Fetal echocardiography

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Introduction

Fetal heart is a relatively complex structure. It starts developing from 3rd weeks & continue to develop till 10th completed week. So it’s formation extends right through out the organogenesis period. That’s why it is having association with other malformations. Cardiac malformations occur in 8-13 / 1000 live birth (1), among all pregnancy including still born, the incidence is 30/1000. Structural cardiac anomalies are most frequently missed fetal malformations. (2, 3) It is associated with chromosomal abnormality in approximately 50% of CHD & the incidence is high among the prenatal series compared to neonatal series due to high SB rate. Prenatal detection can improve the fetal outcome. (4, 5)

In 274 prenataly confirmed diagnosis of CHD, 109 were found to have aneuploidy in a study published in Ob gyn 1993

Chromosomal abnormality in CHD
**Etiology:** It’s complex etiology with interplay of chromosomal abnormality & environment factors. Maternal disease, Infection, Drugs, Radiation also play important role in CHD.

**Indications**

- P/H/O child born with CHD in the same mother
- Familial
  - Family History of CHD
- Predisposing Maternal Conditions
  - Maternal Diabetes
  - Infection During Pregnancy
  - Maternal Alcoholism
  - Maternal Connective tissue Disorder
  - Maternal Phenyl ketonuria
- Exposure to Teratogens
- Abnormal Pregnancy Progression
  - Polyhydramnios
  - Non immune Hydrops
  - Dysrhythmias
  - Extra cardiac Malformations
  - Chromosomal Aberrations
  - Symmetrical IUGR

**Factors affecting prenatal detection:** Prenatal detection rate vary among various study published due to various factors like examiner experience, maternal obesity, transducer frequency, abdominal scars, gestational age, amniotic fluid volume, and fetal position. (6, 7) Standard technique and a guideline along with the training of the personnel will gradually change the scenario. But still the fact that ASD, small VSD & patent ductus are easy to miss remains.

**Fetal echo cardiography**

1. **Basic fetal echocardiography**
   a. Detailed 4 chamber view examination

2. **Extended fetal echocardiography**
   a. Outflow tracts
      i. Left ventricular outflow tract (LVOT)
      ii. Right ventricular outflow tracts (RVOT)
   b. 3 vessel view
      i. Ductal arch view
      ii. Aortic arch view (Tracheal view)

3. **Advance fetal echocardiography**
   a. Color Doppler
b. M mode examination

c. Spectral Doppler

d. Stic

Basic & extended fetal echocardiography guidelines are designed to diagnose & suspect majority of cardiac malformations during 2\textsuperscript{nd} trimester (8). It will help in improving pick up rate in low risk population screening for cardiac malformations of fetus (9) & if still suspicious, one can refer for advanced fetal echocardiography.

**When to do? Timing for echocardiography**

The best time to do echocardiography is 18-22 weeks of pregnancy – to be more accurate – 22 weeks. This is the when heart is significantly large, Amniotic fluid is relatively more & ribs do not cast a shadow to obscure the imaging of heart. If there is P/H/O CHD one can do early echo at 16-18 weeks with reasonable accuracy. Early echo is indicated also in cases where NT was high at 11-13 weeks scan with normal chromosomes, DV flow & TR is abnormal.

**Setting of machine:**

It’s most important to set the parameters of the machine for optimizing the image for fetal echo. It’s beyond the capacity of this chapter. Reader is requested to refer to the lecture on ISUOG website on this subject by de vore.

**Steps for fetal echo**

1. Define side of fetus
2. Confirm situs of fetal organ.
3. Different heart view for fetal heart
   a. 4 chamber view
   b. Outflow tracts
      i. LVOT

**1. Define laterality and abdominal situs**

Determine how the fetus is lying inside the uterus and figure out which is the right and left of the fetus:

- The presentation of the fetus is cephalic, breech or transverse
- The spine is upwards towards the transducer, backwards or lateral
- Confirm that both the stomach and heart are on the left side
Obtain the 4-chamber view and maintaining a transverse section of the fetal trunk, angle or slide the transducer downwards to the abdomen, in order to image the stomach and situs

**Abdominal situs**

**Simple observation**
1. Fetal cephalic presentation – abdominal organs are in clock wise rotation like – spine stomach, portal vessel
2. Fetal position is breech - – abdominal organs are in Anti-clock wise rotation like – spine stomach, portal vessel
The basic intra cardiac views:

By single sweep from AC upward one can get it.

- The 4-chamber view
- The left ventricular outflow tract (or aortic origin) view
- The 3-vessel view (Ductal arch view) – RVOT is part of it
- The transverse aortic arch view – tracheal view

Normal 4-chamber view

Overview

The 4-chamber view:

- Most important section of the heart and it is essential to evaluate this correctly
- It’s much more than 4 chamber count
- It is abnormal in about 60% of major cardiac malformations
- Systematic analysis: size, position, structure and function
- Views
  - Apical view with spine away from probe – ideal
  - Lateral view – Apex facing on either side laterally – reasonable
  - Basal view – spine near probe, gives poor imaging of heart
- The rules for analysis of the 4-chamber view are the same no matter which way the fetus is lying
Heart size

The heart normally occupies central one third of the area of the chest

- Circumference of the heart should be compared to the thoracic circumference (C/T ratio). The normal C/T ratio is around 0.55 (range 0.5-0.6). However, this is not a precise measurement and should only be used as a rough guide

Heart position

Most of the heart lies in the left chest with tilt of the axis to left at 45° ± 20° to the midline of the thorax with apex pointing to left anterior chest wall.

- The left atrium (LA) is the most posterior chamber in the normal heart, lying just anterior to the descending aorta, which lies anterior to the spine
• The right ventricle (RV) lies behind the sternum

**Heart structure**

There are many structures to note in the 4-chamber view but with experience, this can be achieved within seconds of finding the correct image

• There are two atria of approximately equal size & contract equal & simultaneously
• There are two ventricles of approximately equal size & contract equal & simultaneously
• The crux or centre of the heart is formed by the junction of the atroventricular septum and the septal leaflets of the mitral and tricuspid valves
• There are two atroventricular valves opening equally, the mitral valve on the left inserted more towards base and the tricuspid valve on the right & inserted more apically and therefore there is “off-setting” of the two valves into the crux
• Remember that valves belong to ventricles
• The apex of the right ventricle is more trabeculated than the left and contains a particularly thick muscle bundle - moderator band
• There is normally a small amount of fluid in the pericardium producing a dark line around the myocardium
• The ventricular septum is intact from the apex to the crux
• The primum atrial septum attaches to the crux. There is a defect in the middle third of the atrial septum (the foramen ovale) which is guarded by the foramen ovale flap in the left atrium
• There is one vessel lying behind the heart (the descending aorta), just to the left of the midline, between the spine and left atrium
• The pulmonary veins attach to the back of the left atrium. Their connection must be confirmed on colour flow mapping

**Heart function**

• The two ventricles contract equally and briskly
• The two atroventricular (AV) valves open equally and freely
• On colour flow mapping, there is equal filling of both ventricles and there is no significant AV valve regurgitation
• A small amount of tricuspid regurgitation on colour flow mapping is not uncommon with modern sensitive ultrasound machines and is usually of no significance in the midtrimester fetus
• The atria and ventricles contract synchronously and regularly at a rate of about 140 beats per minute with a range of 120-180

**Extended Fetal echo**
Normal Outflow tracts

Overview

- About 40% of major heart defects are seen in the great artery views. It is therefore important to extend cardiac evaluation from the 4-chamber view to image the outflow tracts.
- The great arteries should be analyzed systematically, with reference to size, position, structure and function.
- The great artery views include:
  - Left ventricular outflow tract (aortic origin) view
  - 3-vessel view
  - Transverse aortic arch view

Additional views or complimentary view

- Long axis view of the left ventricle
- Arch and duct view
- Long axis view of the duct
- Long axis view of the arch
- Short axis view of the left ventricle
- Tricuspid-aorta view
- Caval vein view

- If you can recognize an abnormal appearance of any of these views and describe accurately why it is different from normal, you can reach the correct diagnosis.

Left ventricular outflow tract view

- In the normal heart, the first great artery, seen just above (cranial to) the 4-chamber view, is the aorta.
- The aorta arises wholly from the left ventricle and initially sweeps out towards the right.
- There are no visible branches of the aorta close to the valve.
- The anterior wall of the aorta is continuous with the ventricular septum.
- The posterior wall of the aorta is continuous with the anterior leaflet of the mitral valve.
- The aortic valve opens freely during systole visible as dot in diastole. (the valve cusps disappear in systole).
- On color flow mapping there is laminar (non-turbulent) forward flow across the aortic valve and no regurgitation.
Arterial crossover

- Just above the aortic valve, the pulmonary artery arises from the right ventricle. Note that they arise almost at right angles to each other: the flow is directed cranially and rightwards in the aorta and directly posteriorly in the pulmonary artery.
- As the beam is moved up towards the head from the view of the aortic origin, the pulmonary artery is seen to cross over the aortic origin.
- By moving the ultrasound beam back and forward between the view of the aortic origin and the three vessel view (which images the pulmonary artery), the relative size and position of the two great arteries can be noted.

The 3-vessel view

Maintaining a transverse section, sweep the beam further up towards the head. Just above the aorta, the pulmonary artery, arising from the right ventricle, crosses over the aortic origin and continues as the arterial duct.
The 3-vessel view (Also called Line/dot/dot view)

- The pulmonary artery is normally slightly bigger than the aorta. (For example, at 20 weeks the pulmonary artery is about 3.5 mm and the aorta is about 3.0 mm).
- The pulmonary valve is anterior and cranial to the aortic valve.
- The pulmonary valve opens freely with laminar flow across it.
- The pulmonary artery continues as the arterial duct and connects to the descending aorta.
- The pulmonary artery branches laterally soon after the valve. The branches of the pulmonary artery are seen just below the level of the arterial duct, therefore just below the 3-vessel view.
- In the video the left pulmonary artery is seen better in the black and white image, whereas the right pulmonary artery is more clearly seen by color flow.
- The branching characteristic of the pulmonary artery serves to distinguish this vessel from the aorta, in situations where the great arteries are not normally connected. As the first main branches of the aorta are distal from the valve and are directed superiorly, they are seen in the long-axis views.
- Note that the first aortic branches are the coronary arteries, which lie just above the aortic valve, but they are small and they are not normally seen in the fetus.

From Left to right Pulmonary artery(Line), Ascending aorta(Dot) & superior vena cava (Dot) is visible The aorta is slightly bigger than the superior vena cava.
Transverse aortic arch view

The transverse aortic arch is seen just above the 3-vessel view. The arch:

- Lies above the arterial duct
- Crosses the midline of the thorax from right to left in front of the trachea
- Has an even caliber along its length
- Demonstrates forward flow on color Doppler

Transverse aortic arch view

Maintaining a transverse section of the fetal trunk, sweep the beam further up towards the head. Just above the pulmonary artery, the aorta forms the aortic arch

Position & relations of Valves of heart
Fetal echo advantage

Conclusion:

Fetal echocardiography is a recommended guideline by American society of ultrasound & fetal medicine as a part of routine screening. When suspect cardiac malformation – advanced fetal echo by trained & experienced person shall be carried out. Association of fetal cardiac malformations with chromosomal abnormality & other malformations, high abnormal in utero out come makes ir worth to screen the heart by basic & extended fetal heart examination guidelines. It may be difficult, not impossible.

References:


