

Fetal
Echocardiography:
Beyond the Four
Chambers

Chapter 35

Embryology of the Cardiovascular System ²

- Most sensitive period for cardiac development in first trimester is between 3.5 and 6.5 weeks.
- Cardiovascular system is first organ system to reach functional state.
- By end of third week, circulation of blood has begun.
- In fifth week, heart begins to beat.

Embryology of the Cardiovascular System ³

- Human teratogens produce or raise incidence of congenital malformations.
- 7% caused by environmental agents or teratogens
- Spontaneous abortion usually occurs if genetic malformation severe.

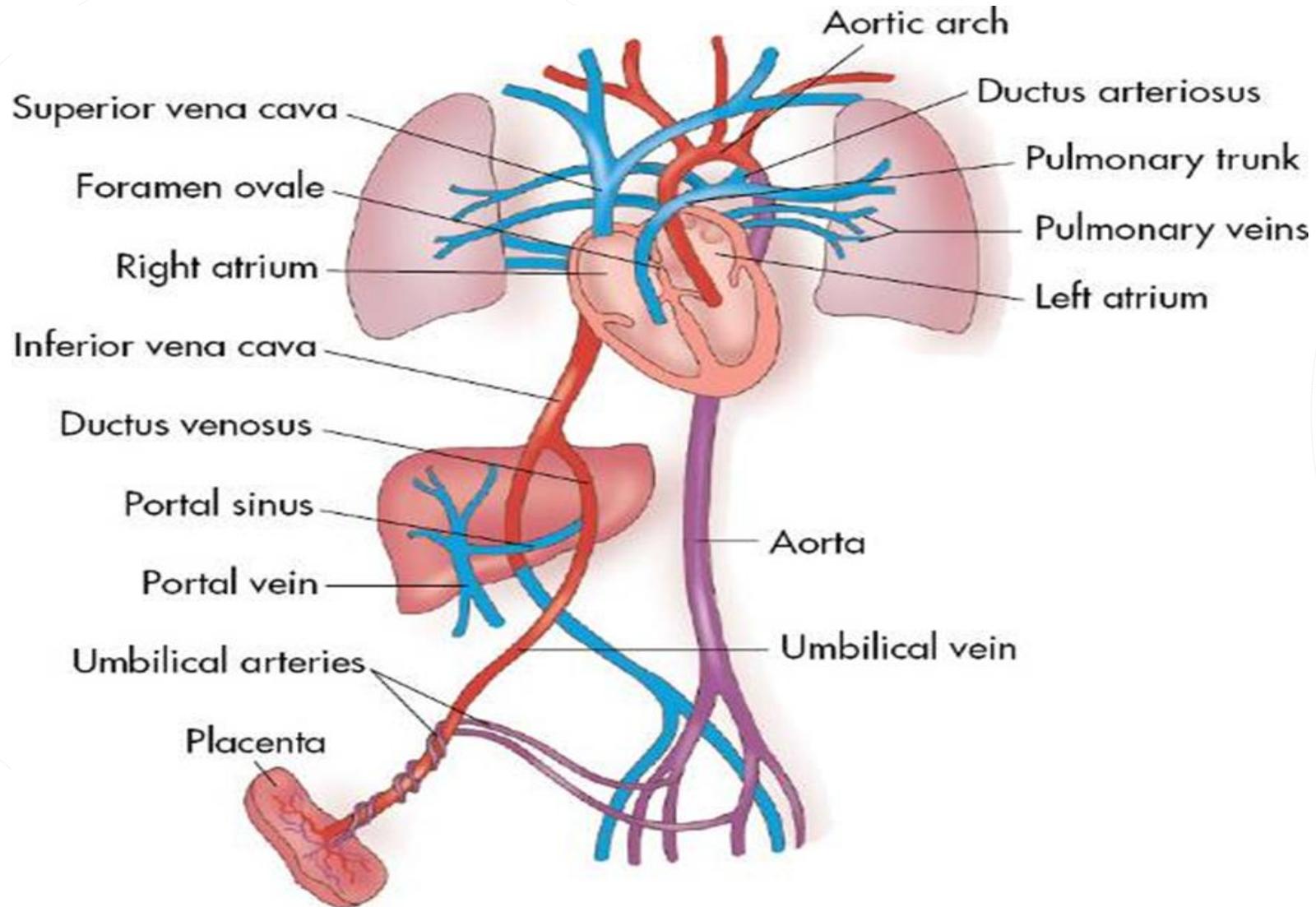
Development of Blood Vessels

- Circulation of blood starts by end of third week as tubular heart begins to beat.
- Embryo obtains sufficient nourishment during second week of development by diffusion of nutrients from maternal blood flow.
- Vascular system begins during third week in wall of yolk sac, connecting stalk, and chorion.

Development of Blood Vessels

- Blood vessels form two days later.
- Blood islands form; cavities develop in islands to form primitive blood cells and vessels.
- Primitive vessels form vascular network in wall of yolk sac.
- Umbilical veins return oxygenated blood from placenta; only one umbilical vein persists.
- Blood formation in embryo begins at fifth week.

Fetal Circulation



Fetal Circulation

- Communication is open between right and left sides of heart through fossa ovale, and between the aorta and pulmonary artery via the ductus arteriosus.
- Before birth fetus receives oxygenated blood by way of umbilical vein from placenta to heart.
- Approximately half of the blood passes through hepatic sinusoids; the rest bypasses the liver to go through ductus venosus into the inferior vena cava.
- Blood flows from the IVC and SVC and enters the right atrium.

Fetal Circulation

- Blood in RA flows through the tricuspid valve into the right ventricle and leaves the RV through main pulmonary artery.
- Bifurcates into right and left pulmonary artery branches that lead to their respective lungs.
- Most of this blood passes through the connection of ductus arteriosus into the descending aorta; only a very small amount goes to the lungs.

Fetal Circulation

- Blood mixes with small amount of deoxygenated blood as it returns from lungs via the four pulmonary veins into LA.
- Blood then flows from LA into LV through bicuspid mitral valve and leaves heart through ascending aorta.
- Rest of mixed blood in descending aorta passes into umbilical arteries and is returned to placenta for reoxygenation.

Fetal Circulation

- Circulation of fetal blood through placenta ceases after birth when the neonatal lungs begin to function.
- Fetal cardiac structures that are no longer necessary: foramen ovale, ductus arteriosus, ductus venosus, and umbilical vessels.

Heart Rate

- Normal fetal heart rate (HR) is between 120 and 160 beats per minute (bpm).
- First trimester of pregnancy: HR begins around 90 bpm and increases to 170 bpm before returning to normal rate and sinus rhythm.
- HR <100 bpm is bradycardia.
- HR >200 bpm is tachycardia.

Heart Rate

- Heart rate <60 bpm places fetus at high risk of associated heart disease.
- Association of complete heart block with structural cardiac defects has poor prognosis, perhaps because of their adverse interaction and the AV regurgitation that commonly complicates the condition.
- Connective tissue disorders like systemic lupus erythematosus are associated with heart block and pericardial effusion.

Indications for Fetal Echocardiography

- Fetal Indications:
 - Polyhydramnios (1.5%)
 - Nonimmune hydrops (7.5%)
 - Arrhythmias (23%)
 - Suspected cardiac abnormality on routine ultrasound

Indications for Fetal Echocardiography

- Fetal Abnormalities and Dysmaturity (11%)
 - Extracardiac abnormalities
 - Chromosome abnormalities
 - Intrauterine growth restriction

Fetal Risk Factors

- IUGR
- Cardiac arrhythmias
- Abnormal amniocentesis
- Abnormal amniotic fluid collections
- Abnormal HR
- Hydrops fetalis
- Presence of extracardiac abnormalities in fetus is frequently associated with congenital heart disease

Maternal Risk Factors

Maternal Disease Affecting the Fetus (7%)

- Diabetes
- Lupus erythematosus
- Infections during pregnancy

Maternal Ingestion of Drugs or Teratogens (4.5%)

- Alcoholism
- Drug exposure during pregnancy

Familial Indications

- Familial history of congenital heart disease (44%)
- Recurrence risk cited given a sibling with one of most common cardiovascular abnormalities varies from 2.5% to 3%.
- If one parent has congenital heart defect, recurrence risk ranges from 2.5% to 4%.

Beyond the Four-Chamber View

- Transducer selection
- Instrumentation
- M-Mode
- Doppler (color and PW Doppler)
- 3D and 4D

Transducer Selection

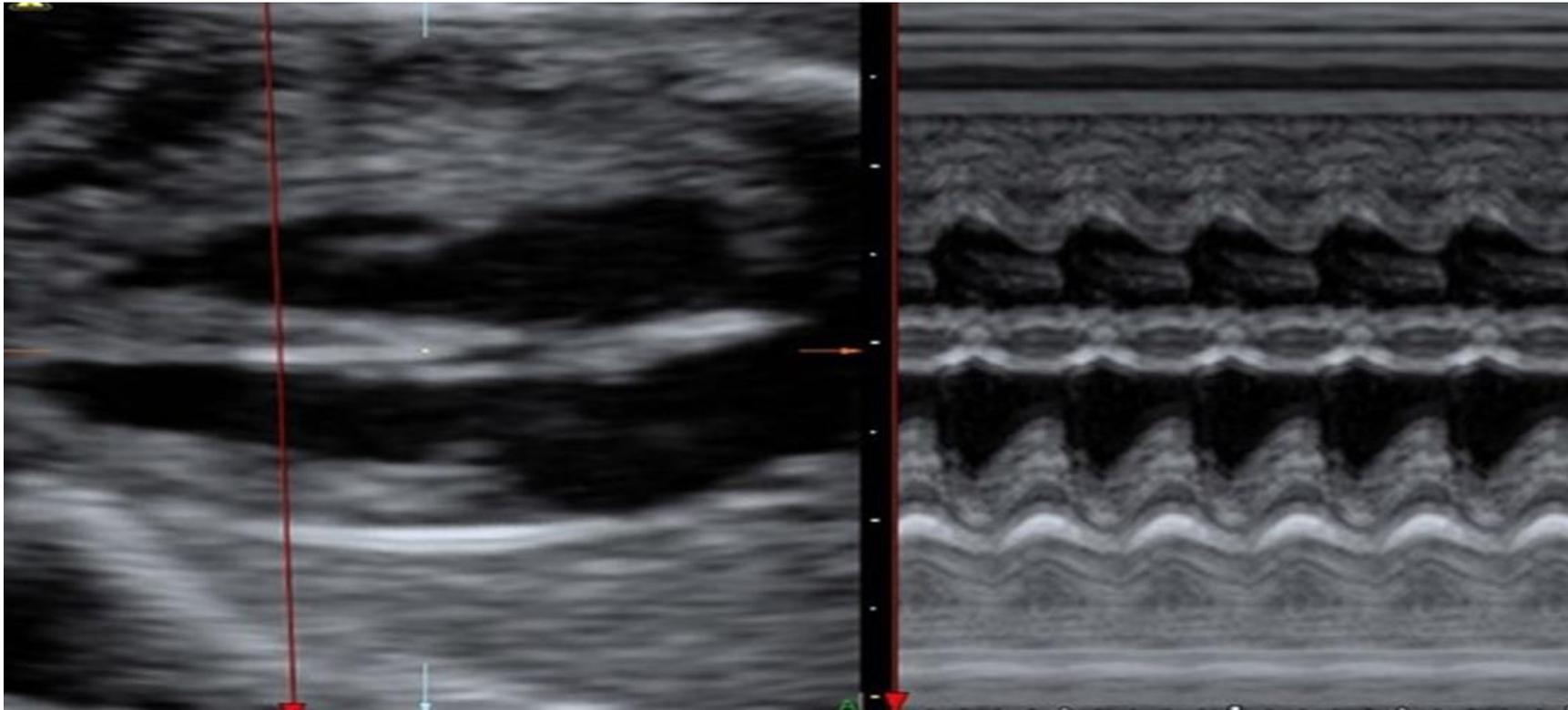
- Ideal transducer for fetal echocardiography is multifrequency transducer: can be quickly and easily changed from low to a high frequency.
- Early second trimester fetus may be adequately imaged with curved array transducer or small-sector, high-frequency probe.

Instrumentation

- Cine-loop
- High-power resolution (write zoom) capability
- Simultaneous M-mode with range expansion (for cardiac arrhythmias)
- Simultaneous Doppler capability with pulsed and continuous wave (to record high-velocity flow)
- Color Doppler

M-Mode Evaluation

- Once the two-dimension image is made, a single vertical line of information can be obtained from the face of the transducer through the fetal cardiac structures

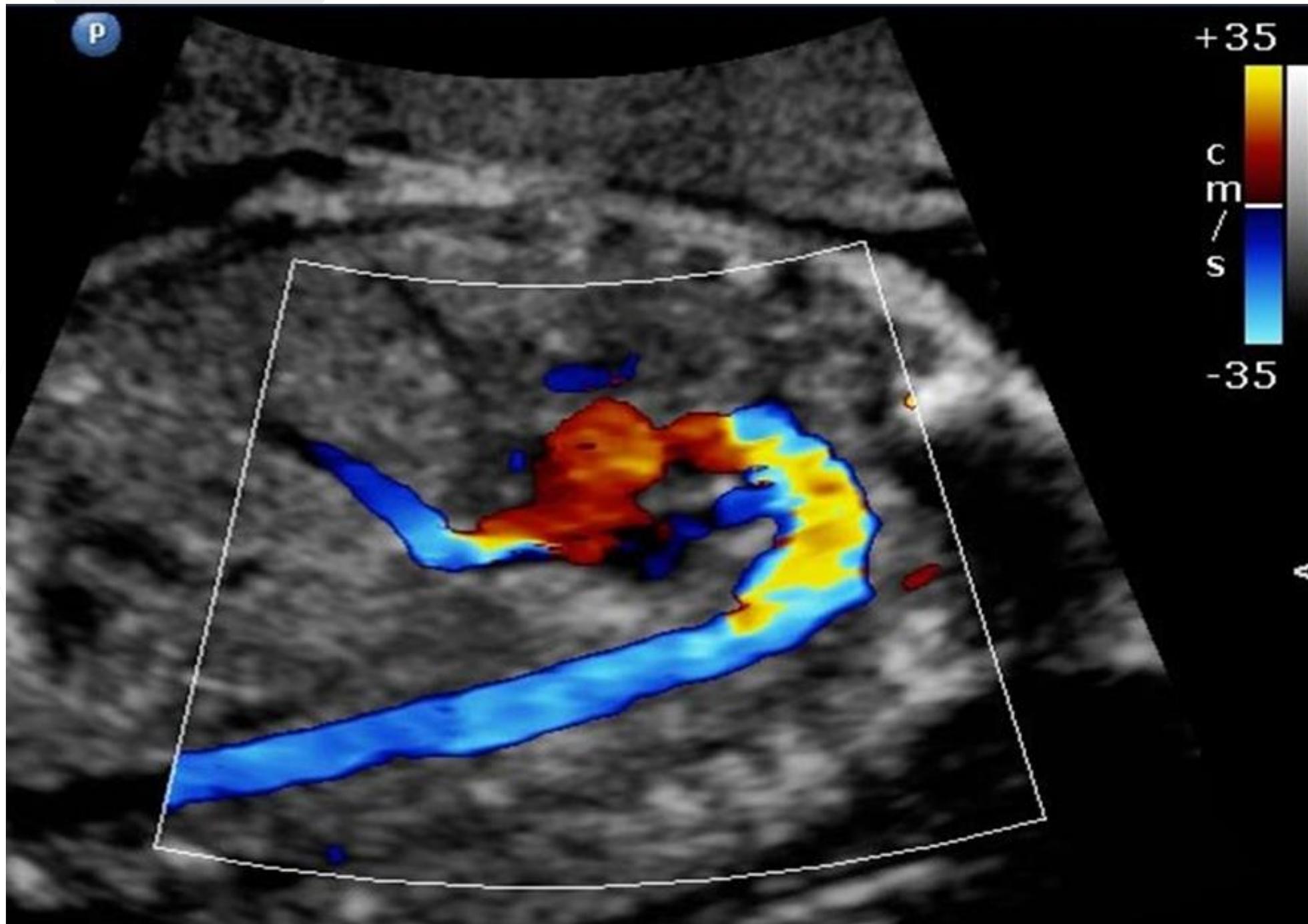


Pulsed Doppler Imaging

- Pulsed Doppler demonstrates the direction and characteristics of blood flow within the fetal heart and great vessels and allows the qualitative and quantitative definition of flow disturbances, such as those that occur with valvular stenotic or regurgitant lesions.

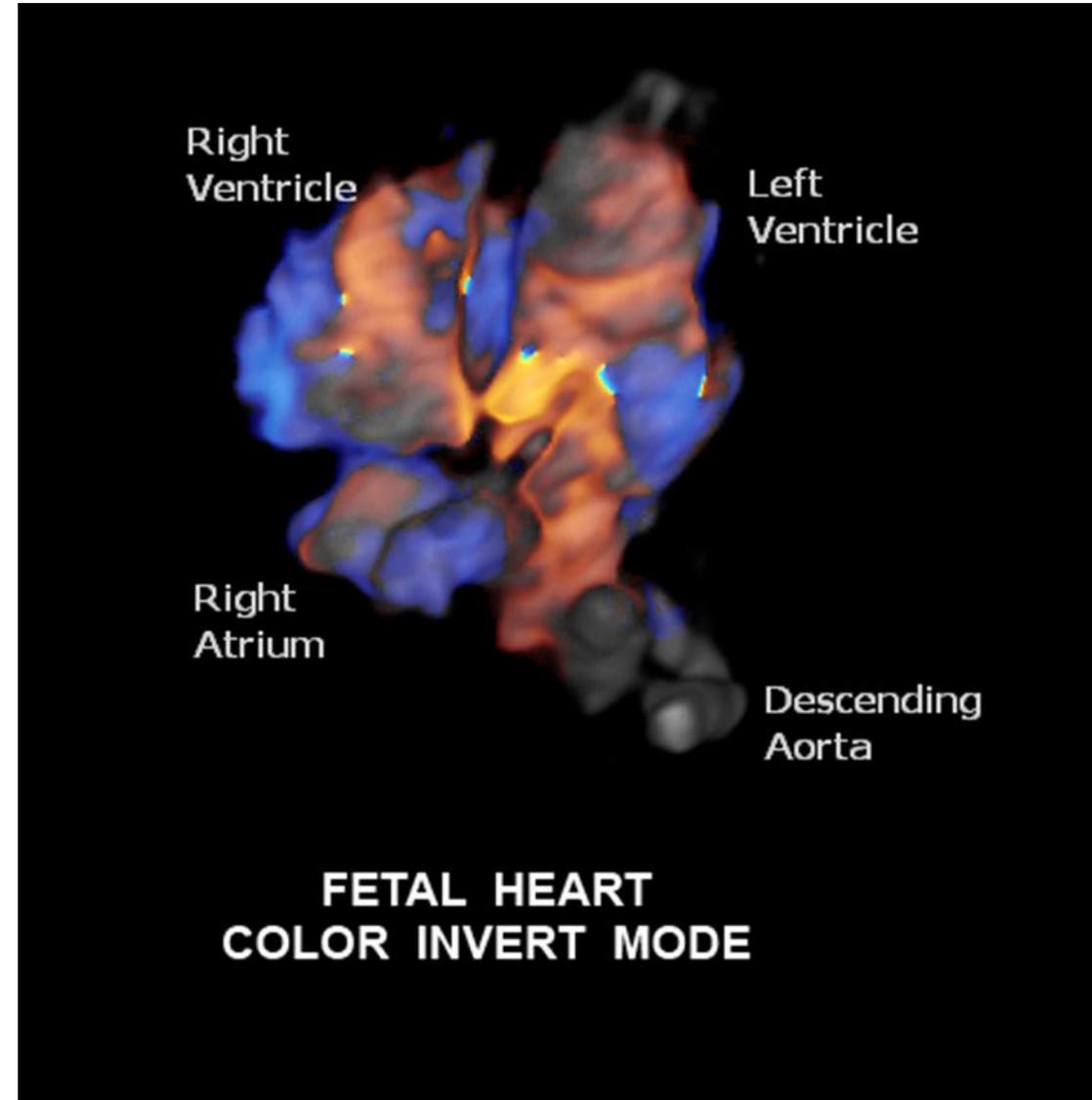
Color Flow Doppler Imaging

- Color Doppler may help detect flow disturbances and flow direction (to check whether vessels or chambers are patent) and should be integrated into the fetal echocardiogram.
- Color displays are usually oriented so that flow toward the transducer is projected in shades of red and orange, and flow away is projected in cool blue colors.
- Disturbed flow is seen as a mixture of red, orange, and yellow or blues and greens.
- The color gain should be adjusted to each image to eliminate color “blooming.”



3D Imaging

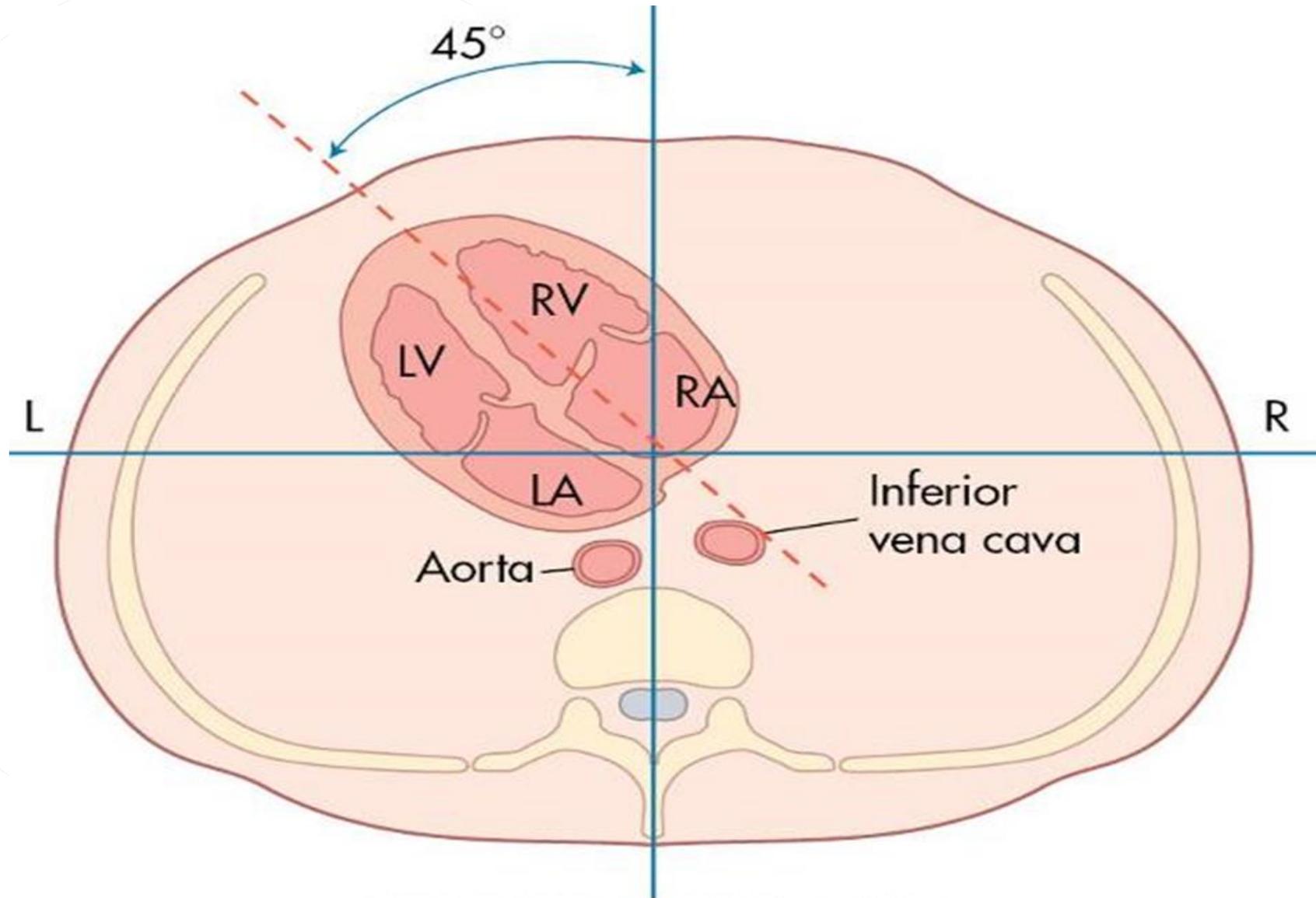
- Clinical investigation of three-dimensional echocardiography has been performed both with and without cardiac gating.
- Clarity of images is still the primary problem in this technique: The fetal heart is beating so quickly and the volume is too small to acquire enough data points to display an image better than the current real-time two-dimensional images.



Fetal Ultrasound Landmarks

- Fetal position
- Fetal thorax
- Fetal stomach
- Apex of heart
- Location of fetal aorta and IVC
- Position of placenta
- Biparietal diameter/femur length

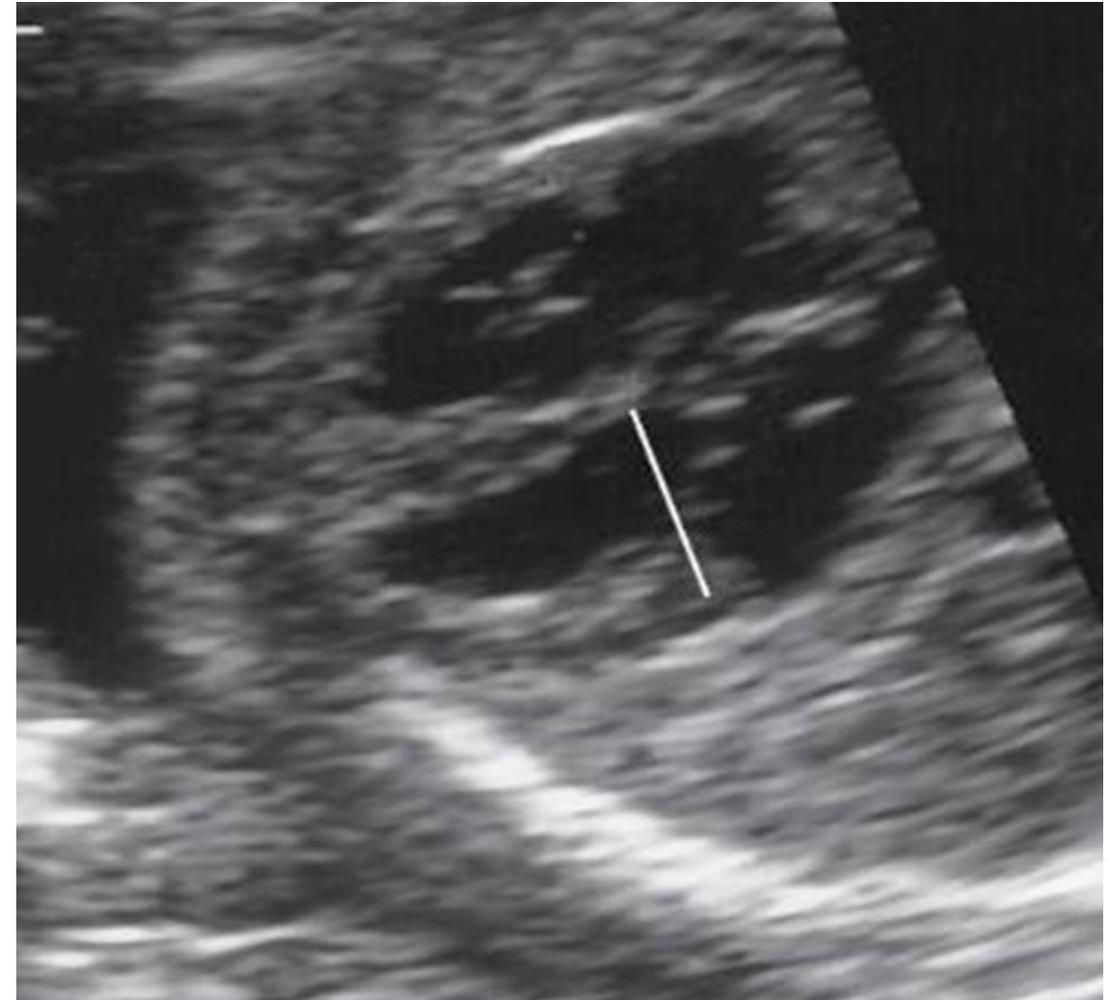
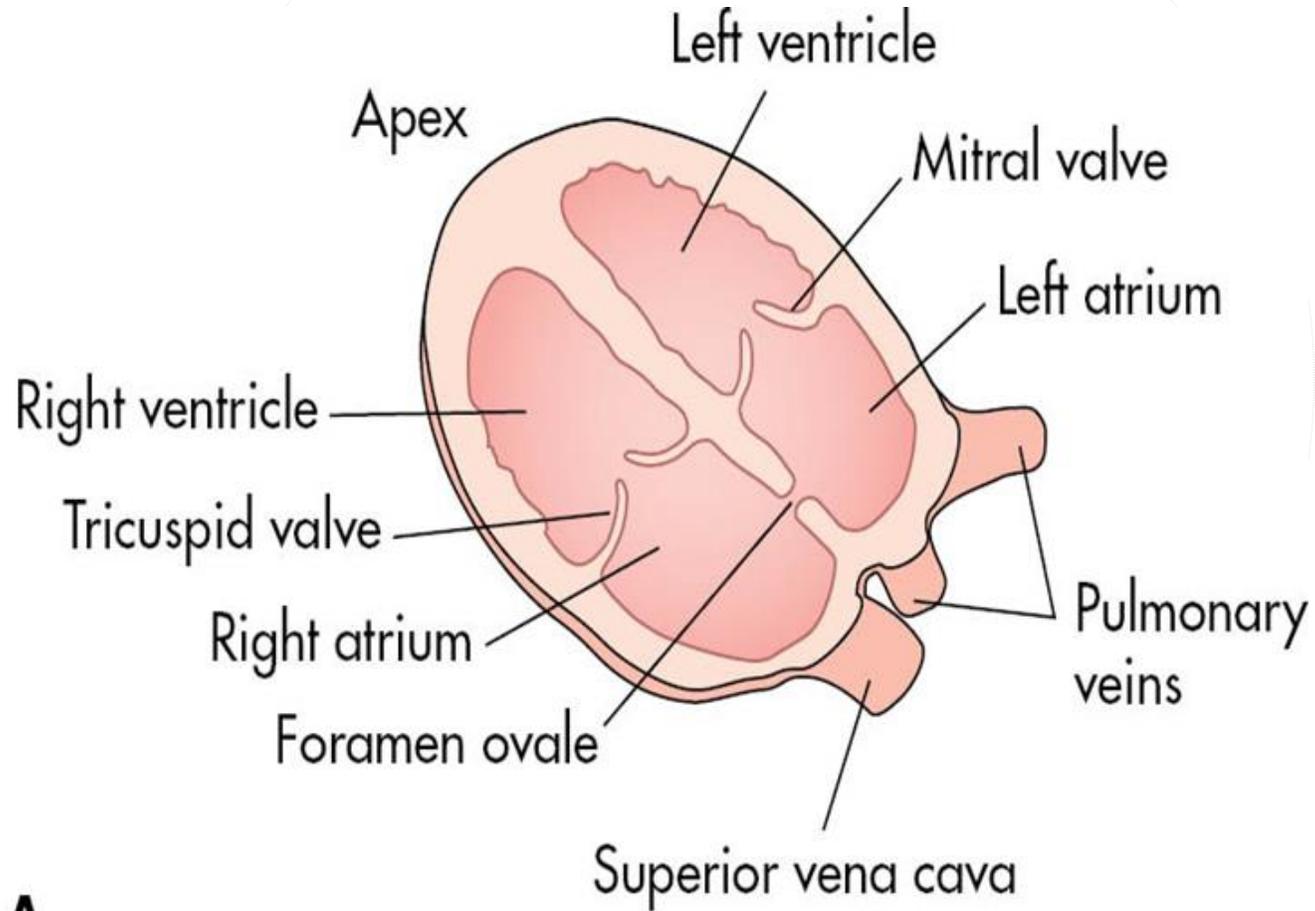
Fetal Ultrasound Landmarks



Echocardiographic Evaluation of the Fetus

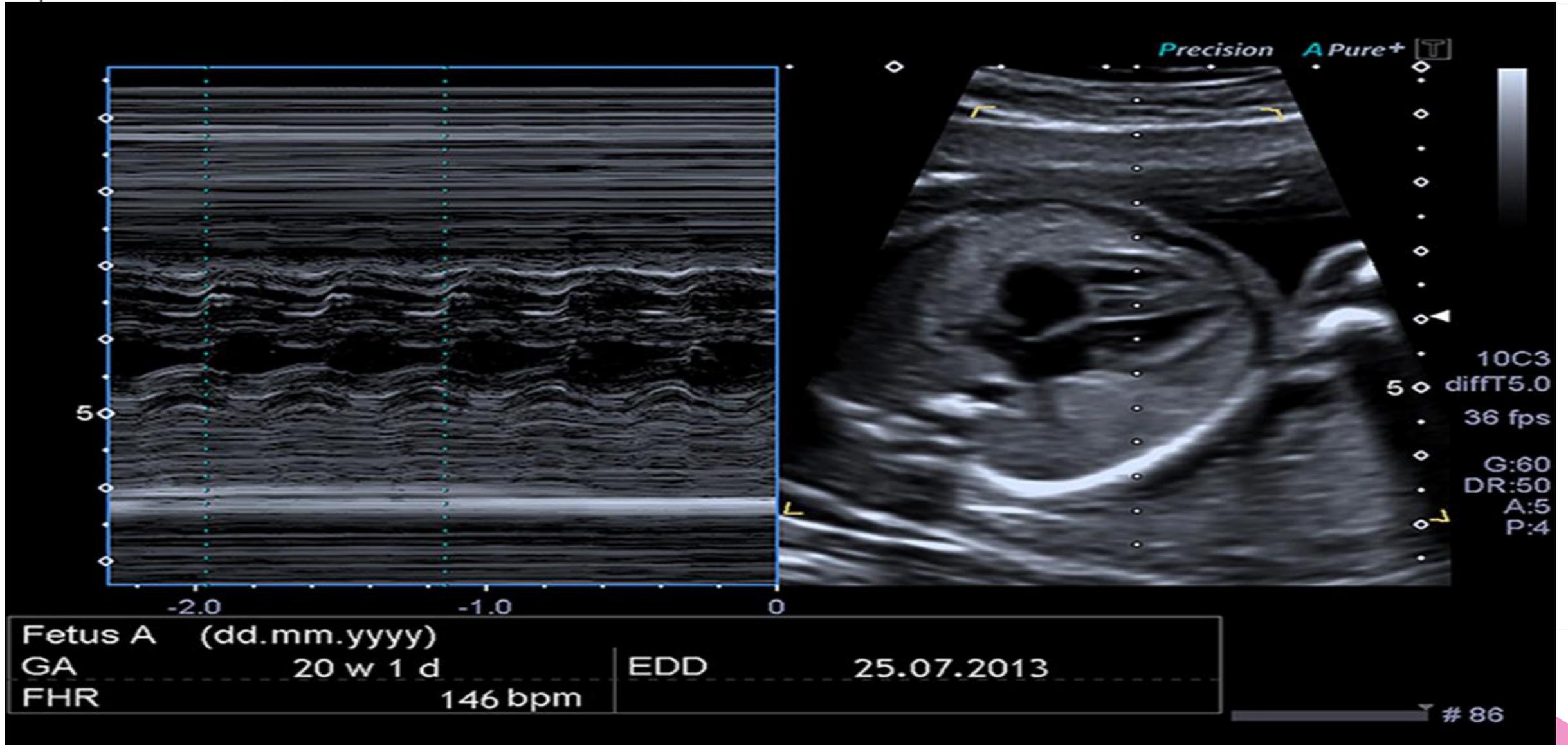
- Normal cardiac study should include the following views:
 - Four-chamber
 - Outflow tracts
 - Oblique long-axis view for aortic arch and ductus arteriosus

Four Chamber View



A

Four Chamber View

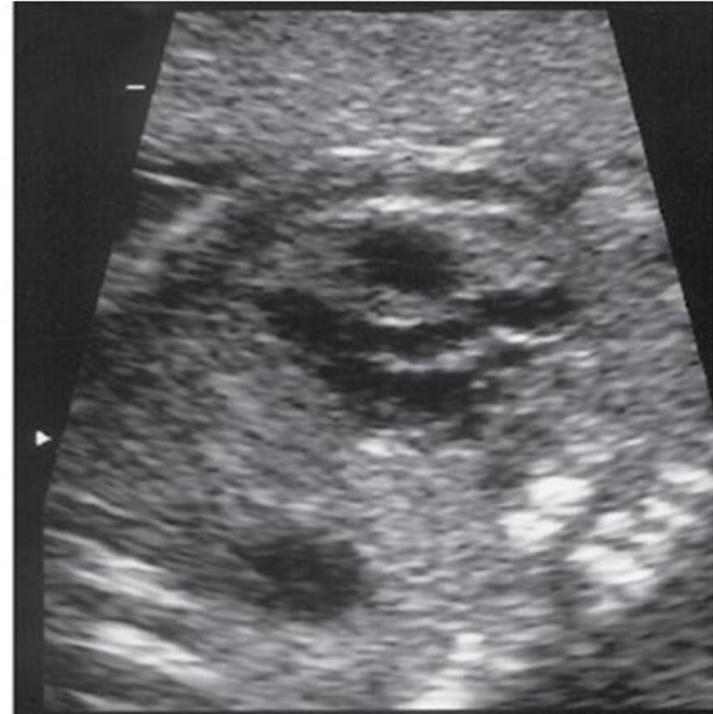
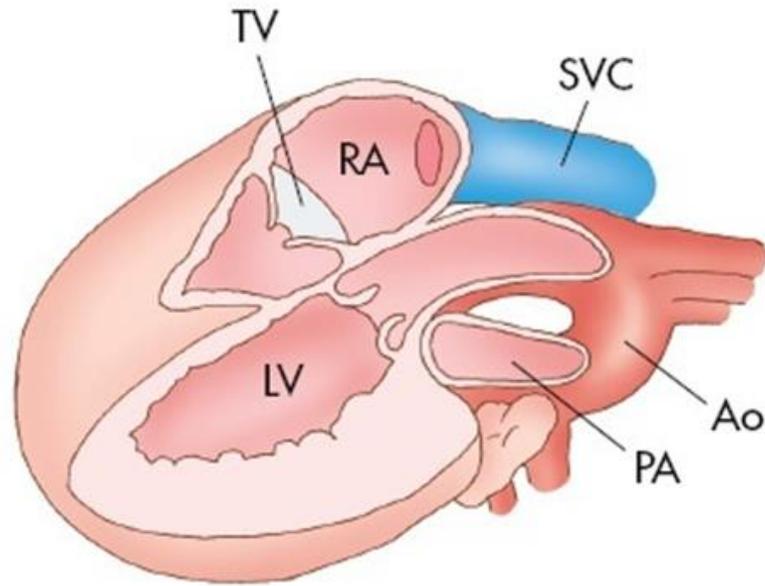
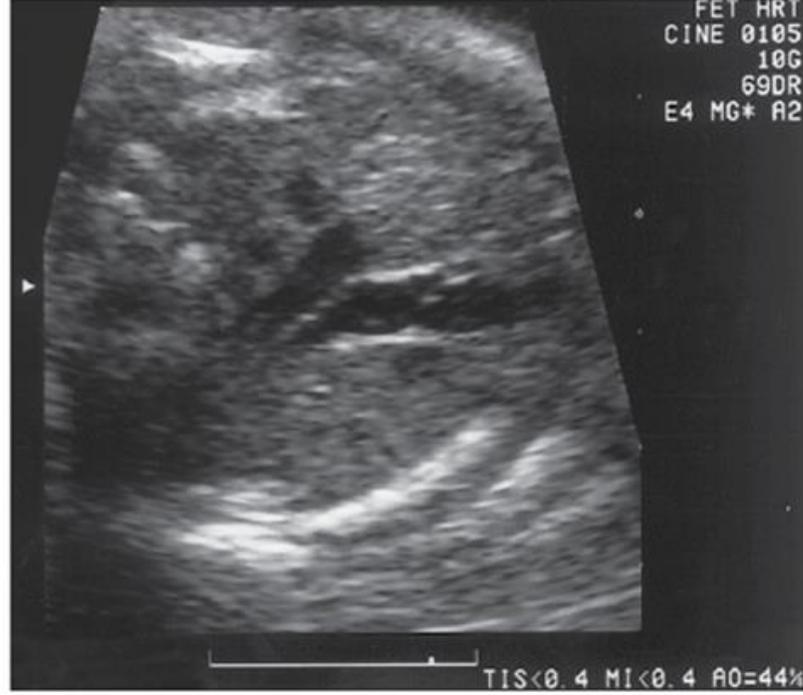
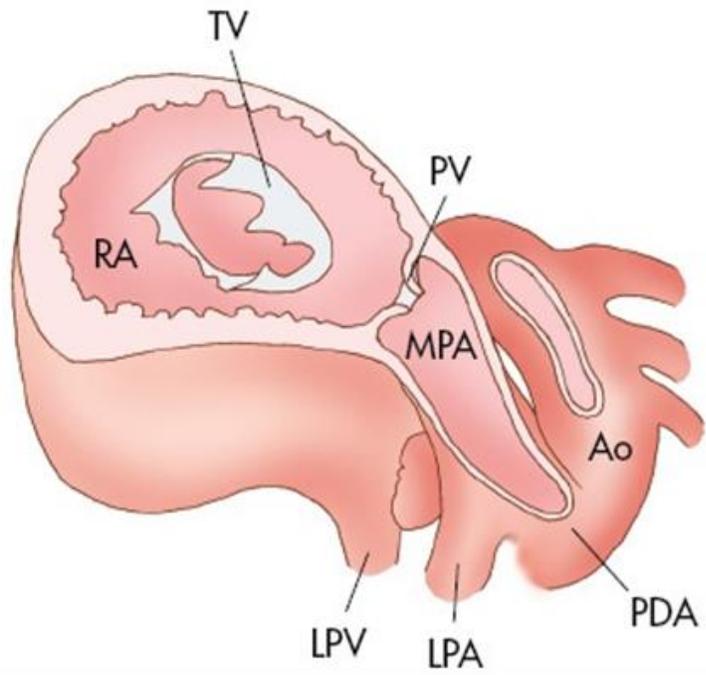


Four-Chamber View

- Right atrium and ventricle (with moderator band)
- Tricuspid valve
- Left atrium and ventricle
- Mitral valve
- Interventricular septum
- Interatrial septum
- Foramen ovale
- Pulmonary veins as they enter left atrium

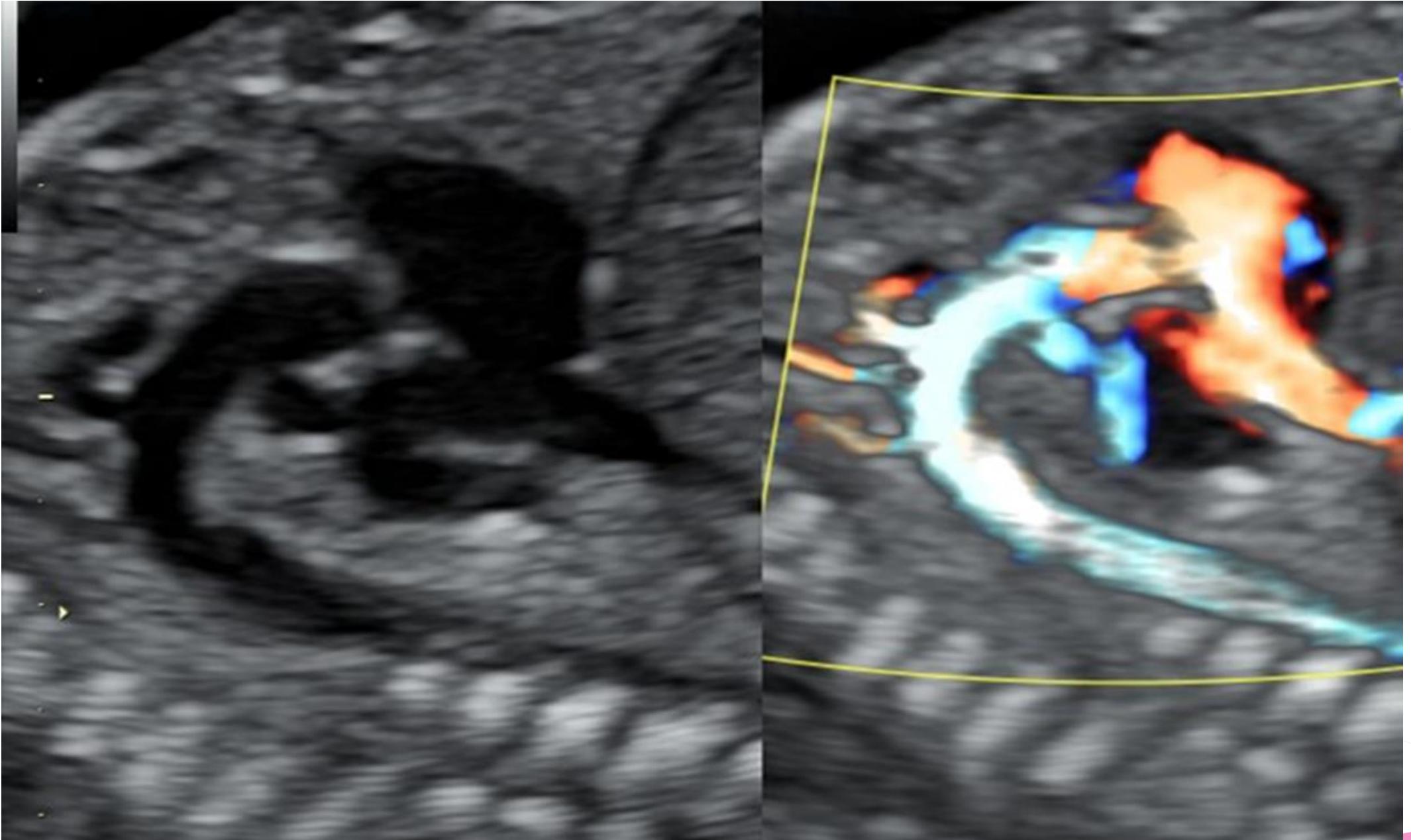
Left and Right Ventricular Outflow Tracts

- Considered a “Criss-Cross View” to visualize each outflow tract
 - Begin by angling slightly anterior from the four-chamber view to find the left ventricle and the aortic outflow tract
 - Called the LVOT – left ventricular outflow tract
 - To obtain the right ventricle and pulmonary artery outflow, angle the transducer slightly medial and anterior from the LVOT view
 - Called the RVOT – right ventricular outflow tract (also referred to as the 3VV)



Ductal and Aortic Arch Views

- Find fetal spine in sagittal plane and angle slightly inward toward left chest to search for descending aorta and arch.
- Tubular dimension of vessel should be somewhat uniform as one follows aorta from its base into thorax and abdomen.
- Three head and neck branch arteries (innominate, carotid, and left subclavian) arise from perfect curve of aortic arch as they ascend into fetal head.
- “Candy cane” appearance of ascending aorta, arch, and descending aorta.



Ductal and Aortic Arch Views

- Angulation inferior to the aortic arch will show another “arch-type” structure
- Represents patent ductus arteriosus
- Ductus slightly larger than aortic arch and has sharper angle (“hockey stick”) as it drains into descending aorta
- Does not have arterial structures arising from its wall as the aorta does

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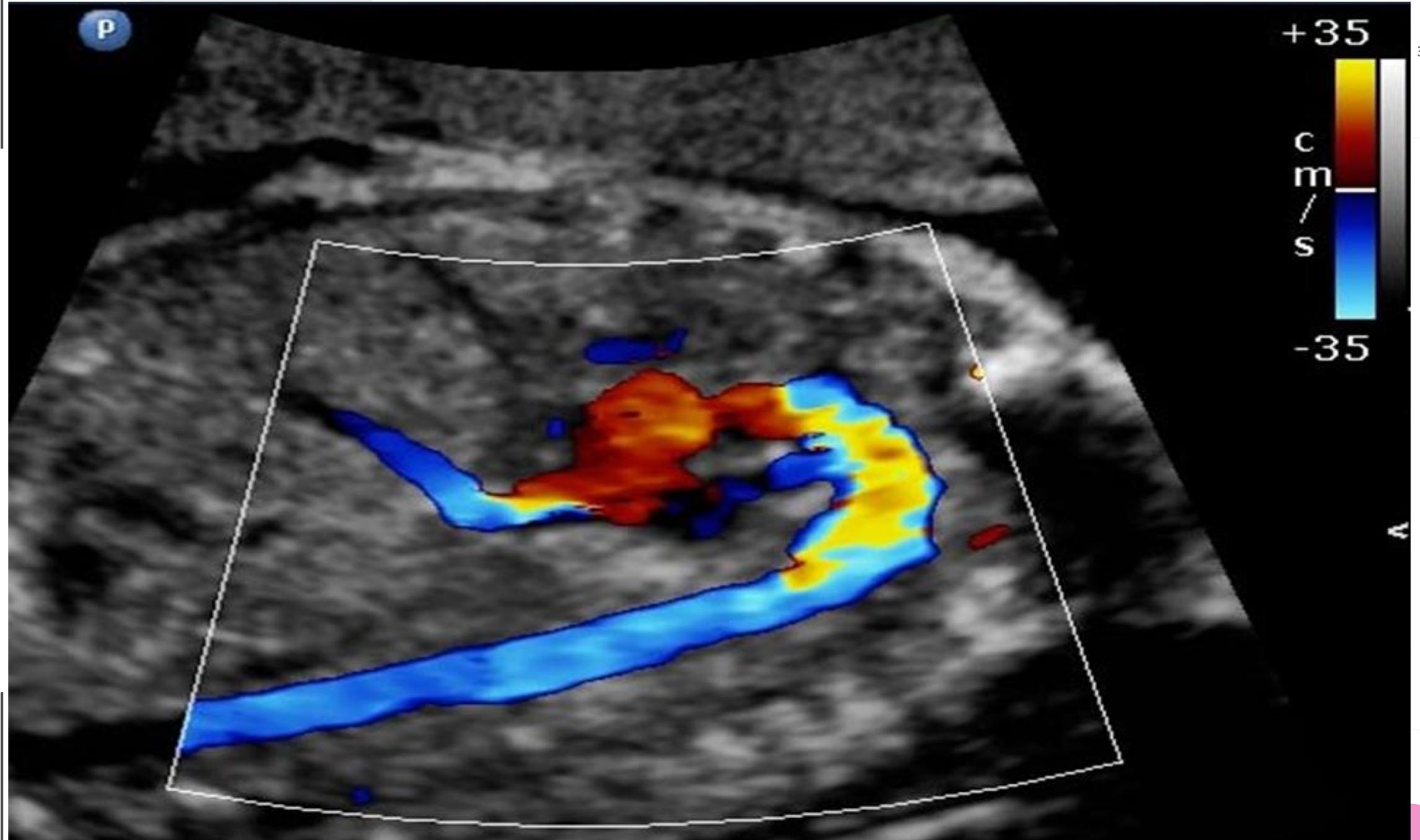
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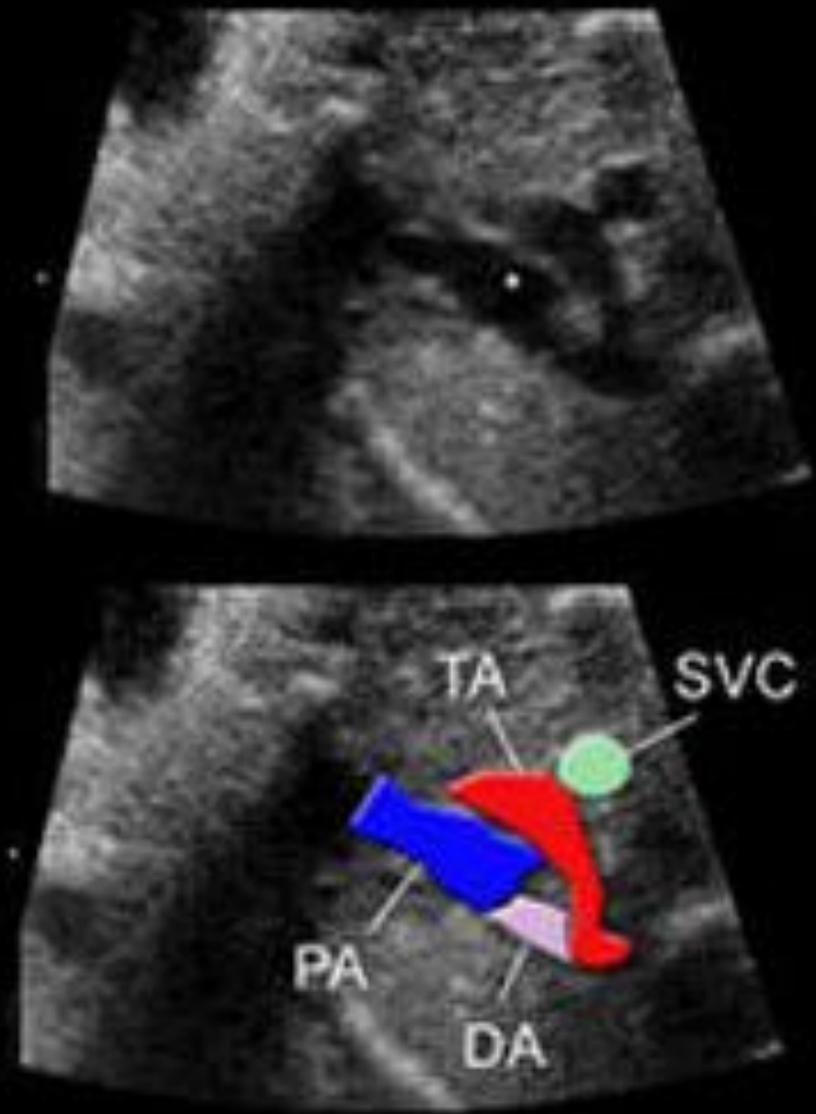
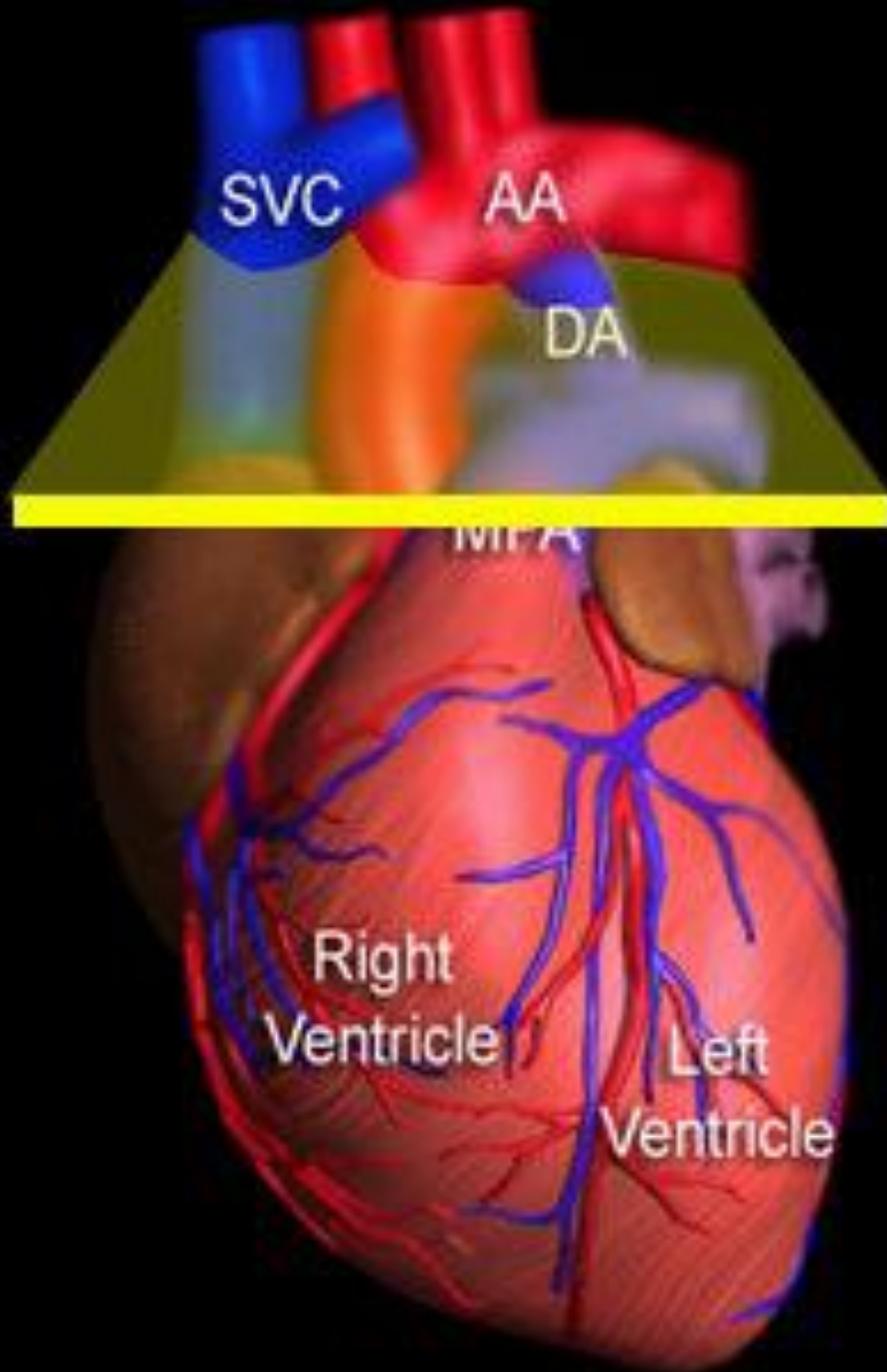
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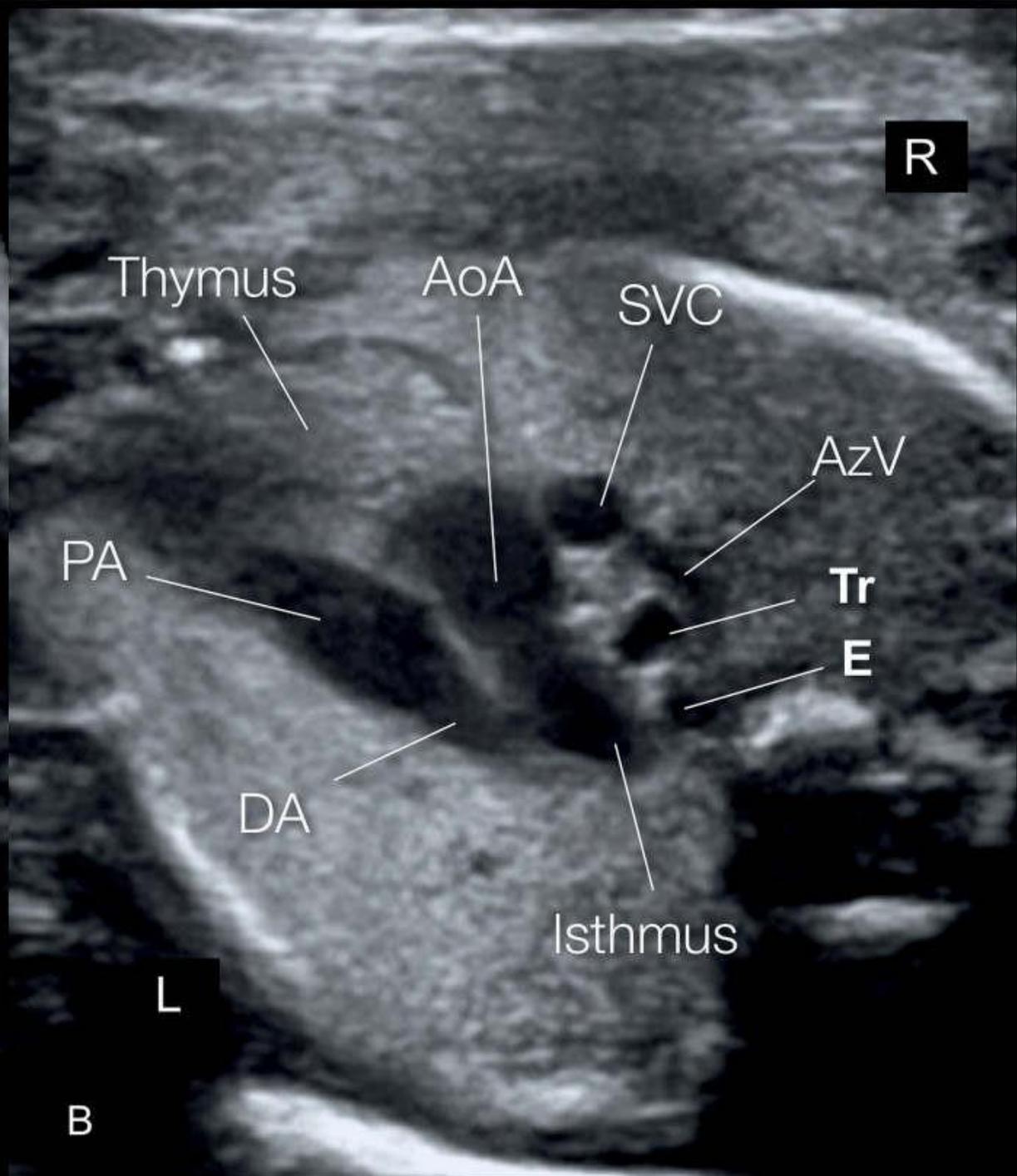
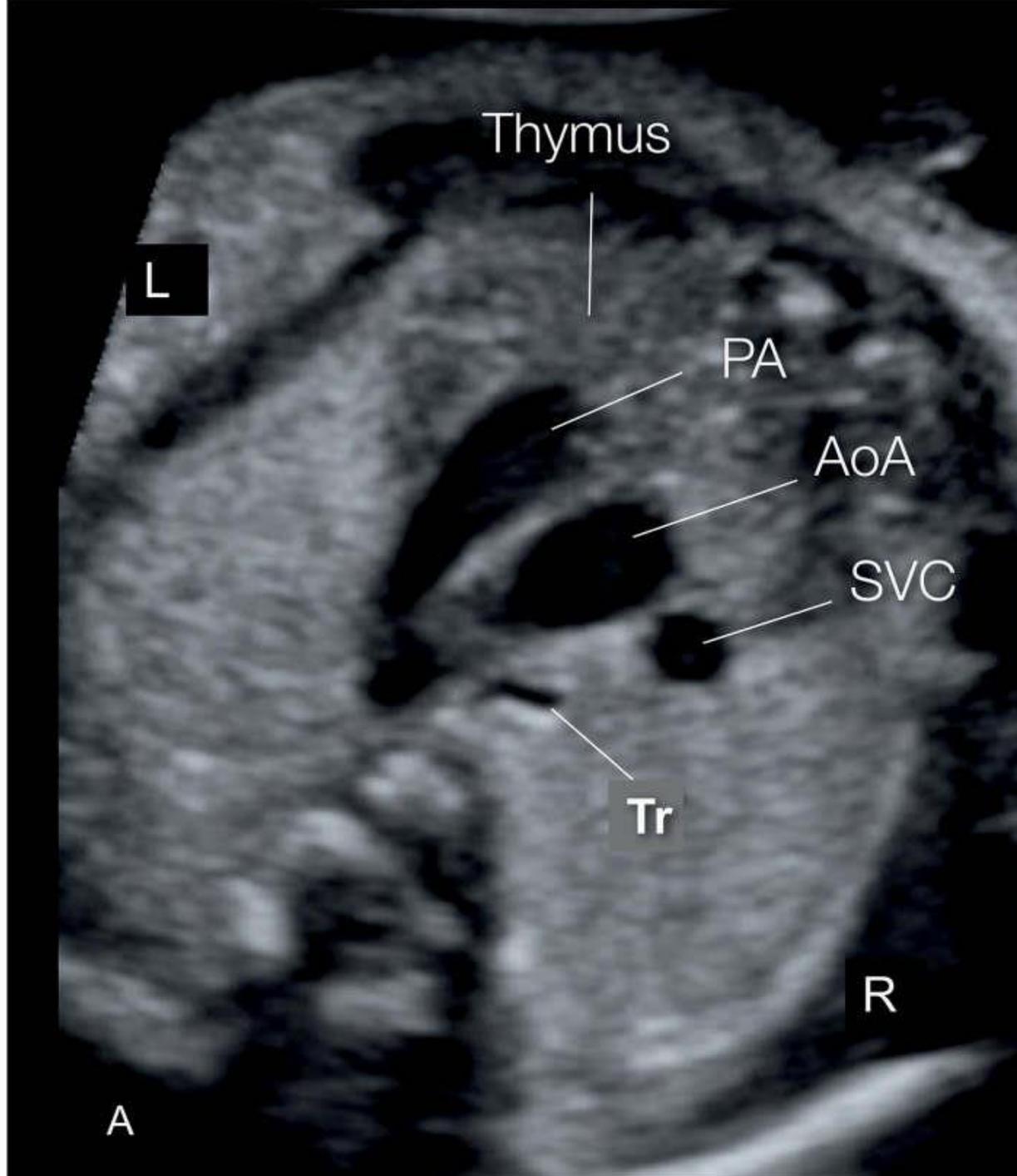


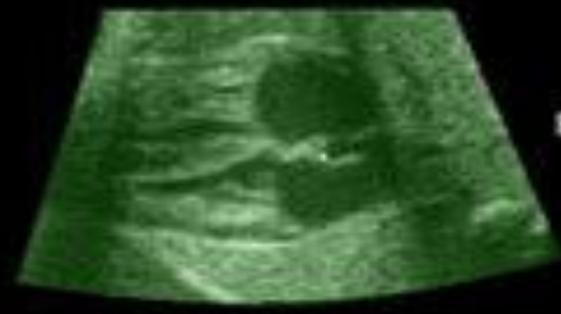
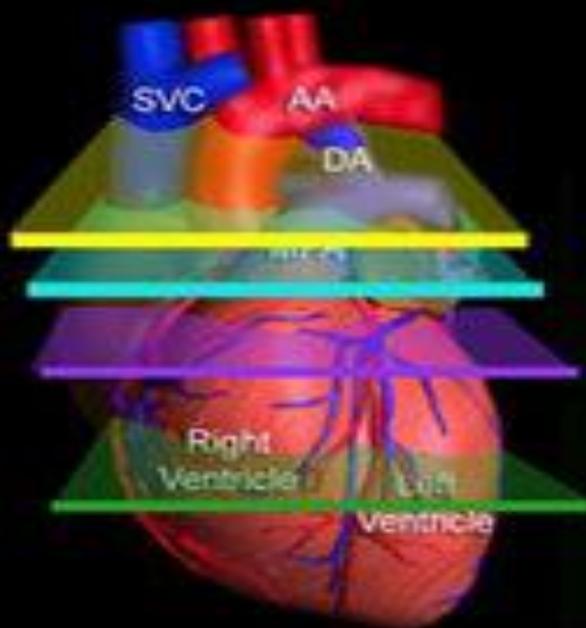
Ductal and Aortic Arch Views

- Can obtain an image of both the aortic and ductal arches
- Appears as a V-shaped confluence
- Should always be found left of the trachea
- Thymus may also appear in the image
- Called the 3VT view

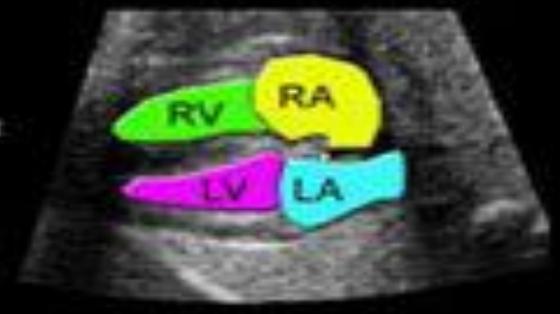


Tracheal View

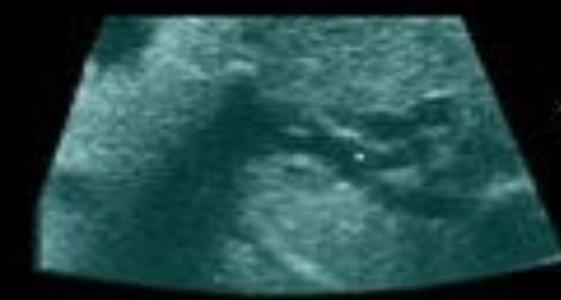
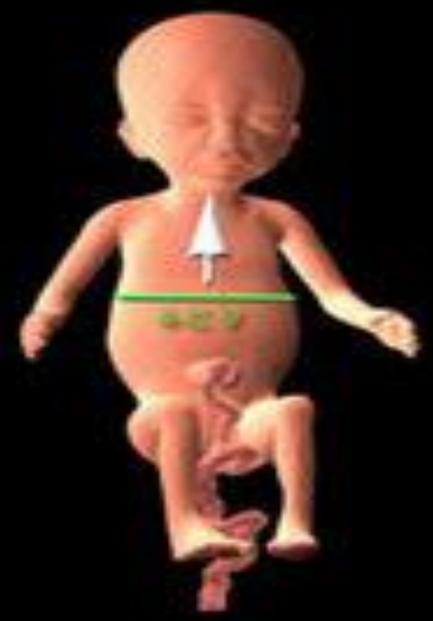
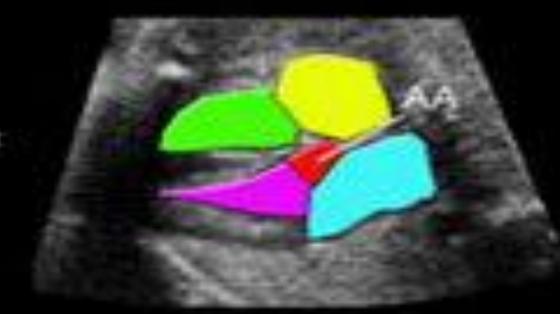




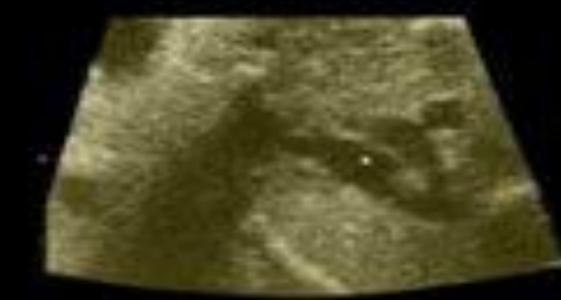
FOUR-CHAMBER VIEW



FIVE-CHAMBER VIEW



THREE-VESSEL VIEW



TRACHEAL VIEW

