

An update on technique of fetal echocardiography with emphasis on anomalies detectable in four chambered view.

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- Fetal echocardiography is an essential tool for screening of fetal cardiac anatomy. The spectrum of congenital heart disease (CHD) that can be encountered in the fetus is wide, with a significant number of very complex defects. Prenatal diagnosis of cardiac defects is important because it allows families to receive appropriate counseling and to properly prepare for the birth of a child with CHD.
- The description of these cardiac defects can benefit from a sequential and segmental analysis, which consists of a step-by-step procedure that defines the central cardiovascular connections, beginning from the venous pole to the arterial one. The first step is the description of the viscero-atrial situs; then the atrioventricular and ventriculoarterial connections are defined and described.
- The steps of the imaging technique are summarized as follows;
 1. Identification of left and right sides of the fetus: This can be achieved by identifying the position and orientation of the fetus relative to long axis of the mother.
 2. Determination of the visceral situs: Transverse view of the abdomen
 3. Cardiac views can be further classified as :
 - * Axial views:
 - 4-chamber view
 - 3-vessel view
 - 3-vessel-tracheal view (transverse aortic and ductal arch view)
 - * Oblique views
 - Long axis of left ventricle
 - Long axis of right ventricle
 - Short axis of the right ventricle (Basal short axis view)
 - * Sagittal views:
 - Cavo atrial junction/ Bicaval view
 - Aortic arch view (candy cane-like)
 - Ductal arch view (hockey stick-like)

Transverse view of the abdomen; check list

- This is the view that is used for measurement of abdominal circumference.
- The larger lobe of the liver and gall bladder are on the right, and the stomach on the left .
- The cross section of the abdominal aorta is at the left anterior corner of the spine , whereas the cross section of the inferior vena cava is on the right.
- The IVC is a anterior structure compared with aorta because it courses forward as it connects to the right atrium.
- Sickle shaped spleen is seen behind the stomach.

Figure 1

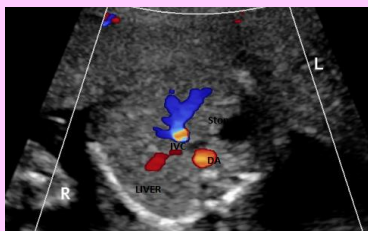


Figure 1: Transverse abdominal view. The fetal stomach is on left side and liver is on right side. The descending aorta lies anterior and to the left of the spine, whereas IVC lies anterior to the right of the descending aorta (DA).

Four-chamber view

- From the transverse view of the abdomen, the transducer is moved up towards the fetal head to obtain the 4-chamber view.
- If the cardiac apex is directed towards the transducer and the inter ventricular septum is aligned with the insonating beam it is termed as apical four chamber view. If the inter ventricular septum is at 90 degree angle with the insonating beam, it is termed as transverse four chamber view. For a correct assessment of the four chamber view, both approaches should be sought. The atrioventricular plane and the posterior atrial walls are better assessed on the apical 4-chamber view, whereas the septa, the myocardial walls and the chordae tendinae are better displayed on the transverse 4-chamber view.
- Assignment of the cardiac chambers: the cardiac chamber in front of the spine/ descending aorta is the left atrium, while the chamber located just below the sternum is the right ventricle. The remaining two chambers (left ventricle and the right atrium) are consequently assigned. Presence of one complete rib on either side of the thorax ensures the true axiality of the 4-chamber view.
- The following are the checklist
 - 1) A normal heart is approximately 1/3 of thorax in size.
 - 2) Two third of the heart is in the left hemithorax.
 - 3) The cardiac axis lies at a 45 degree angle to the left of mid line (levocardia). This is calculated tracing a line along the interventricular septum and measuring the angle between this line and the mid sagittal line, traced between sternum and spine.
 - 4) At least two of the 4 pulmonary draining veins into the left atrium.
 - 5) The two atria are equal in size.
 - 6) The flap of foramen ovale opening into the left atrium.
 - 7) The two atrio ventricular valves are equally opened and differentially inserted : the septal leaflet of the tricuspid valve is inserted more apically than the mitral valve in the ventricular septum. Blood flow across both valves should be evaluated by color dopler imaging to ensure that both ventricles fill equally in diastole without regurgitation. The pulsed waveforms are optional. The E wave corresponds to the early ventricular filing of diastole and is followed by a A wave which corresponds to active ventricular filling of diastole (atrial contraction). The A-wave is always higher than E-wave in the normal foetus. The peak velocity of both waves is 30-60 cm/sec and is constant through out the gestation.
 - 8) The two ventricles of roughly similar size , with the right one slightly wider and rounder than left , due to the presence of moderator band in the apical part.
 - 9) Free right and left myocardial walls of similar thickness and with regular contractility.
 - 10) The ventricular septum is intact.
 - 11) The crux of the heart, the area of the junction of atrial septum, atrio ventricular valves and inter ventricular septum is intact.
 - 12) The descending aorta is located anterior and the left of spine

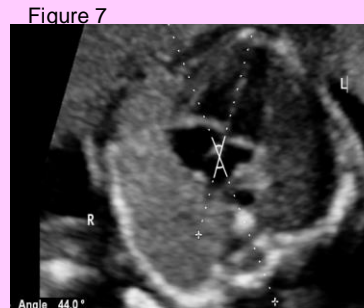
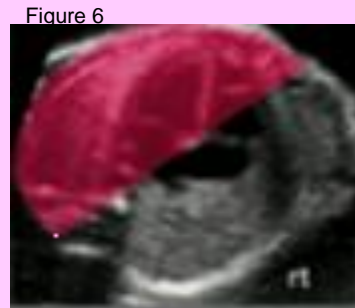
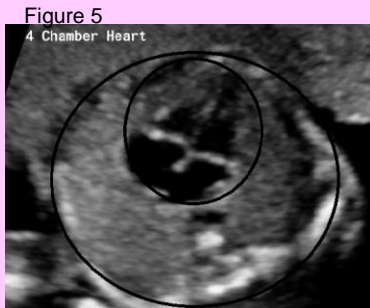
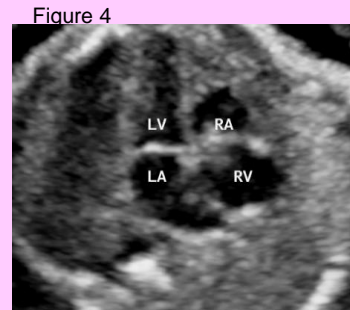
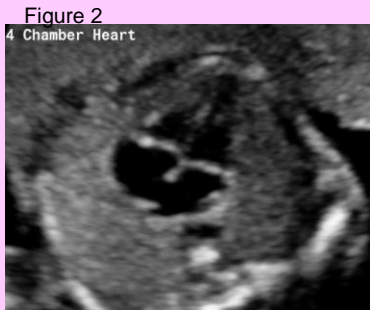


Figure 2 & Figure 3 : Apical and transverse 4-chamber views.
 Figure 4: Assignment of cardiac chambers.
 Figure 5: Assessment of cardiac size.
 Figure 6: Two third of the heart is in left hemithorax.
 Figure 7: Assessment of cardiac axis.

Figure 8

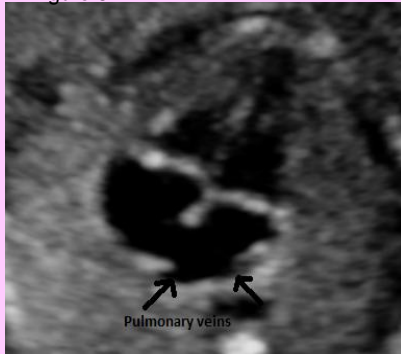


Figure 9



Figure 8: Inferior pulmonary veins draining to left atrium.

Figure 9: Two atria are of equal size.

Figure 10: Foramen ovale flap opening into left atrium.

Figure 11: Pulsed wave doppler waveform across the tricuspid valve demonstrating 'E' and 'A' waves corresponding to early ventricular filling and active ventricular filling/ atrial contraction.

Figure 12: Two ventricles are of equal size.

Figure 13: Moderator band in the right ventricle.

Figure 14: Free myocardial walls are of similar thickness.

Figure 15: Interventricular septum is intact.

Figure 10

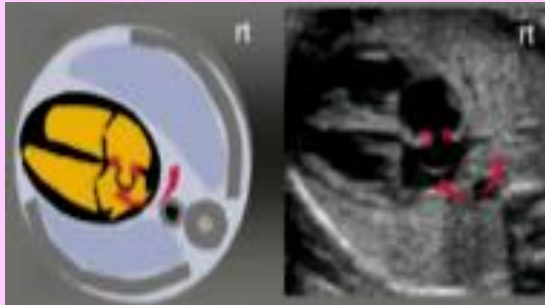


Figure 11

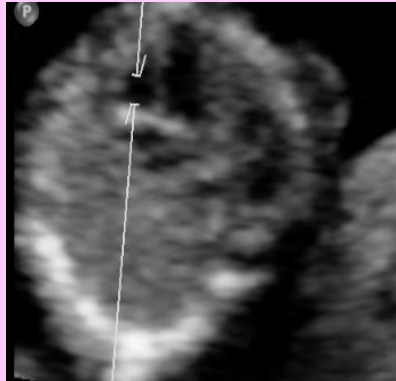


Figure 12



Figure 13



Figure 14

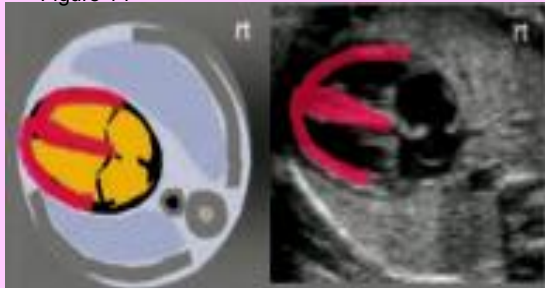
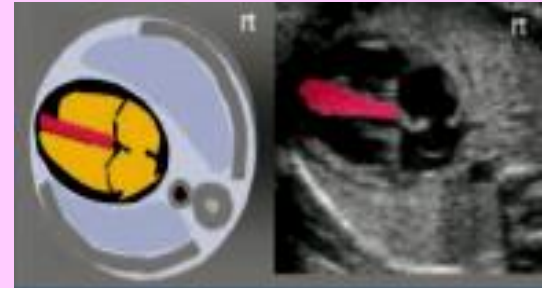


Figure 15



From the 4-chamber view, when the transducer is moved upward along the long axis of fetal body, the 5 chamber view is seen. The aortic valve seen to arise from the left ventricular valve in the center of 4 chambers.

3 vessel view

- Further upward movement of creates the 3 vessel view in which the oblique section of the main pulmonary artery and cross-sections of the ascending aorta and superior venacava (SVC) are seen.
- The three vessels are arranged in a straight line from the left anterior to right posterior with decreasing order of size. The pulmonary artery is the largest in size, followed by ascending aorta and SVC.
- The thymus is also clearly visible in this view.

3 vessel tracheal view / Transverse aortic and ductal arch view

- Slight angulation of the transducer shows the 3 vessel tracheal view.
- The aortic and ductal arches make a 'V' shaped confluence at the descending aorta .
- The aortic arch is a sausage-like structure coursing obliquely from right anterior to left posterior on the left side of trachea. To emphasize the presence of the trachea this view has been termed as 3 vessel tracheal view. The ductal arch is slightly bigger than the aortic arch.
- Colour doppler shows the same direction of blood flow in both the arches.
- The main pulmonary artery divides into right and left pulmonary arteries. The right pulmonary artery takes a long horizontal course in front of the tracheal bifurcation before it reaches the right hilum.
- The left pulmonary artery courses obliquely, backward and leftward to reach the left lung hilum.

Figure 16



Figure 17



Figure 16: 3 vessel view showing oblique sections of the main pulmonary artery and Cross sections of the aorta and IVC.

Figure 17: 3 vessel tracheal view shows the 'V' shaped confluence of the aortic and The ductal arch. The trachea is located to the right of aorta.

Long axis of the left ventricle

- From the 4 chamber view, the transducer is rotated towards the fetal right shoulder to obtain the left ventricular outflow tract (LVOT).
- This view shows the left ventriculoarterial connection as well as the intact ventricular septum.

Checklist

1. The presence of a vessel that connects with the morphologically left ventricle positioned on the left and that can be defined as the aorta (branching at wide angle far from the semilunar valve)
2. Septo-aortic continuity .
3. The presence of a semilunar valve showing normal systo-diastolic excursion (the leaflets disappear completely during systole, being flattened on the aortic walls).
4. The presence of crossover: the direction of the aorta is at roughly 90 degree to the direction of the pulmonary trunk displayed on the long axis of the right ventricle.
5. The size of the vessel is similar to (slightly smaller than) that of the other vessel visualized on the long axis of the right ventricle.
6. Blood flow across the aortic valve is laminar flow with no turbulence in systole and no regurgitation in diastole. Peak systolic velocity in the aorta increases linearly with advancing gestational age, and it ranges from approximately 30cm/sec at 19 weeks to 100cm/sec at full term. PSV in aorta is greater than in the pulmonary artery.

Long axis and short axis view right ventricle

- Long axis view of the right ventricle : This view is obtained from the long axis of the left ventricle, by curving the transducer towards the fetal head. It depicts only the infundibular part of the main pulmonary artery with the semilunar valve. It can be obtained in virtually all positions.
- The short axis view of the right ventricle is more complete, since all the connections of the right heart are displayed. This view visualises three components of the right ventricle, namely inlet, trabecular and outlet parts. This plane is easily achieved only if the fetus is lying with a posterior spine. To obtain this view, from the 4-chamber view, the transducer should perform a rotation mirroring that needed for the long axis of the left ventricle, i.e., towards the left fetal shoulder
- Checklist:
 1. The presence of a vessel that connects to the morphologically right ventricle positioned on the right and that can be defined as the pulmonary artery (acute angle bifurcation).
 2. The presence of a semilunar valve showing normal systolic-diastolic excursion (the leaflets disappear completely during systole, flattening on the pulmonary artery walls).
 3. The presence of crossover : the direction of the pulmonary artery is at roughly 90 degree to the direction of the aorta displayed on the adjacent long axis of the left ventricle.
 4. The size of the vessel is similar to (slightly larger than) that of the aorta visualised on the long axis of the left ventricle.

Figure 18

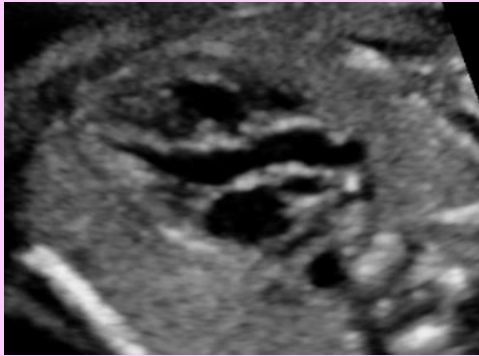


Figure 19



Figure 20

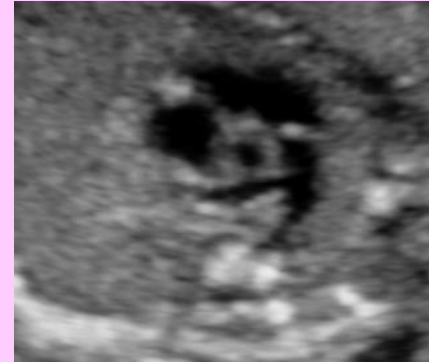


Figure 18 : Long axis view of LVOT.
Figure 19: Long axis view of RVOT.
Figure 20 : Short axis view of the RVOT / Basal short axis view.

Cavoatrial junction view/ Bicaval view/SVC and IVC view/ Saegull wing's view

- This view is obtained in right parasagittal plane.
- The SVC and IVC drain into the posterior aspect of the right atrium.
- The SVC and IVC are similar in size; however the IVC is widened as it enters the right atrium because of interflow from ductus venosus and hepatic veins.

Figure 21



Figure 21: Cavoatrial junction showing the SVC and IVC draining into the right atrium

Aortic arch view (sagittal)

- By rotating the transducer 90 degree either clockwise or counter-clockwise from the 3VV, a candy cane-like aortic arch is seen. In the aortic arch view, the ascending aorta arises from the centre of the heart between the right and left atria and therefore is some distance from the anterior chest wall
- The aortic arch gives rise to the three arterial branches. Aortic arch view shows the right Innominate, left carotid and left sub clavian arteries arising from the greater curvature side of the arch.

Ductal Arch View (sagittal)

- By sliding the transducer from the aortic arch view to the left, a hockey stick like ductal arch is visualised.
- The ductal arch arises far anteriorly, immediately behind the anterior chest wall, as its proximal part is the main pulmonary artery. It takes rather long course backward as it connects to the descending aorta through the ductus arteriosus. Unlike aortic arch, ductal arch does not give any branch

Figure 22



Figure 23



Figure 22: Aortic arch view (sagittal)
Figure 23: Ductal arch view. (sagittal)

M- Mode

- M-mode is useful in assessing motions and rhythms of the heart. With M- mode a recording of the variations of echoes along a single line are produced.
- This is helpful for quantifying cardiac frequency and atrioventricular sequence of contractions can be inferred.

Pulsed wave and colour doppler:

- Color doppler overlays a representation of flow velocity over a conventional gray scale image. This allows a rapid recognition of flow pattern. Color doppler is useful to assess normal anatomy and physiology, valvular regurgitation and stenosis, shunting and orientation of flows.
- Pulsed wave Doppler is used to analyse the spectral shift (to assess the resistance in a vessel), to obtain flow velocities (how the resistance affects the flows) and flow predictions (to estimate the perfusion). Pulsed doppler can be useful in the detection and assessment of severity of valvar abnormalities (stenosis, insufficiency).

Figure 24

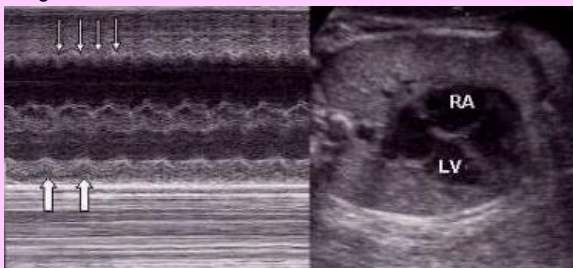


Figure 24: M-mode showing atrial and ventricular contractions

Anomalies recognizable in 4 chamber view



Anomalies recognisable in 4-chamber view.

Figure a. Normal heart.

Figure b. Right atriomegaly from tricuspid dysplasia & insufficiency.

Figure c. Ebstein's anomaly, apical displacement and insertion of the tricuspid valve.

Figure d. Ventricular septal defect.

Figure e. Atrioventricular septal defect with common atrioventricular valve.

Figure f. Left ventricular hypoplasia with mitral atresia (Hypoplastic left heart syndrome)

Figure g. Right ventricular hypoplasia (with VSD) due to tricuspid atresia.

Figure h. Double inlet single ventricle.

Figure i. Ventricular disproportion and moderate prevalence of the right ventricle. (an indirect sign of aortic coarctation).

Figure j. Biventricular hypertrophy (Cardiomyopathy).

Figure k. Tumors (rhabdomyomatosis)

Fetal echocardiography requires knowledge of normal fetal cardiac anatomy and physiology as well as major forms of congenital heart diseases and their haemodynamics. The prenatal diagnosis of cardiac defects depends on knowledge, skill and experience of the practitioner. A well standardized protocol should be set in order to reduce the examination time while maintaining a degree of diagnostic accuracy

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