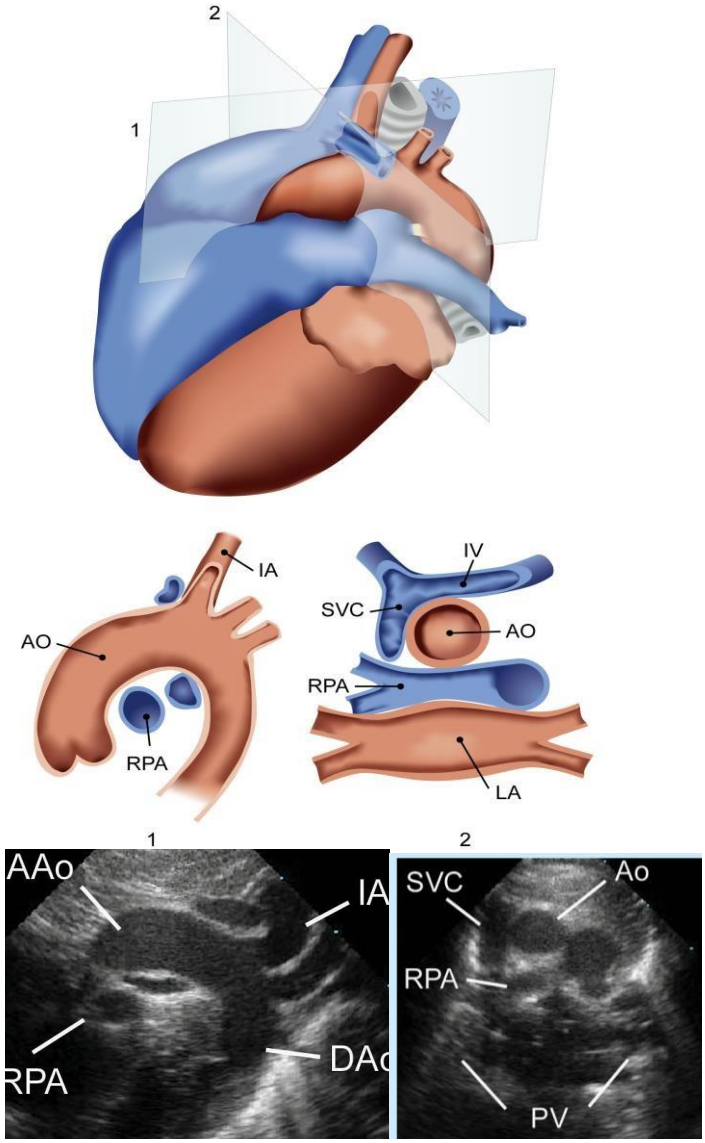
6a 6b 6c

6.

Suprasternal views: in neonates and infants this view is better obtained just to the right of the suprasternal notch in the right first intercostal space angulating the transducer to the left between 11:00 and 1:00 o'clock [Figure 7].

- Long axis view Arch view: illustrates the ascending aorta, aortic arch , isthmus and descending aorta, innominate vein could be visualised most anterior to the arch and could be traced to the right superior vena cava,the origin of the 3 head and neck vessels [Figure 7a]. The arterial duct can be easily seen as well
- Transverse view (3 vessel view): aortic arch in cross section with superior vena cave to the right and pulmonary artery posterior and to the left giving rise to the right pulmonary artery posterior part of the image the LA could be demonstrated with the 4 pulmonary veins draining [Figure 7b], with angulation to the left a better profile of the ductus could be obtained.

Figure 7:



7a 7b

M-Mode: modality is created by a very narrow ultrasound beam plotted against time, it is important in evaluation of cardiac function, measurement of dimensions and timing [Figure7].

1. measurement of cardiac dimensions and wall thickness
2. LV systolic function
    a. Fractional shortening normal value (28-44%, 95% CI).
    b. EF ejection fraction is the cubed derivative normal value (64 – 83%, 95% CI)

FS (%) = LVIDd – LVIDs/LVIDd X 100

3. assessment of valve motion
4. detection of pericardial fluid

Colour flow mapping: it is a colour-coded Doppler superimposed on the 2-D image demonstrating the direction and turbulence in the blood flow across cardiac structures. The coding is red towards the transducer, blue away from the transducer, and mosaic of red blue and yellow in turbulent flow.

Doppler echocardiography: it detects frequency shifts which enable the detection of blood flow velocity and direction the pulsed Doppler provides precise sampling site but the maximum velocity is limited so at high velocities aliasing becomes a limiting factor, then continuous Doppler (CW) have to be used instead

The formula used to calculate the pressure gradient is called the Bernoulli equation:

$P1 - P2 = 4(V2^2 - V1^2) = 4V^2$ >>>>>> $4V^2$

V2 is the Doppler velocity post obstruction and V1 the velocity pre obstruction.

MAJOR ABNORMALITIES TO BE PICKED UP BY PAEDIATRICIANS:

Diagnosing a major abnormality which have been during general fetal screening, and which is duct dependent, could be lifesaving. The first one to be faced with this problem is the On-call neonatologist or the paediatrician if the baby went home and then presented collapsed to A&E.

Examples:

1. Duct dependant pulmonary circulation: critical pulmonary stenosis, pulmonary atresia, tricuspid atresia.
2. Duct dependant systemic circulation: Critical aortic stenosis, Coarctation, Interruption aortic arch, HLHS.
3. Cyanotic non-duct dependant: obstructed TAPVD, Fallot.
4. Lesions presenting with high cardiac output heart failure and if prolonged pulmonary hypertension: Truncus, CAVSD, large left to right shunts.

Table1.1: Normal M-Mode Echo measurements (mm): mean (95% prediction interval

BW(kg)	3	5	8	10	15	20	25	30	40	50	60	70
BSA(m^2)	0.24	0.34	0.45	0.52	0.68	0.82	0.94	1.06	1.27	1.47	1.65	1.82
IVS	4.5 (3.5-5)	4.5 (4-5.5)	5 (4.5-6)	5.5 (4.5-6)	6 (5-7)	7 (5.5-8.5)	7 (5.5-9)	7.5 (6-9)	8.5 (6.5-10)	8.5 (7-10)	9 (8-10.5)	9.5 (7.5-11)
LVPW	4 (3.5-5)	4.5 (4-5)	5 (4-6)	5 (4.5-6)	6 (5-7)	6.5 (5.5-8)	7 (6-8)	7 (6-8.5)	8 (6.5-9)	8.5 (7-9.5)	8.5 (7.5-10)	9 (7.5-11)
AO	12 (10-14)	13 (11-16)	15 (12-17)	16 (13-18)	18 (15-22)	19 (16-23)	21 (17-24)	22 (18-26)	23 (19-27)	25 (20-29)	26 (21-30)	27 (23-32)
LA	18 (15-21)	20	(16-23)	21 (17-25)	22 (18-26)	25 (21-29)	27 (22-32)	28 (23-33)	30 (24-35)	32 (26-37)	34 (28-41)	36 (29-42)
LVDD	21 (18-23)	25 (22-27)	28 (24-31)	29 (25-32)	33 (29-36)	35 (31-39)	37 (33-41)	39 (34-43)	42 (37-47)	44 (39-49)	46 (41-51)	48 (42-53)
LVSD	14 (12-17)	16 (13-19)	17 (14-21)	18 (15-22)	21 (17-24)	23 (18-27)	24 (19-28)	24 (21-29)	27 (22-32)	28 (23-33)	29 (24-34)	31 (25-36)

Adapted from Henry Ware et al Circulation 1987. 57:278-287. Although it is an old publication, it still holds up as the newer ones tended to underestimate the measurements

AO= ascending aorta; BSA= body surface area; BW=Body weight; IVS=interventricular septum; LA=left atrium; LVDD=left ventricular diastolic dimension, LVPW=left ventricular posterior wall; LVSD=left ventricular systolic dimension

3. Education and Training

None

4. Monitoring Compliance

None identified at present

5. Supporting References

1. Pediatric Echocardiography. Norman Silverman; 1993.
2. Echocardiography in Pediatric Heart Disease. Rebecca Snider; 1990.
3. Moss and Adams Heart Disease in Infants, Children, and Adolescents Volume I; 1989.
4. Illustrated Field Guide to congenital Heart Disease and Repair. Allen D Everett, D Scott Lim; 2005.

6. Key Words

Cardiac, Cardiomyopathy, Congenital Heart Disease, ECG, Echocardiography, Imaging

The Trust recognises the diversity of the local community it serves. Our aim therefore is to provide a safe environment free from discrimination and treat all individuals fairly with dignity and appropriately according to their needs.
As part of its development, this policy and its impact on equality have been reviewed and no detriment was identified.

CONTACT AND REVIEW DETAILS	
Guideline Lead (Name and Title) **Suhair Shebani – Paediatric Cardiologist**	**Executive Lead:** **Chief Nurse**
REVIEW RECORD	
Description Of Changes: No changes to guidance **Added link to sedation guideline** **Format update**	