Fetal Cardiac Screening Sonography: Methodology

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Authors have no disclosures. No funding was obtained for this project.

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Cines

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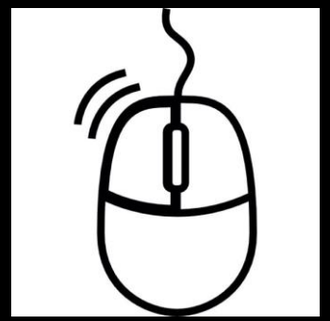

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The cines will loop automatically
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Introduction

- Fetal cardiac views required by national guidelines (American Institute of Ultrasound in Medicine, American College of Radiology, The American Congress of Obstetricians and Gynecologists, and Society of Radiologists in Ultrasound) include four-chamber view, right ventricular outflow tract (RVOT) view, and left ventricular outflow tract (LVOT) view. Three-vessel view is also often used in screening and includes evaluation of the pulmonary artery, aorta, and superior vena cava in a high axial plane of the fetal chest.

- The fetal heart is optimally examined between 18 and 22 weeks. Some cardiac abnormalities can be recognized earlier in pregnancy.

- Obtaining these views is essential for a complete evaluation of the fetal heart. It is important to differentiate normal from abnormal to aid in detection of various congenital abnormalities.

- The guidelines do not include color Doppler imaging as part of cardiac screening; however, in our fetal imaging center, we do use color Doppler imaging for screening. Color Doppler imaging is particularly helpful when we cannot obtain optimal views because of fetal position or maternal body habitus.

- Color Doppler imaging can assist in demonstrating ventricular proportions, septum, and flow across atrioventricular and semilunar valves in the four-chamber view, LVOT view, RVOT view, and three-vessel view.

Introduction

- Two different techniques of cardiac scanning discussed in the literature are rotational and sweep techniques, but they often confuse sonographers and radiologists.

- There is wide variation on reported detection rates of congenital heart disease on fetal ultrasonographic images, likely due to a combination of recognition of significant congenital heart disease, variation in sonographer skill, and variation in patient population.

- Khoo et al (2008) reported 95.2% sensitivity and 99.5% specificity of fetal echocardiography in South Australia. Levy et al (2013) reported a prenatal detection rate of 74.1% for congenital heart disease in an integrated health system in the United States.

- We present new methodology for acquiring screening cardiac images by using maneuvers such as turning the transducer with the sonographer’s thumb as the focal point of rotation. We created this method after surveying and observing sonographers at our institution.

- This method was compared with the general standards of practice, which refer to how the sonographers currently move their hands on the basis of the rotational and sweep techniques described in the literature (discussed later).

Outline

- Normal cardiac screening views
  - Four-chamber view
  - LVOT view
  - RVOT view
  - Three-vessel view
- Literature review
  - Rotational technique
  - Sweep technique
- Congenital heart defects
  - Transposition of the great arteries
  - Tetralogy of Fallot
  - Coarctation of aorta
  - Atrioventricular septal defect, also known as atrioventricular canal defect
  - Ebstein anomaly

Learning Objectives

- Identify normal anatomy on four different cardiac screening views
- List important cardiac structures seen on each screening view
- Describe the newly presented style of scanning to acquire the fetal cardiac screening views
- Differentiate abnormal and normal anatomy on each cardiac screening view

Fetal Cardiac Imaging Considerations

- Select the highest-frequency transducer (5–8 MHz) possible to obtain optimum image resolution but maintain adequate penetration. In some cases such as increased maternal body mass index and/or a late gestational age, a lower-frequency transducer (2–5 MHz) may be selected.

- The patient may be positioned supine or left or right lateral decubitus to optimize fetal positioning and/or decrease imaging depth.

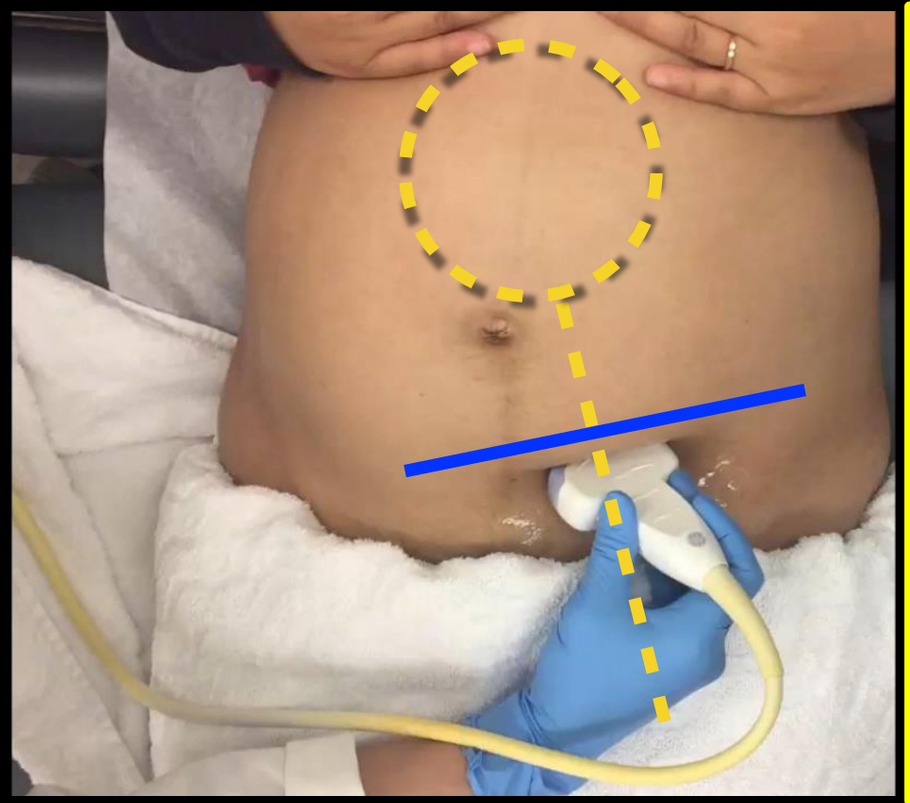
- Depth should be decreased and field of view should be narrowed to include only the fetal chest. Next, images should be magnified until the heart fills at least one-third to one-half of the screen.

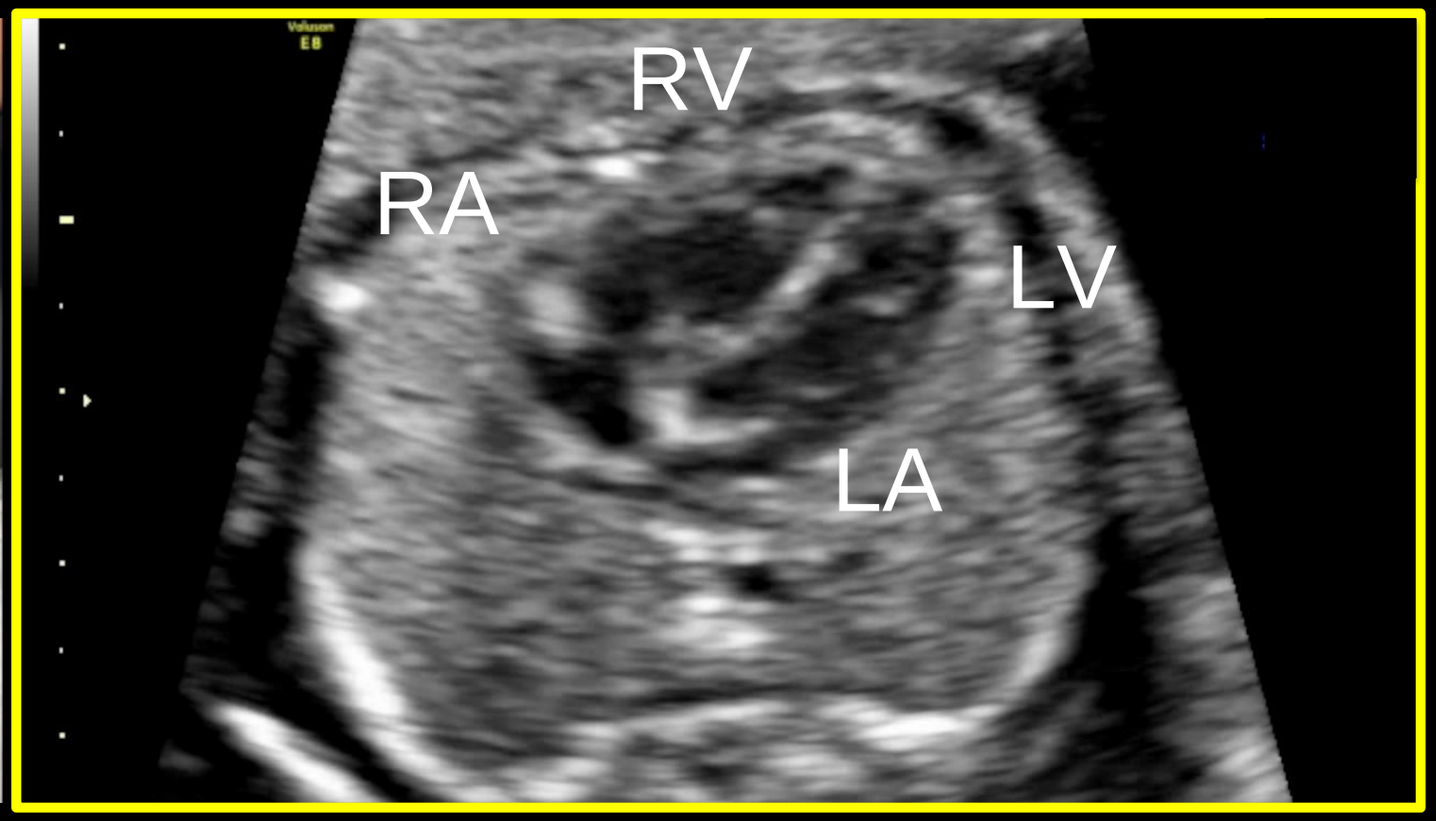
- Initial evaluation begins with determining fetal position in the maternal abdomen. Next, visceral and cardiac situs should be determined.

Four-Chamber View

- First imaging plane after determining situs
- The key is to find a true axial view of the chest with plane of section perpendicular to the long axis of the fetus.
- Typically, the easiest plane to obtain and interpret also is the starting point for acquiring additional cardiac views.
- The orientation will appear different for breech and cephalic positions, but obtaining the true perpendicular plane should be feasible for almost all fetal positions.

Four-Chamber View





Fetus in breech position

Perpendicular plane

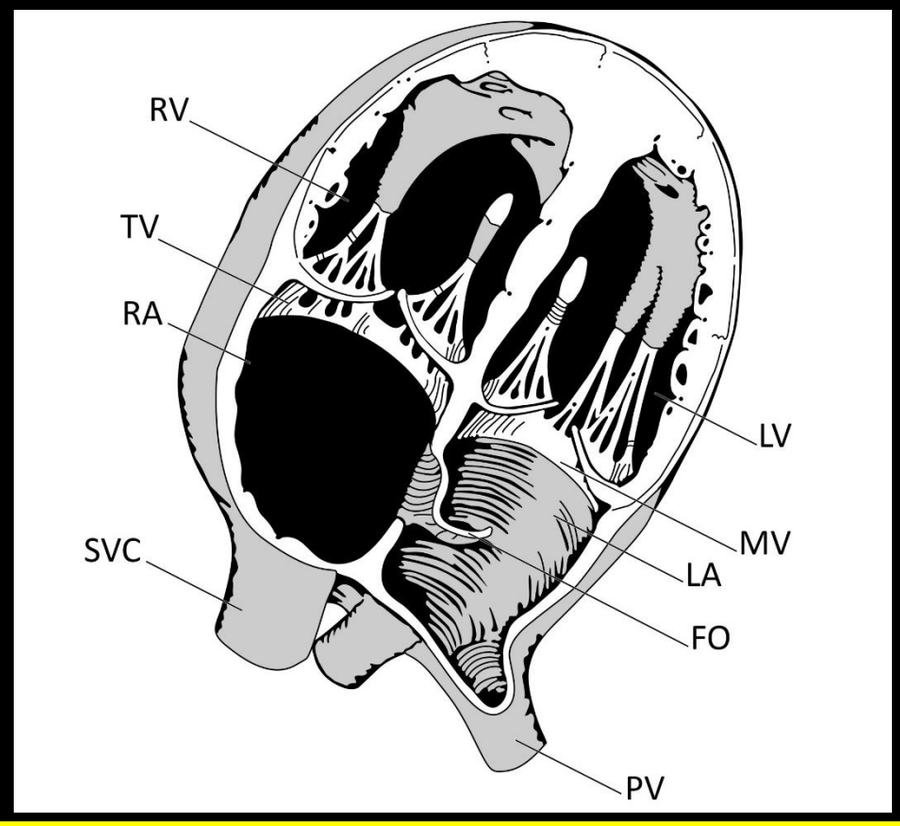
By using a high-frequency transducer (5–8 MHz), find the transaxial view of the chest with plane of section through the chest and perpendicular to the long axis of the fetus.

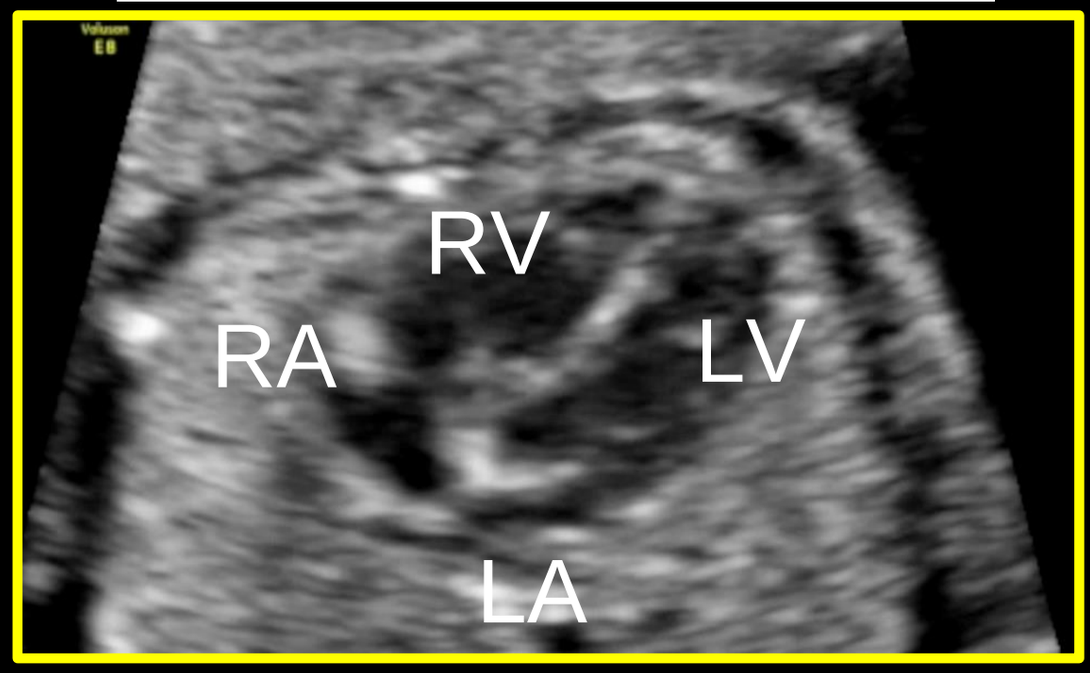
LA = left atrium, LV = left ventricle, RA = right atrium, RV= right ventricle

Four-Chamber View

Features to look for:

- Heart occupies one-third area of the chest
- Cardiac axis directed at a 45° angle with apex toward the left
- Descending aorta in front and to the left of spine
- Equal-sized ventricles and atria
- Interventricular septum is intact
- Crux (primum area of the atrial and ventricular septum) is intact
- Tricuspid valve slight apical offset from mitral valve
- Moderator band in right ventricle
- Pulmonary veins drain into left atrium



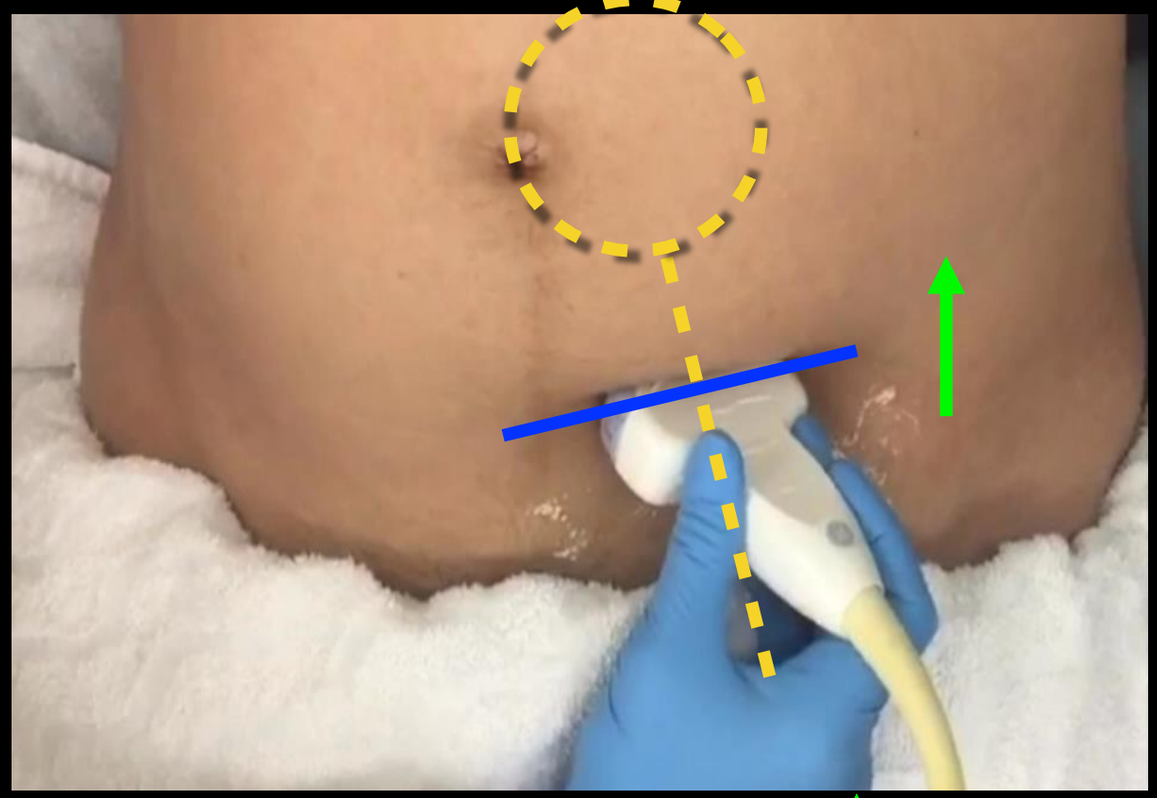


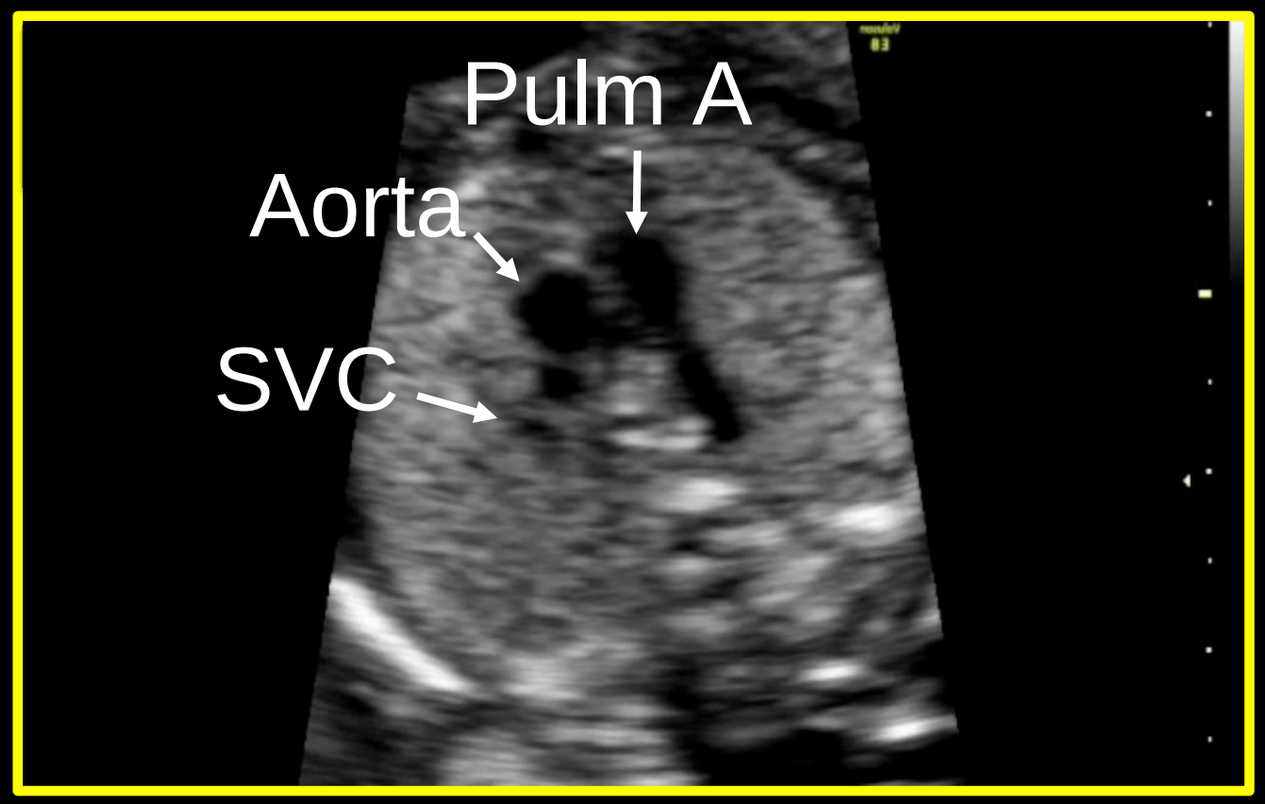
FO = foramen ovale, LA = left atrium, LV = left ventricle, MV = mitral valve, PV = pulmonary vein, RA = right atrium, RV= right ventricle, SVC = superior vena cava, TV = tricuspid value

Three-Vessel View

- Usually the second cardiac plane obtained
- From the four-chamber view, physically move the transducer on the patient without changing angle toward fetal head.
- This movement is usually very slight and can be described as minimal rocking or sweeping.
- The key is to line up the pulmonary artery, aorta, and superior vena cava as they exit or enter the superior aspect of the heart.

Three-Vessel View





Move transducer

From four-chamber view, physically move the transducer on the patient without changing angle toward fetal head.

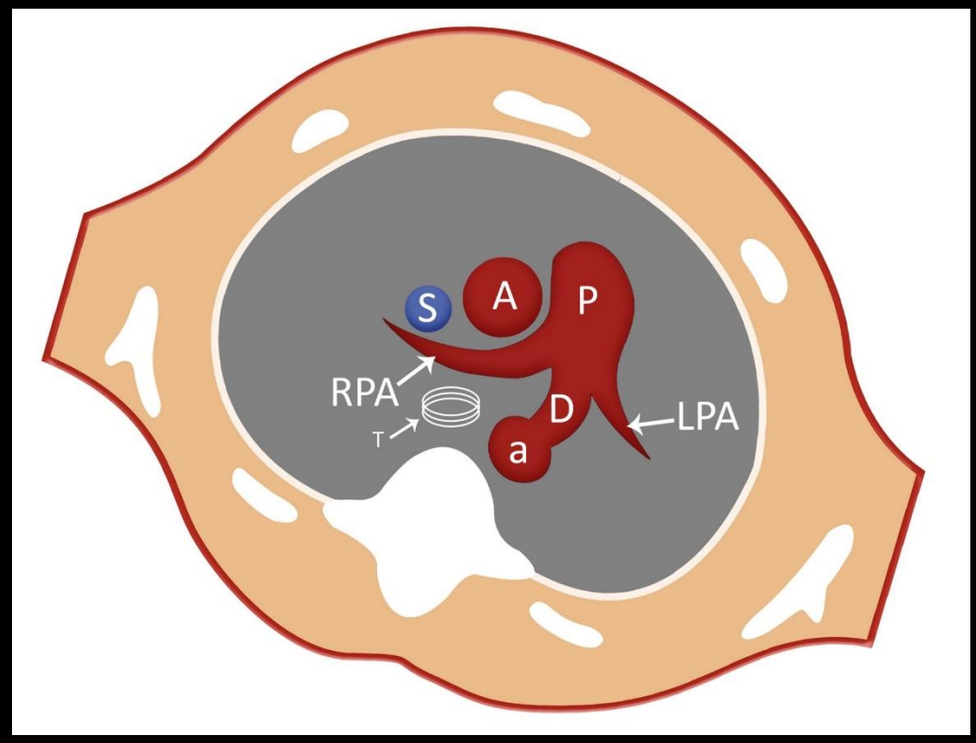
Pulm A = pulmonary artery, SVC = superior vena cava

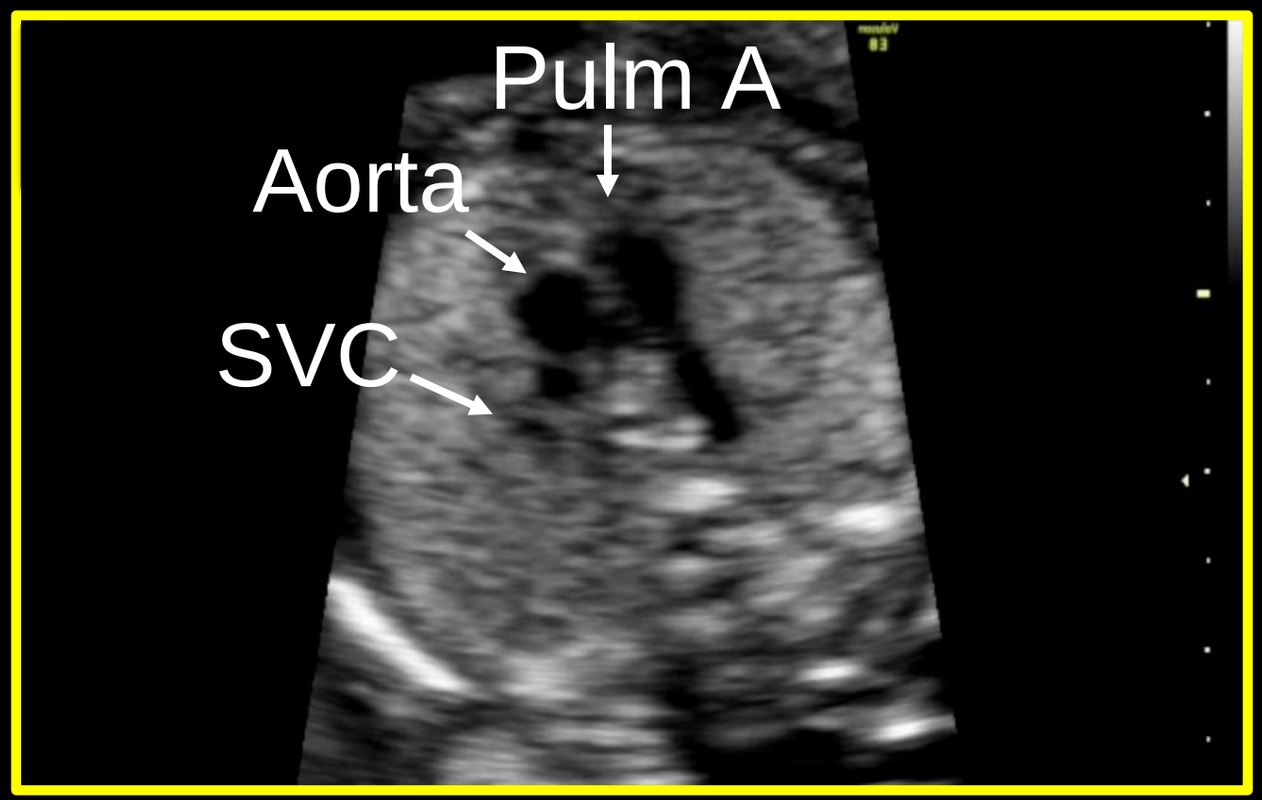
Three-Vessel View

Normal features

- Pulmonary artery *(P)*, which arises from the right ventricle
- Cross section of the ascending aorta *(A)*
- Superior vena cava *(S)*
- Trachea *(T)*

Important to have the three vessels in line with each other in order of largest *(P)* to smallest *(S)*





a = aorta, D = ductus arteriosus, LPA = left pulmonary artery, Pulm A = pulmonary artery, RPA = right pulmonary artery, SVC = superior vena cava

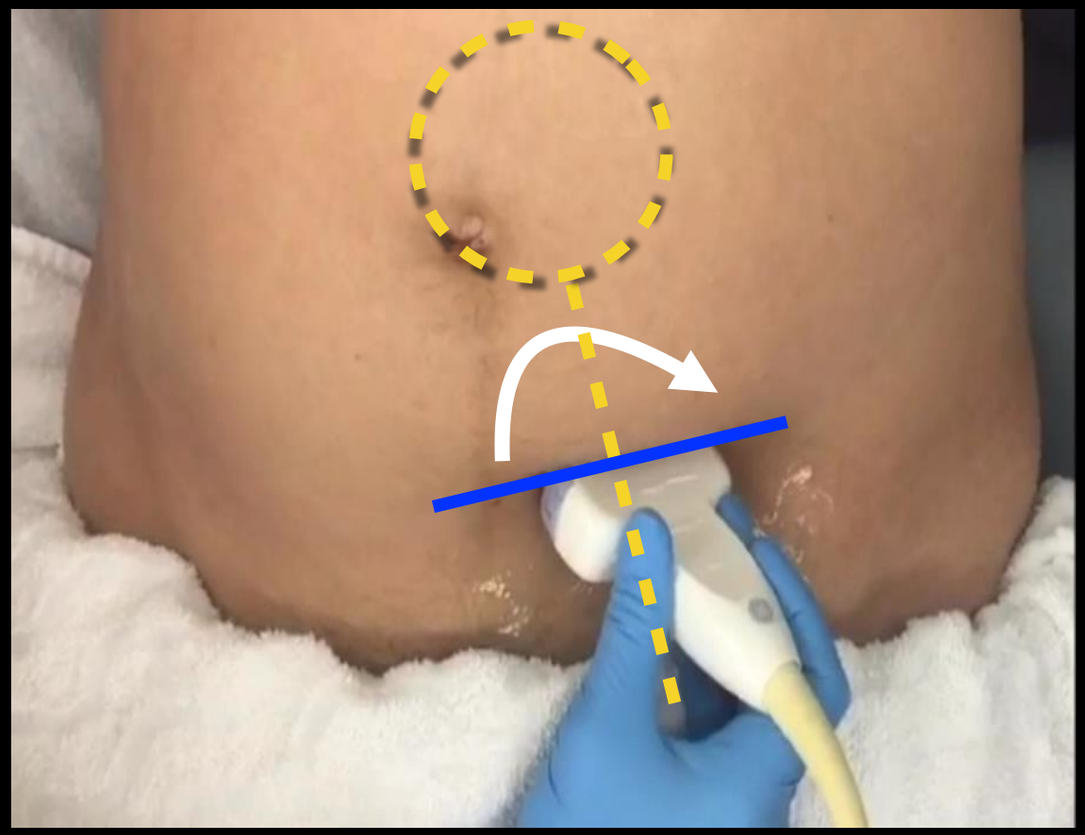
LVOT View

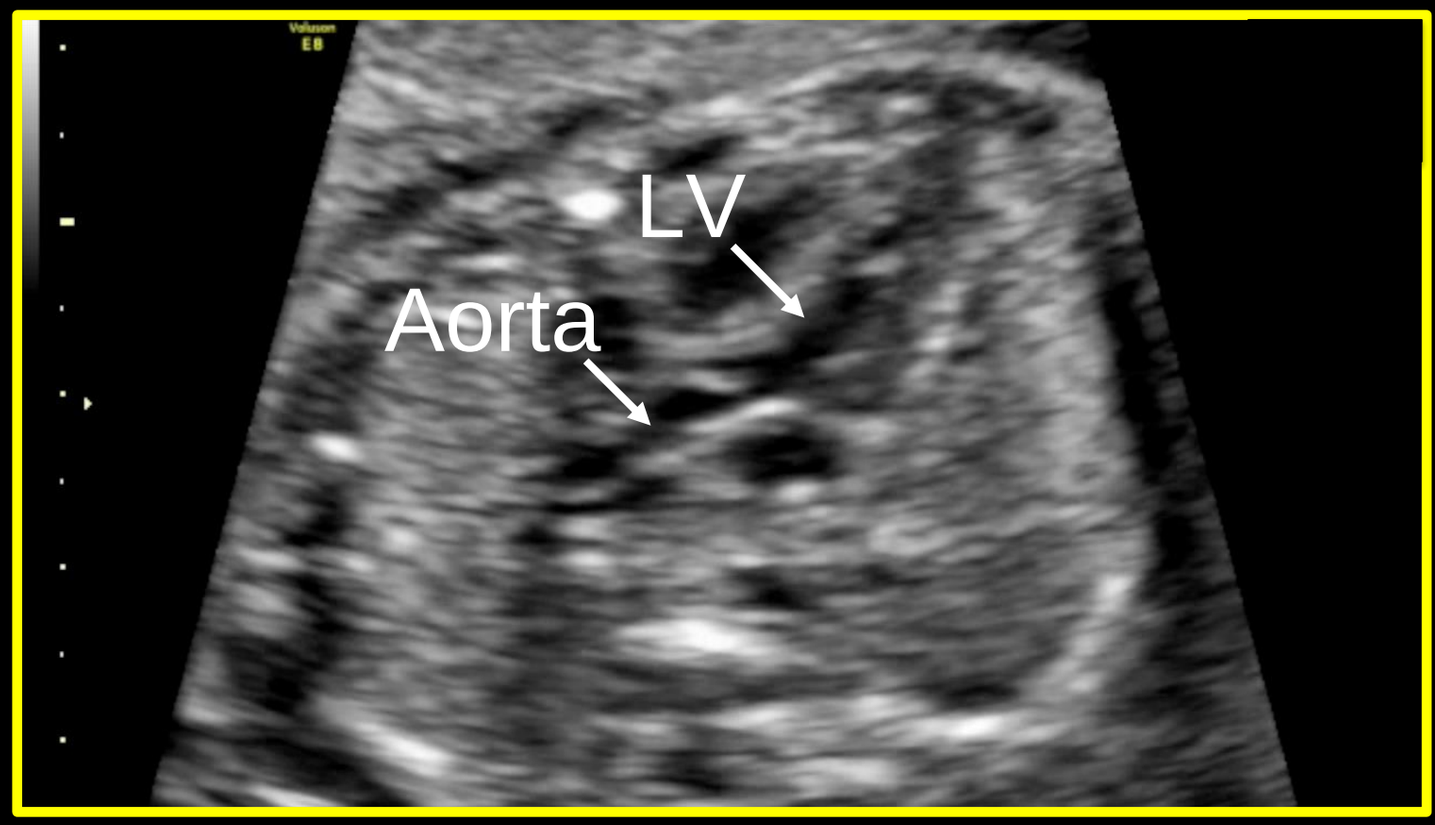
- This is an important cardiac plane as various conotruncal anomalies, such as tetralogy of Fallot and transposition of the great arteries, will have an abnormal LVOT view.

- Start from the four-chamber view and rotate your thumb toward baby's left shoulder, resulting in elongation of the left ventricle, until you see the aorta arise from the left ventricle.

- The key is to have the left ventricle and aorta in the same plane and to visualize the normal thin aortic valve leaflets come and disappear from the view during the cardiac cycle as the valve opens and closes.

LVOT View





Rotate thumb toward baby's left shoulder

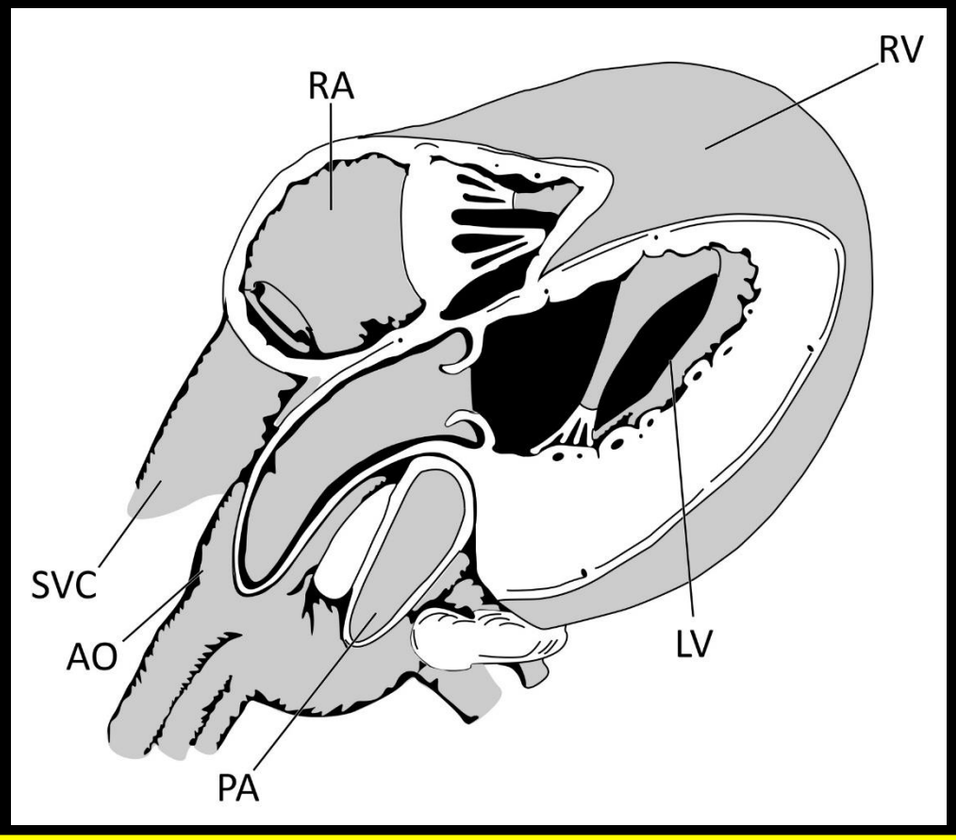
From the four-chamber view, rotate the thumb toward baby's left shoulder, elongating the left ventricle until you see the LVOT.

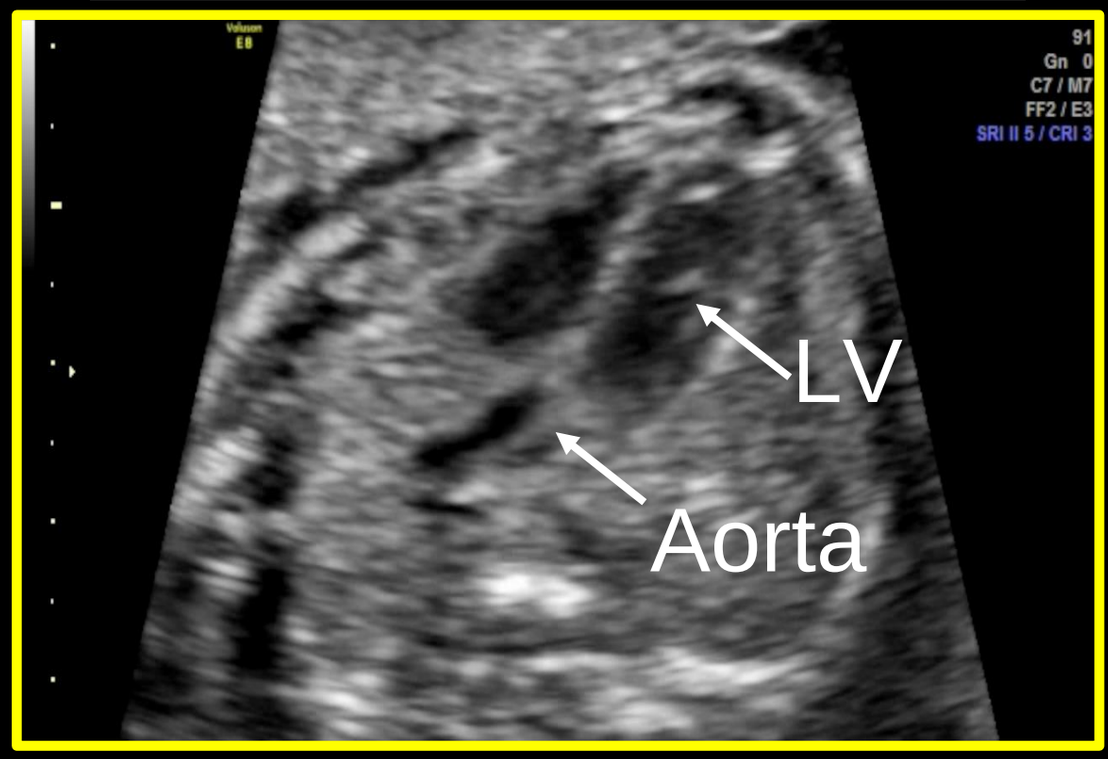
LV = left ventricle

LVOT View

- Evaluate if interventricular septum is intact; look for perimembranous ventricular septal defect
- Medial wall of the ascending aorta should merge with the top of the interventricular septum (ie, no overriding aorta, as in tetralogy of Fallot).
- Aortic valve should be oriented parallel to the vessel and should come and disappear from view during the cardiac cycle.
- No parallel vessels (ie, as in transposition of the great arteries).

AO = aorta, LV = left ventricle, PA = pulmonary artery, RA = right atrium, RV = right ventricle, SVC = superior vena cava





RVOT View

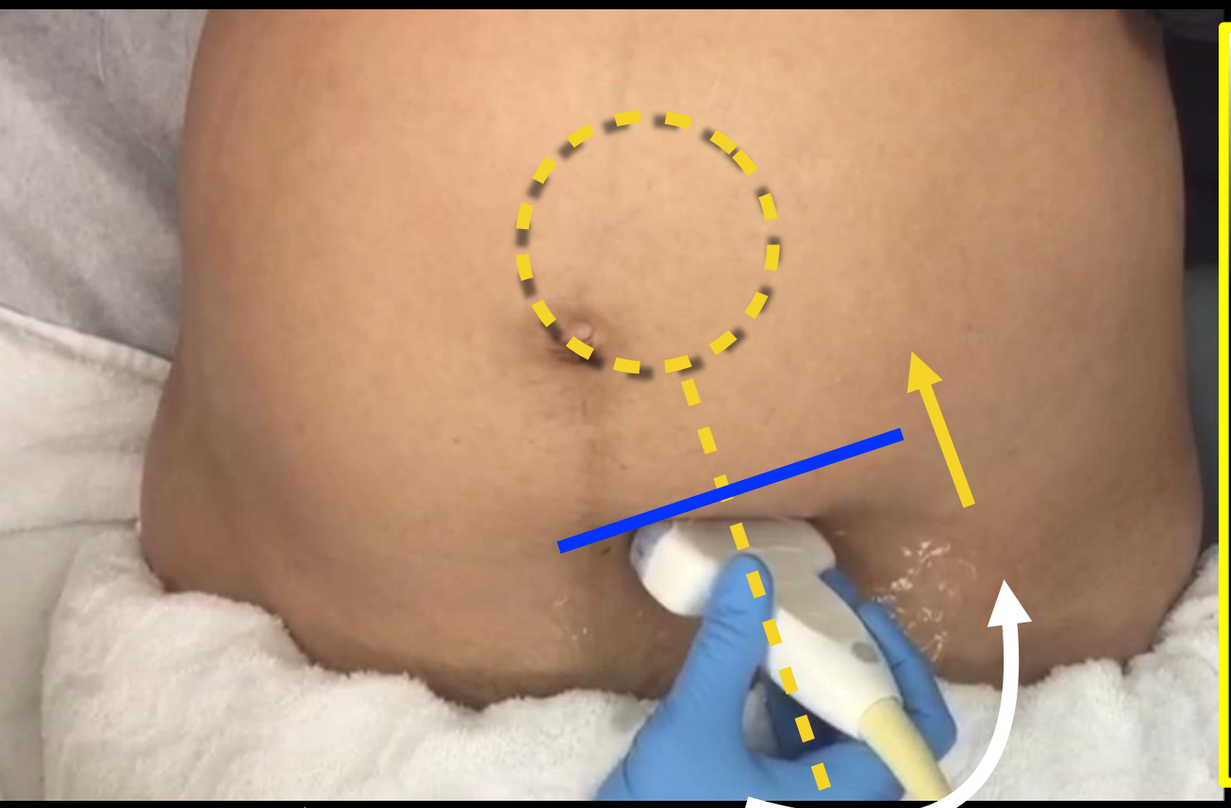
- This view is typically acquired after LVOT view.

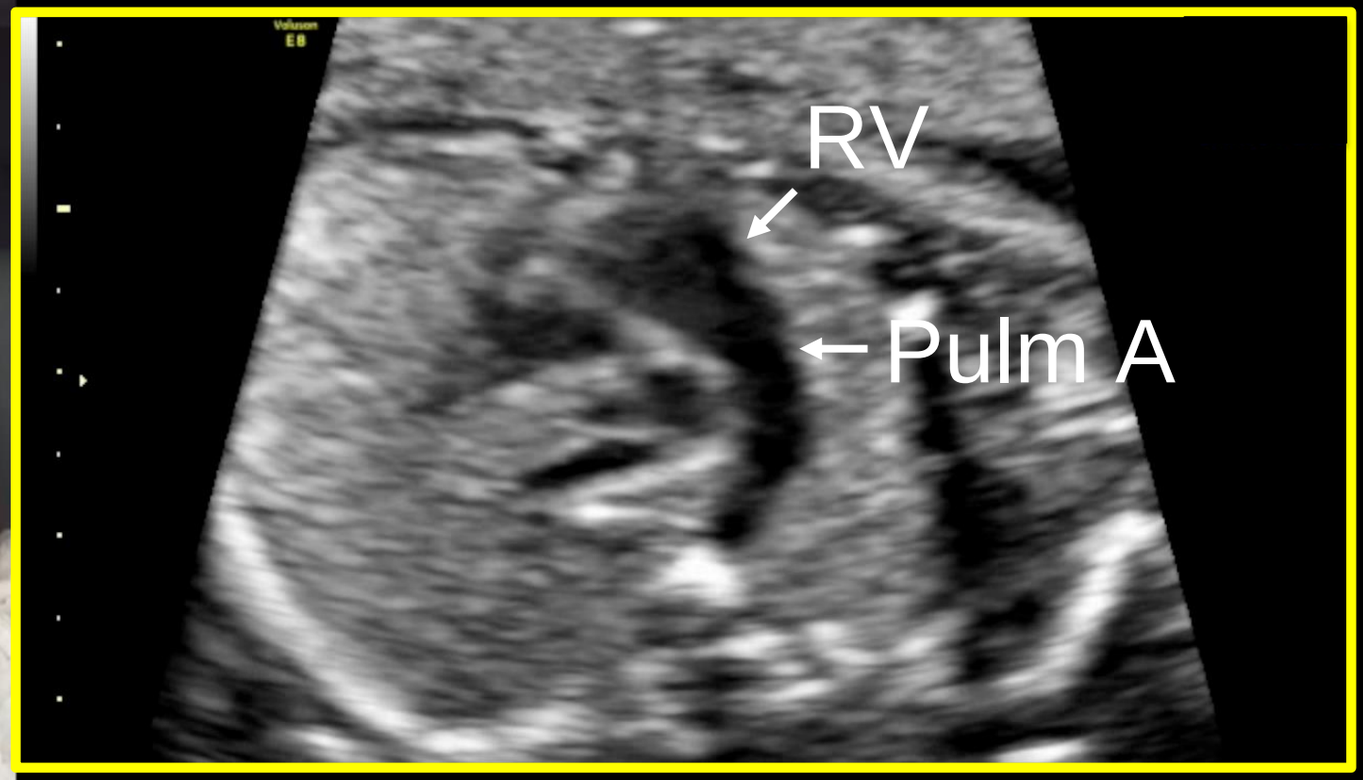
- From LVOT, rotate your thumb 90° away from the baby's left shoulder (in the opposite direction to the movement performed to obtain LVOT view) and angle the transducer ever so slightly toward the fetal head.

- The key is to have the right ventricle and pulmonary artery in the same plane and visualize the normal pulmonary valve leaflets come and disappear from the view during the cardiac cycle.

- It is an important cardiac view to evaluate for congenital cardiac anomalies, such as tetralogy of Fallot, transposition of the great arteries, and so forth.

RVOT View





Rotate thumb away from baby's left shoulder

Angle transducer

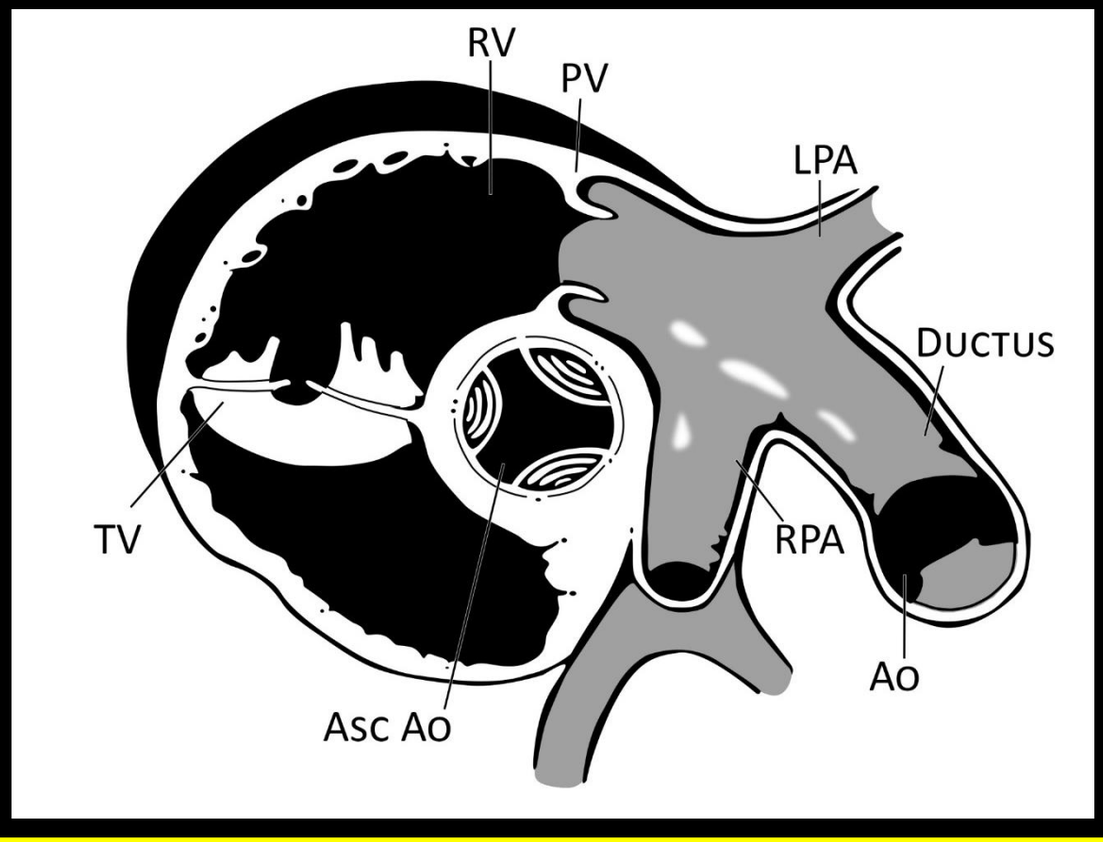
From LVOT, rotate 90° away from baby's left shoulder and angle transducer ever so slightly toward the fetal head.

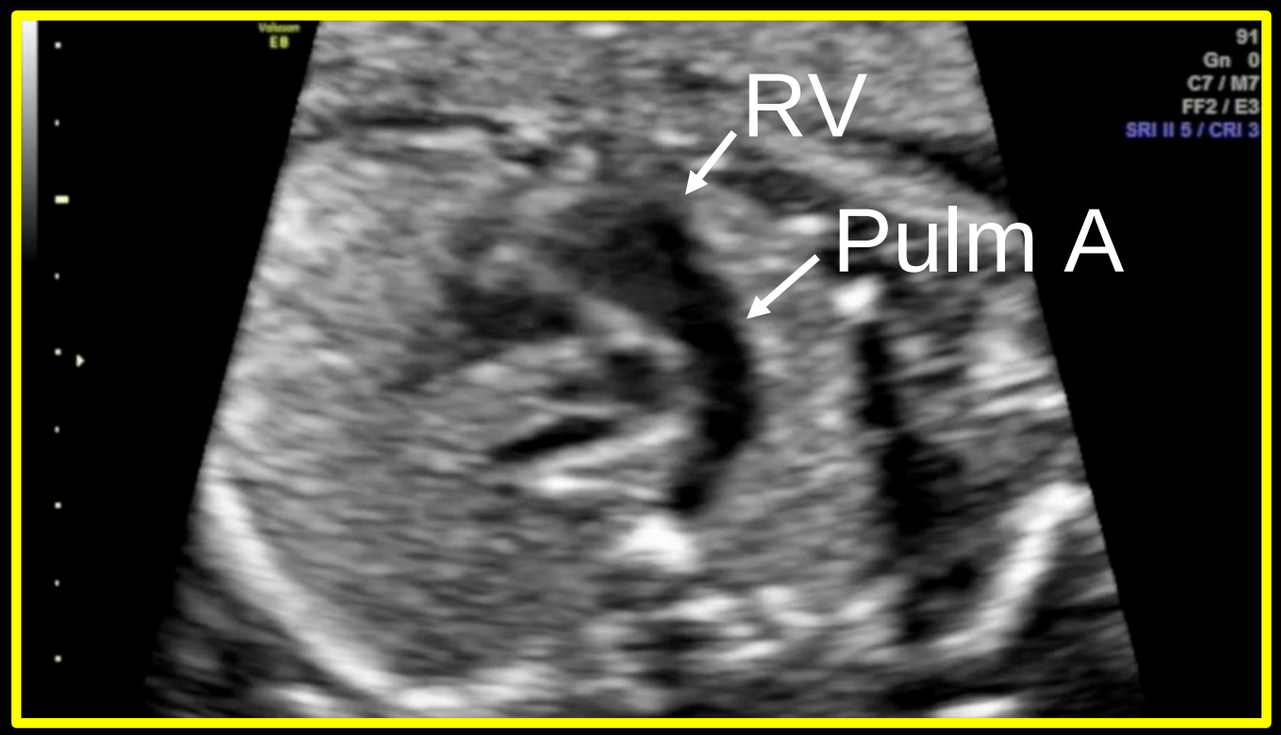
Pulm A = pulmonary artery, RV = right ventricle

RVOT View

Things to look for:

- Branching of the main pulmonary artery into right pulmonary artery and ductus arteriosus (to descending aorta)
- Aorta in cross section equal to or slightly smaller than pulmonary artery
- Pulmonary valve is perpendicular to pulmonary artery and comes and disappears from the view during the cardiac cycle.



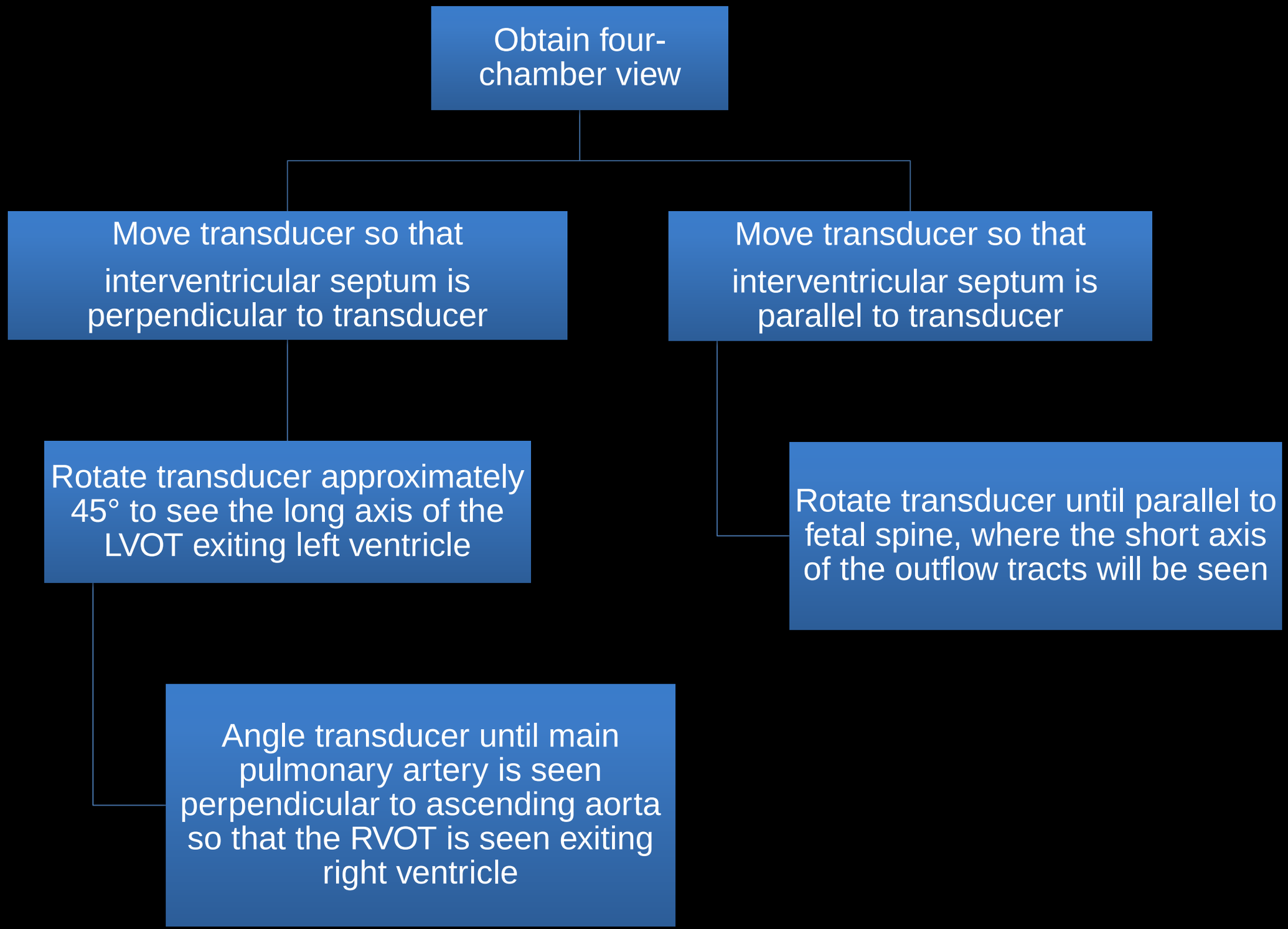


AO = aorta, ASC AO = ascending aorta, LPA = left pulmonary artery, Pulm A = pulmonary artery, PV = pulmonary valve, RPA = right pulmonary artery, RV = right ventricle, TV = tricuspid valve

Techniques from the Literature

- Over time, two basic techniques for obtaining fetal outflow tracts have emerged in the literature.
  - Rotational technique
  - Sweep technique
  - Both start from four-chamber view
- Confusion throughout the literature about how to best explain and teach these techniques to both sonographers and radiologists

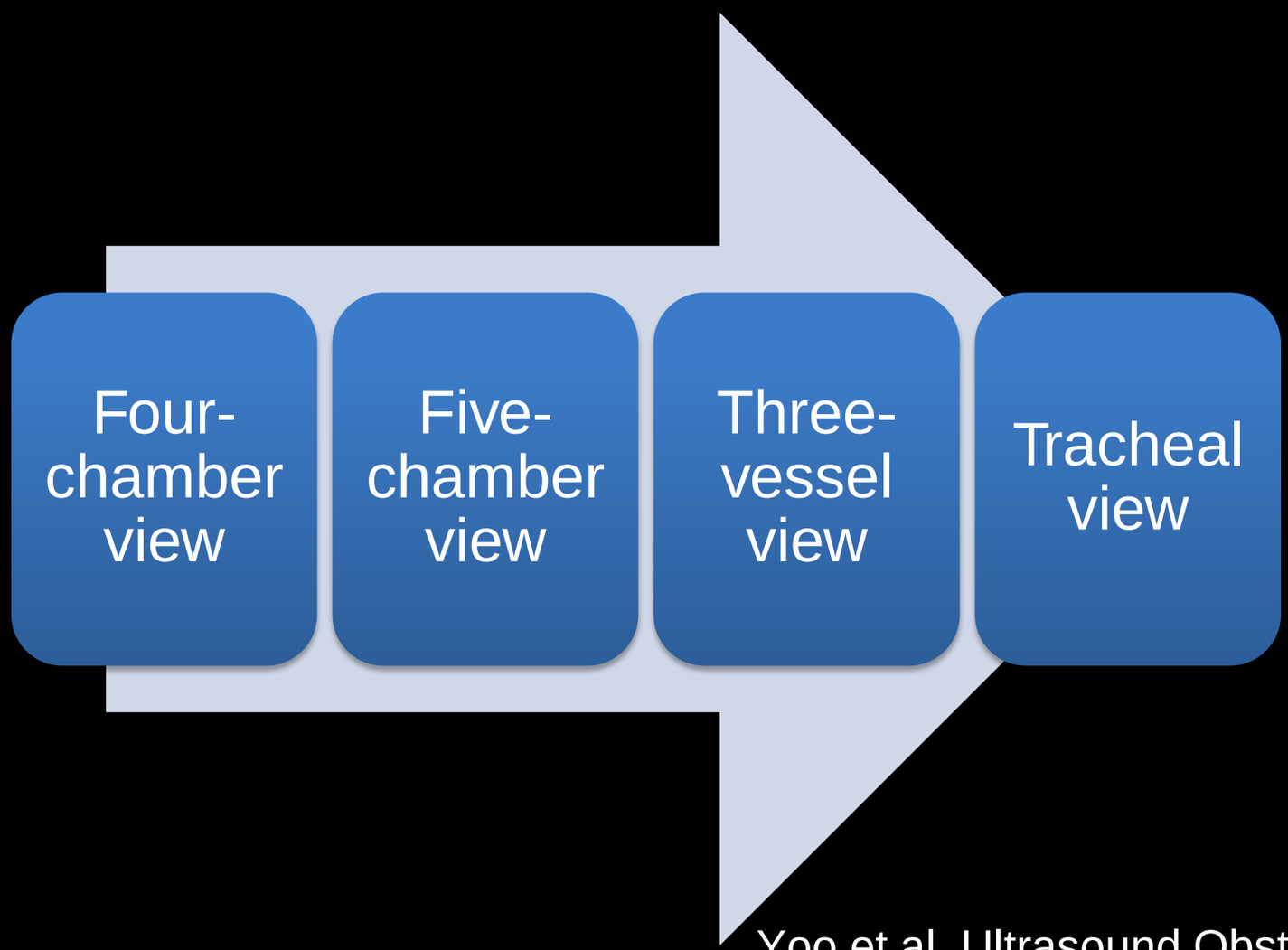
Rotational Techniques



DeVore GR. J Ultrasound Med 1992;11:345–348.

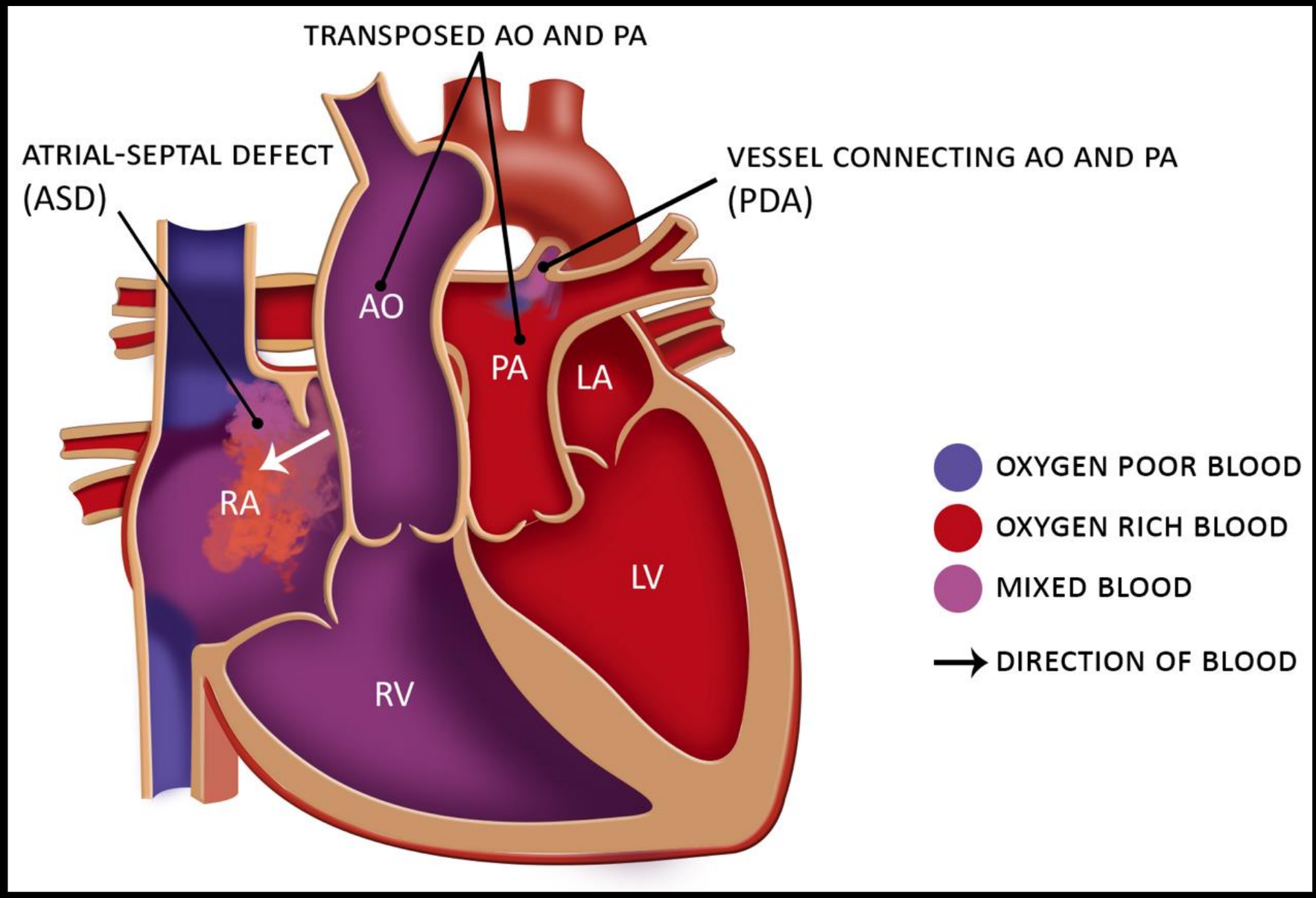
Sweep Technique

- Tilt transducer in a transverse plane toward the fetal neck.
- Slight sliding of the probe cranially can be added to the tilting motion.



Yoo et al. Ultrasound Obstet Gynecol 1997;9:173–182
Yagel et al. Ultrasound Obstet Gynecol 2001;17:367–369

Transposition of the Great Arteries



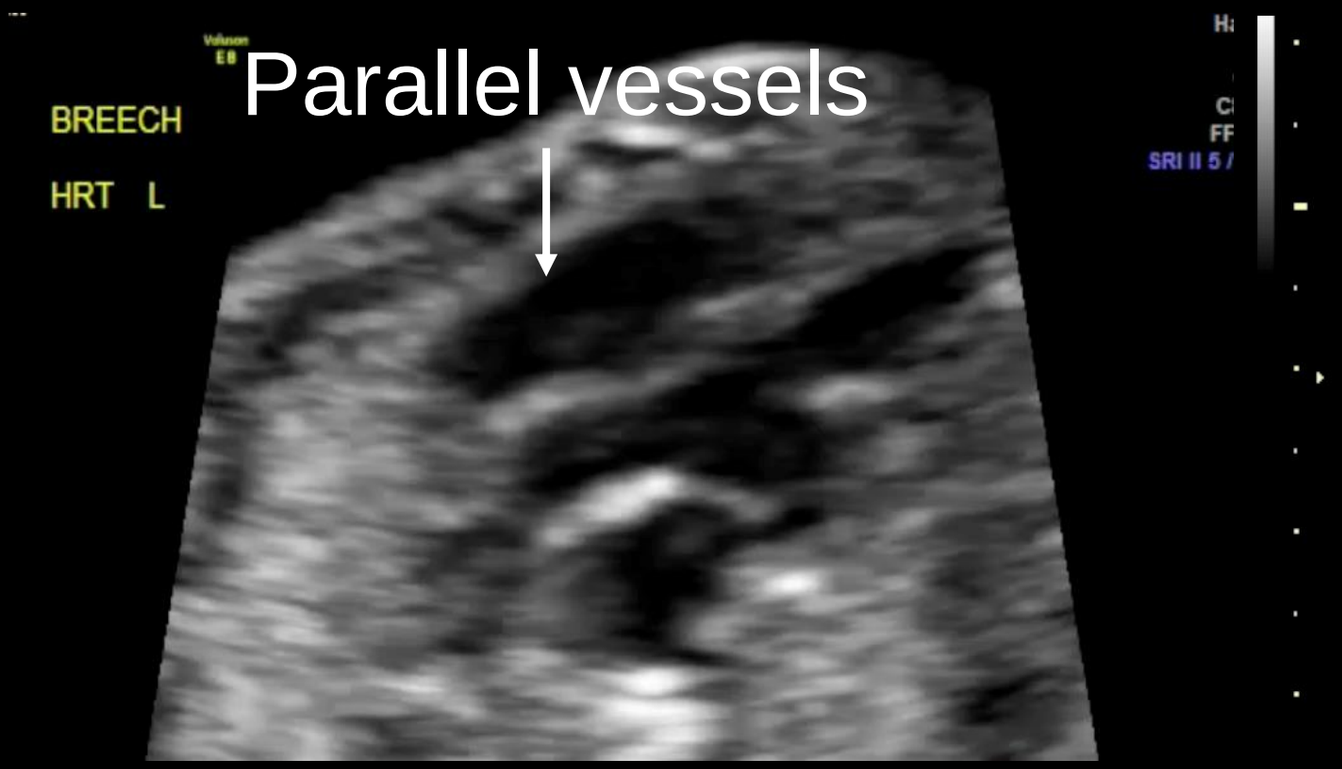
AO = aorta, LA = left atrium, LV = left ventricle, PA = pulmonary artery, PDA = patent ductus arteriosus, RA = right atrium, RV = right ventricle

- Approximately 1 in 5000 births
- Typically an isolated abnormality
- Aorta arises from the right ventricle.
- Pulmonary artery arises from the left ventricle.

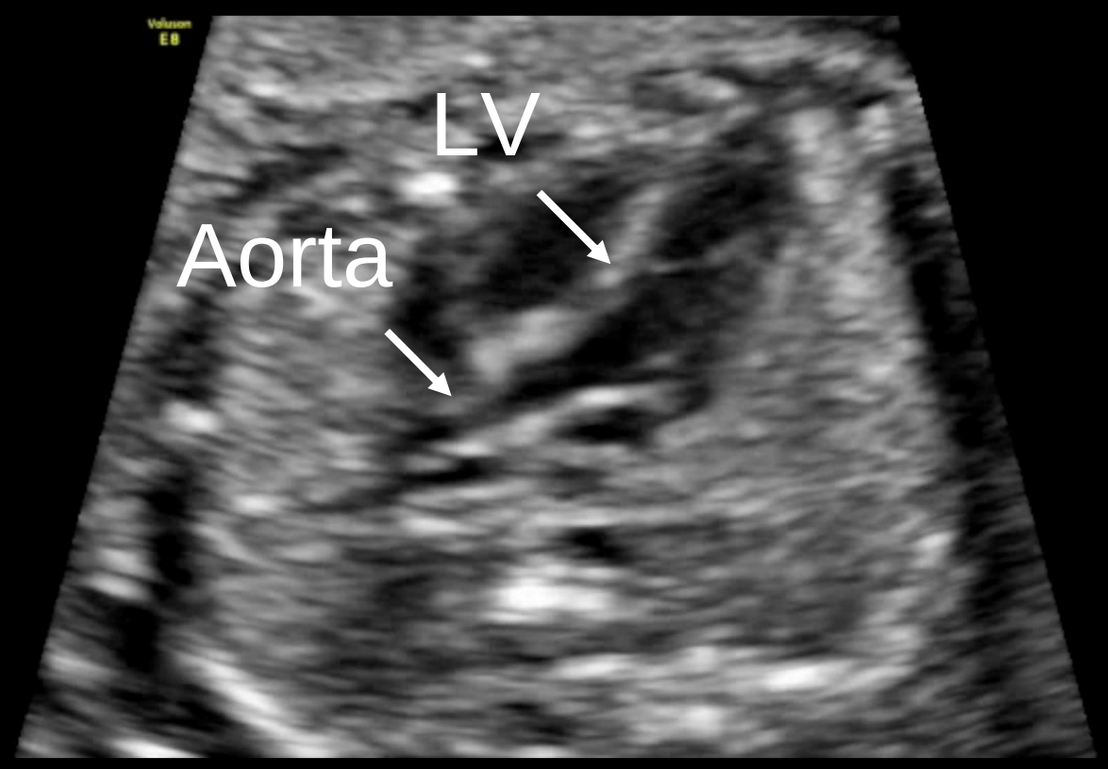
Transposition of Great Arteries: Four-Chamber View

- d-Transposition
  - Incidence: 1 in 3300
  - Four-chamber view is often normal finding.
  - Ventricular ductus arteriosus is present in approximately 40% of cases.
  - Pulmonary stenosis (LVOT obstruction) is present in approximately 25% of cases.
- l-Transposition
  - Incidence: 1 in 33,000
  - Also known as congenitally corrected transposition of great arteries
  - Right atrium -> left ventricle -> pulmonary artery
  - Left atrium -> right ventricle -> aorta
- Anomalies associated with transposition of great arteries: ventricular septal defect, pulmonary stenosis, valvular abnormalities, anomalous coronary circulation

d-Transposition of the Great Arteries



Abnormal LVOT

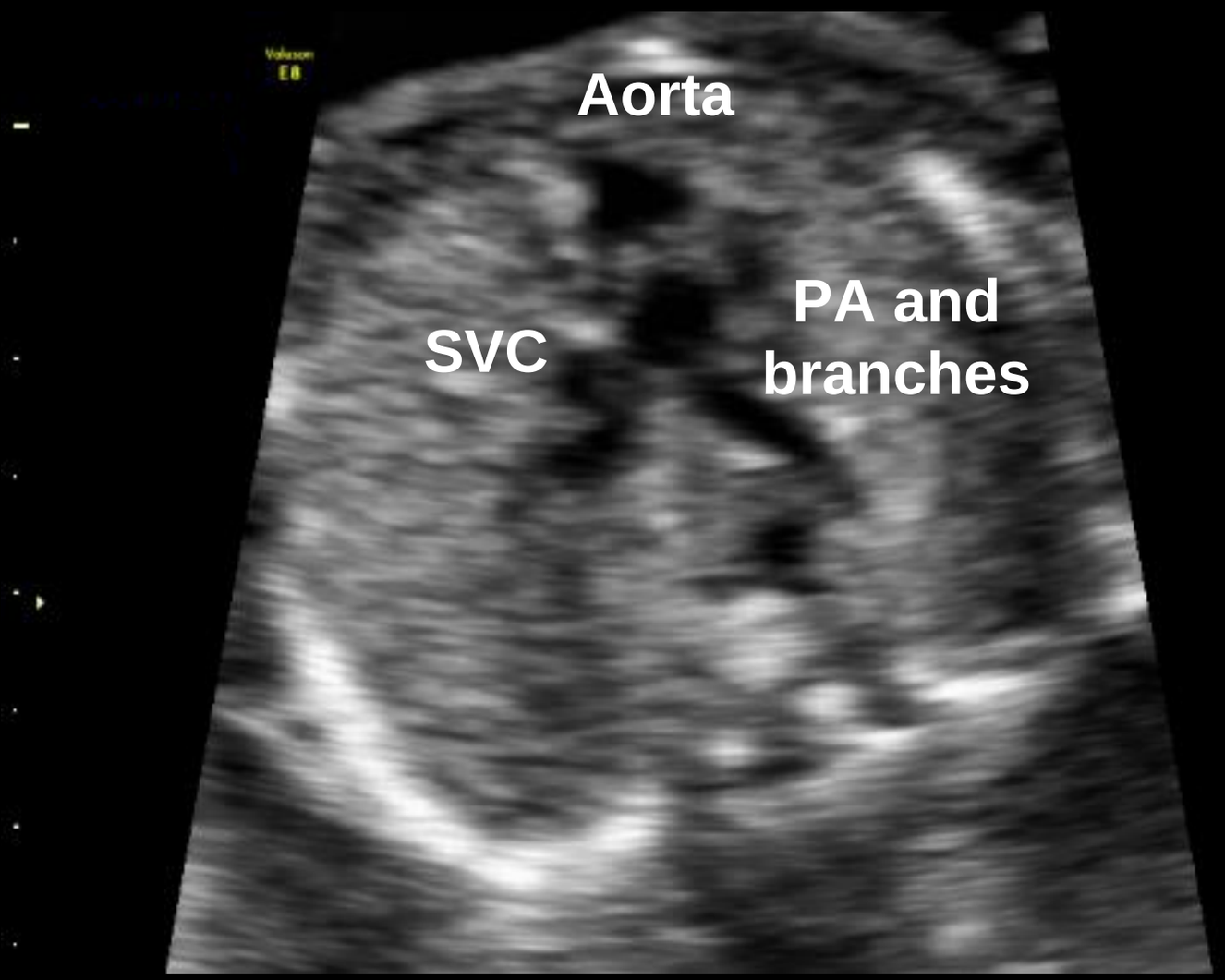


Normal LVOT

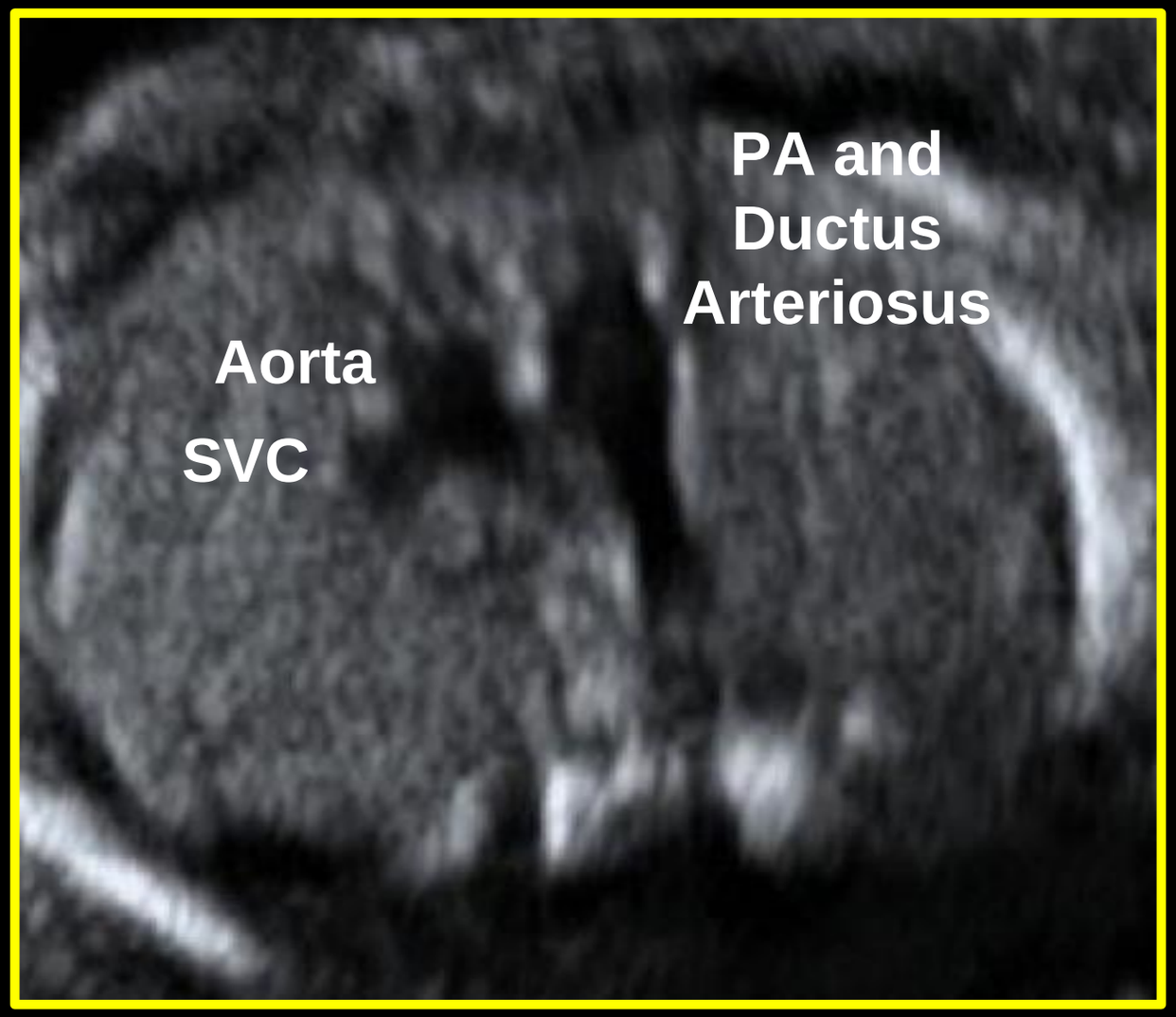
In the LVOT, the great vessels course parallel to each other, with the aorta arising from the right ventricle and the pulmonary artery arising from the left ventricle.

LV = left ventricle

Transposition of Great Arteries: Three-Vessel View



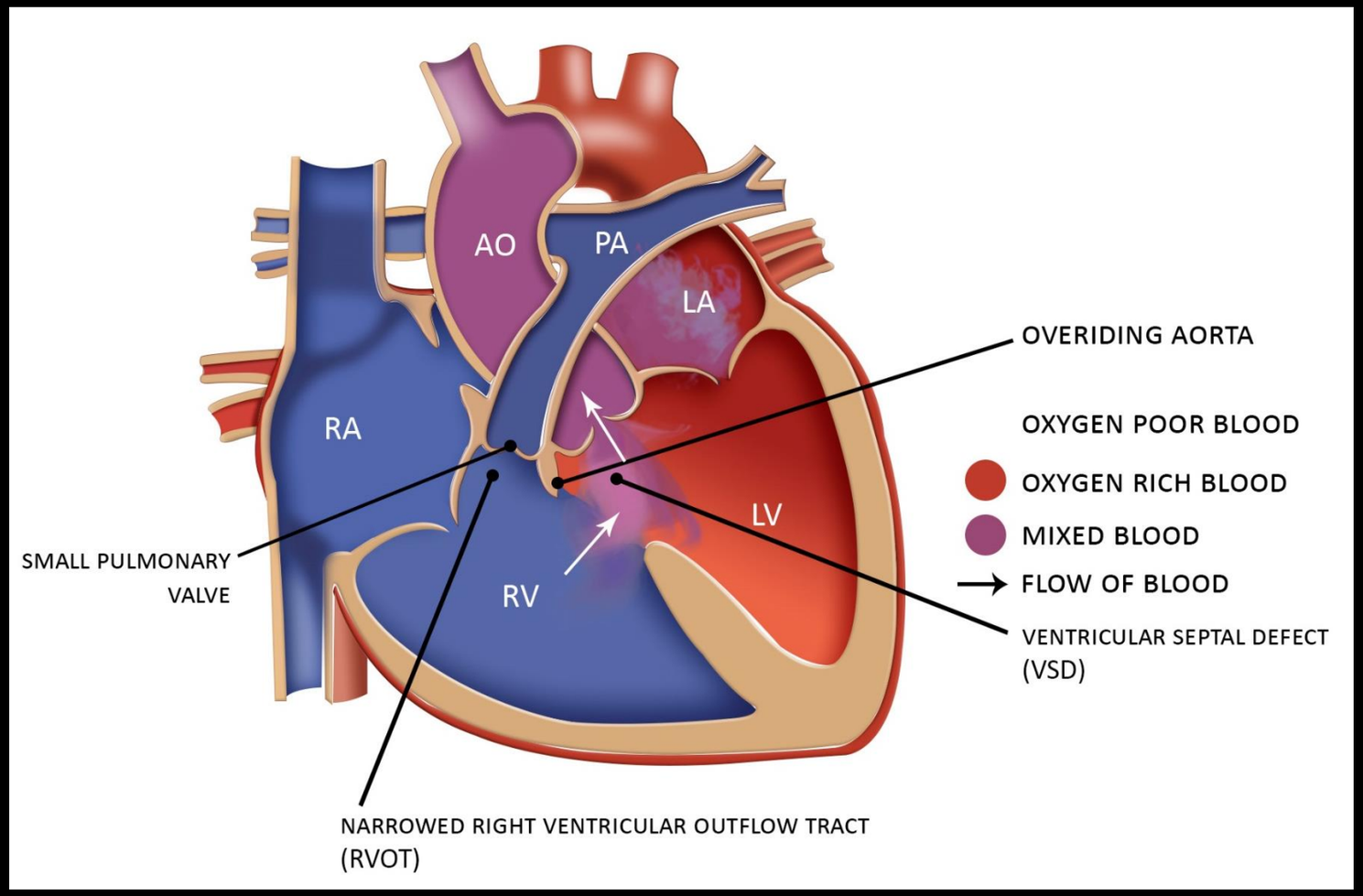
Normal three-vessel view



In the three-vessel view, the aorta is anterior to the pulmonary artery.

PA = pulmonary artery, SVC = superior vena cava

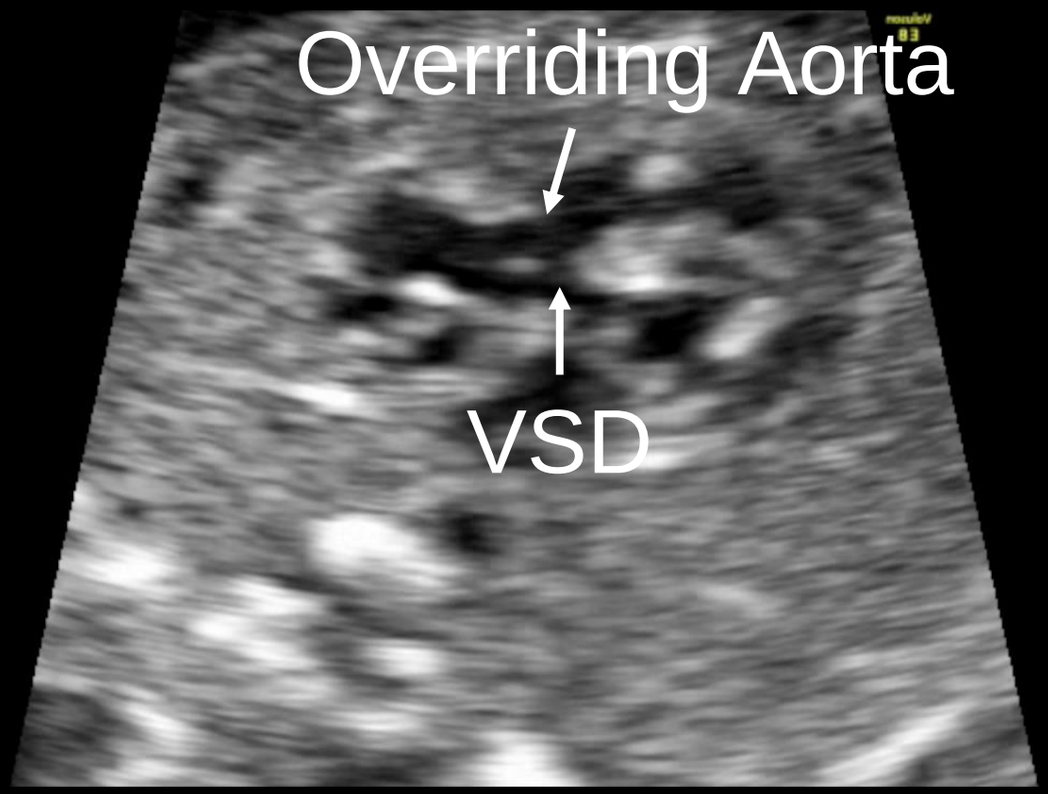
Tetralogy of Fallot

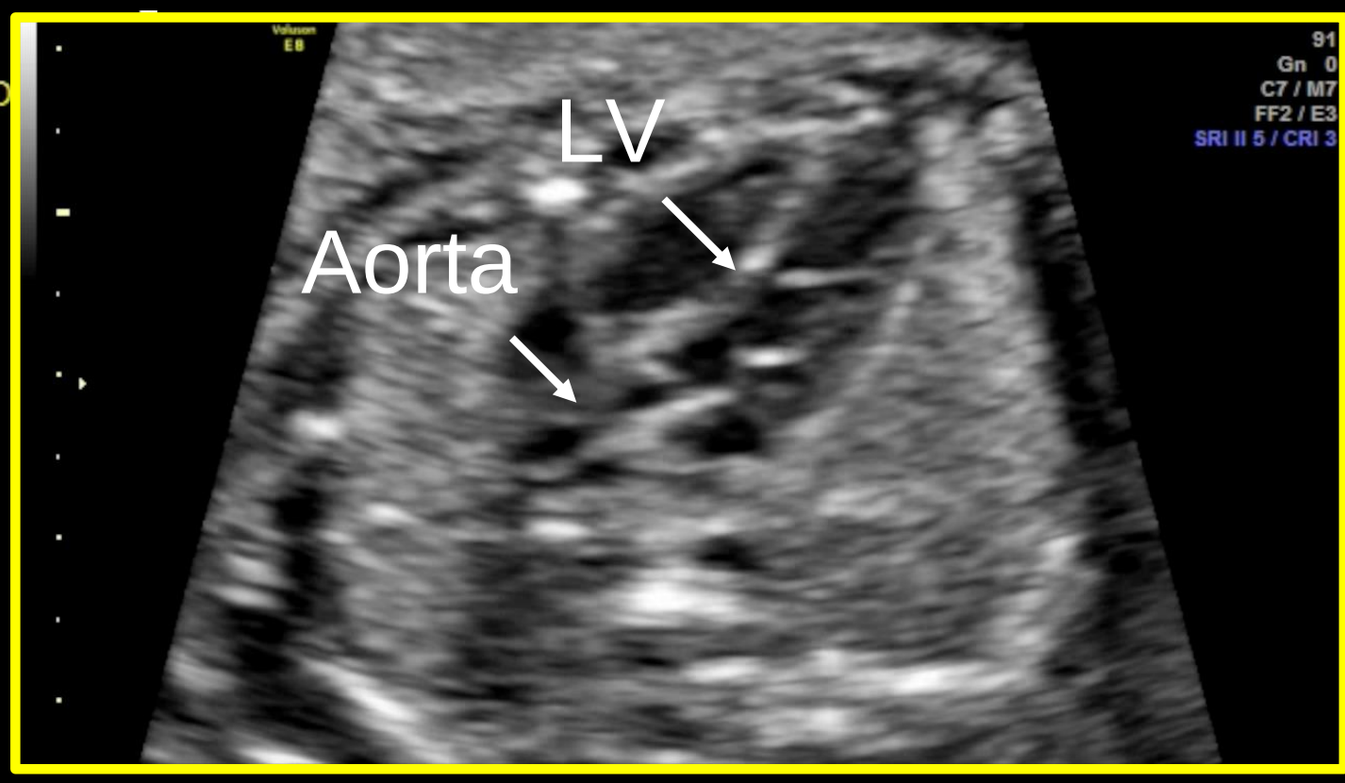


AO = aorta, LA = left atrium, LV = left ventricle, PA = pulmonary artery, RA = right atrium, RV = right ventricle

- Approximately 1 in 4000 births
- Associated with chromosomal abnormality in 45% of cases, such as 22q11 deletion syndrome and trisomy 21
- Four classic components
  1. Pulmonary artery stenosis
  2. Ventricular septal defect
  3. Overriding aorta
  4. Right ventricular hypertrophy—typically not seen until after birth

Tetralogy of Fallot





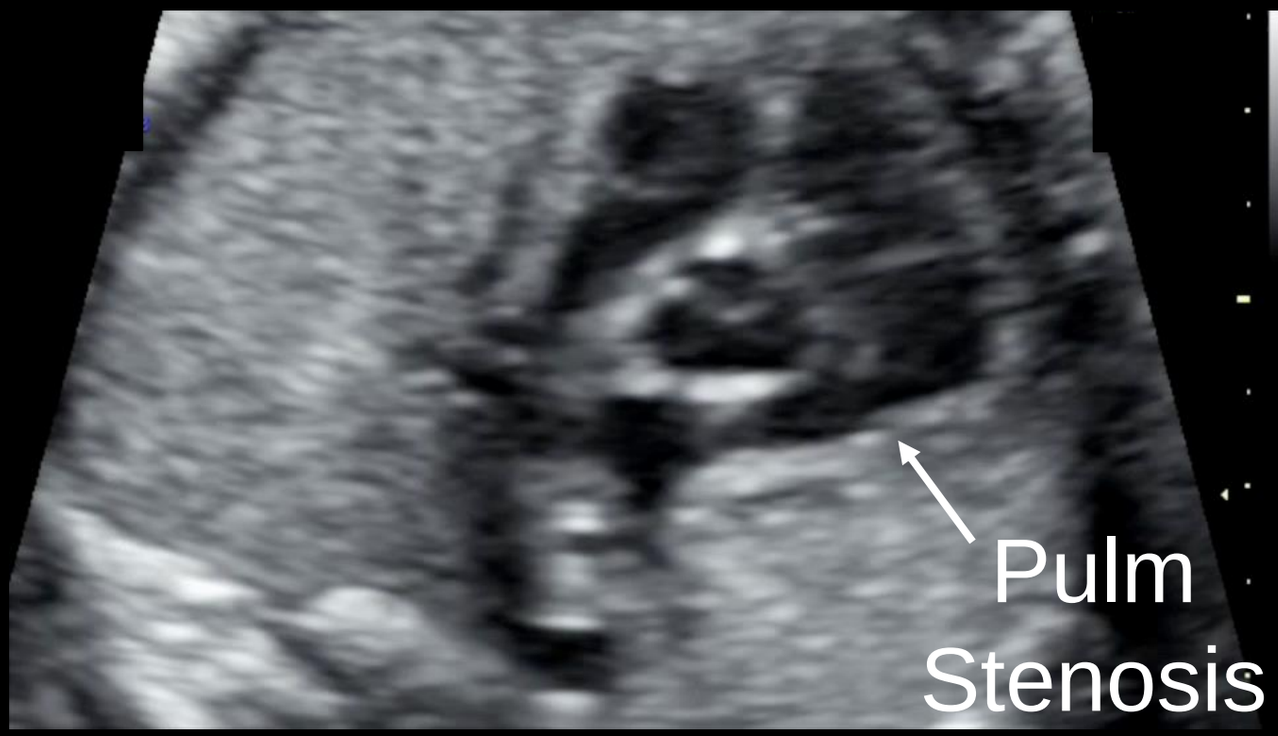
Abnormal LVOT

Normal LVOT

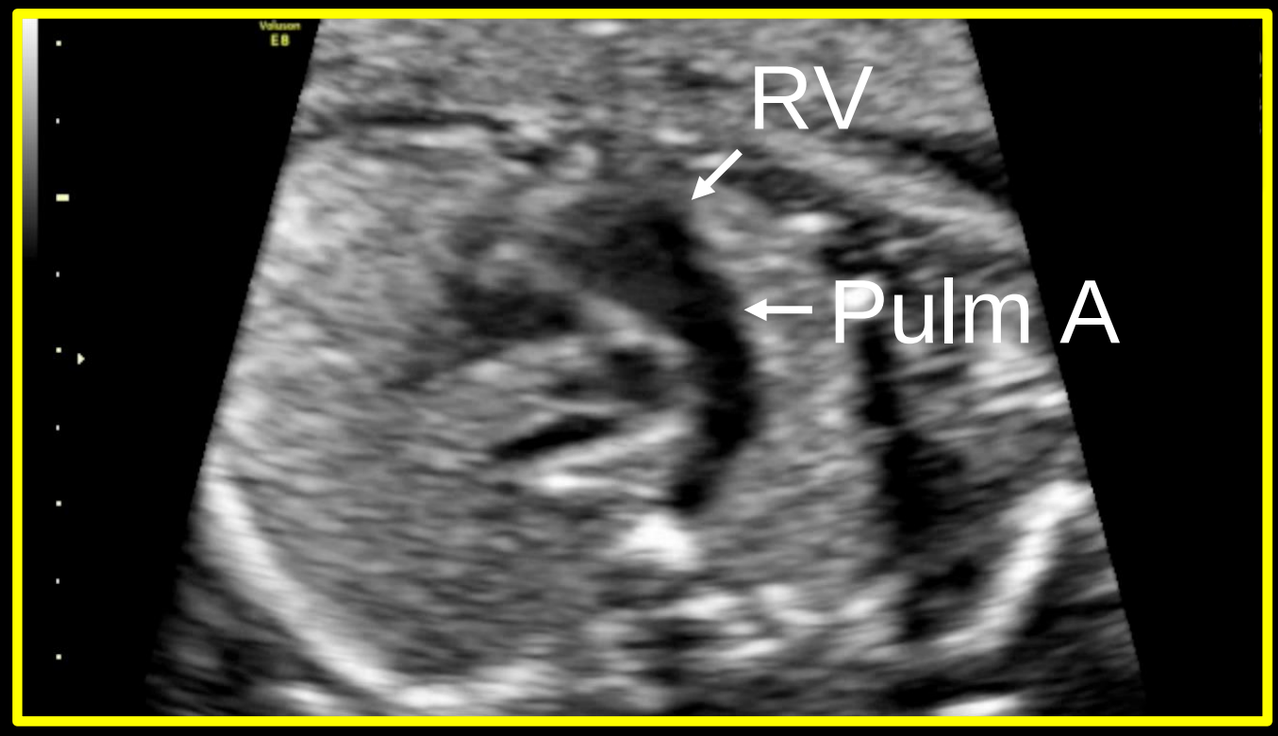
In the LVOT, a ventricular septal defect can be seen. In addition, the aorta is overriding the ventricular septal defect such that it receives outflowing blood from both the right and left ventricles.

LV = left ventricle, VSD = ventricular septal defect

Tetralogy of Fallot



Abnormal RVOT

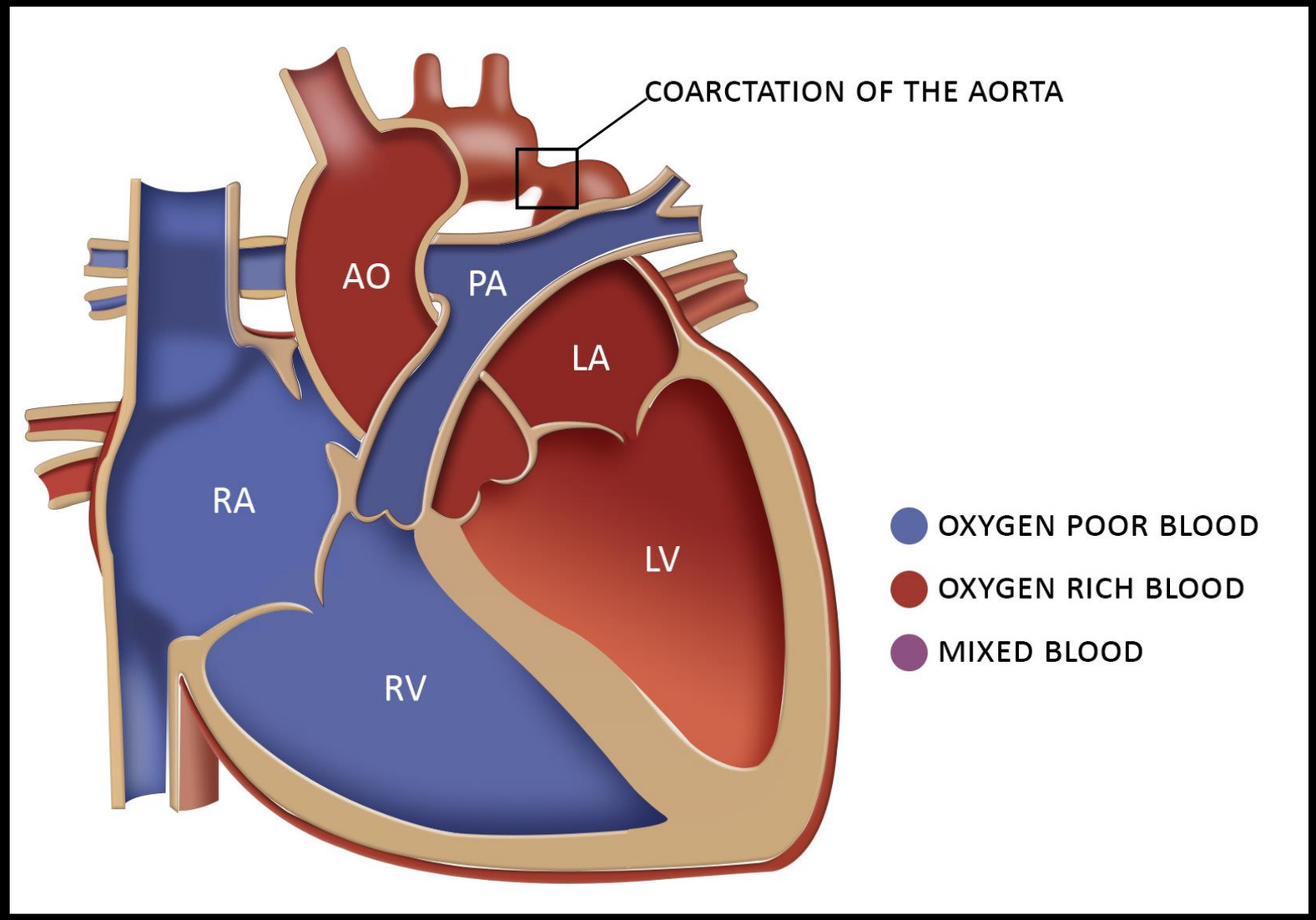


Normal RVOT

In the RVOT, a narrow pulmonary artery can be seen (arrow in abnormal RVOT).

Pulm = pulmonary, Pulm A = pulmonary artery, RV = right ventricle

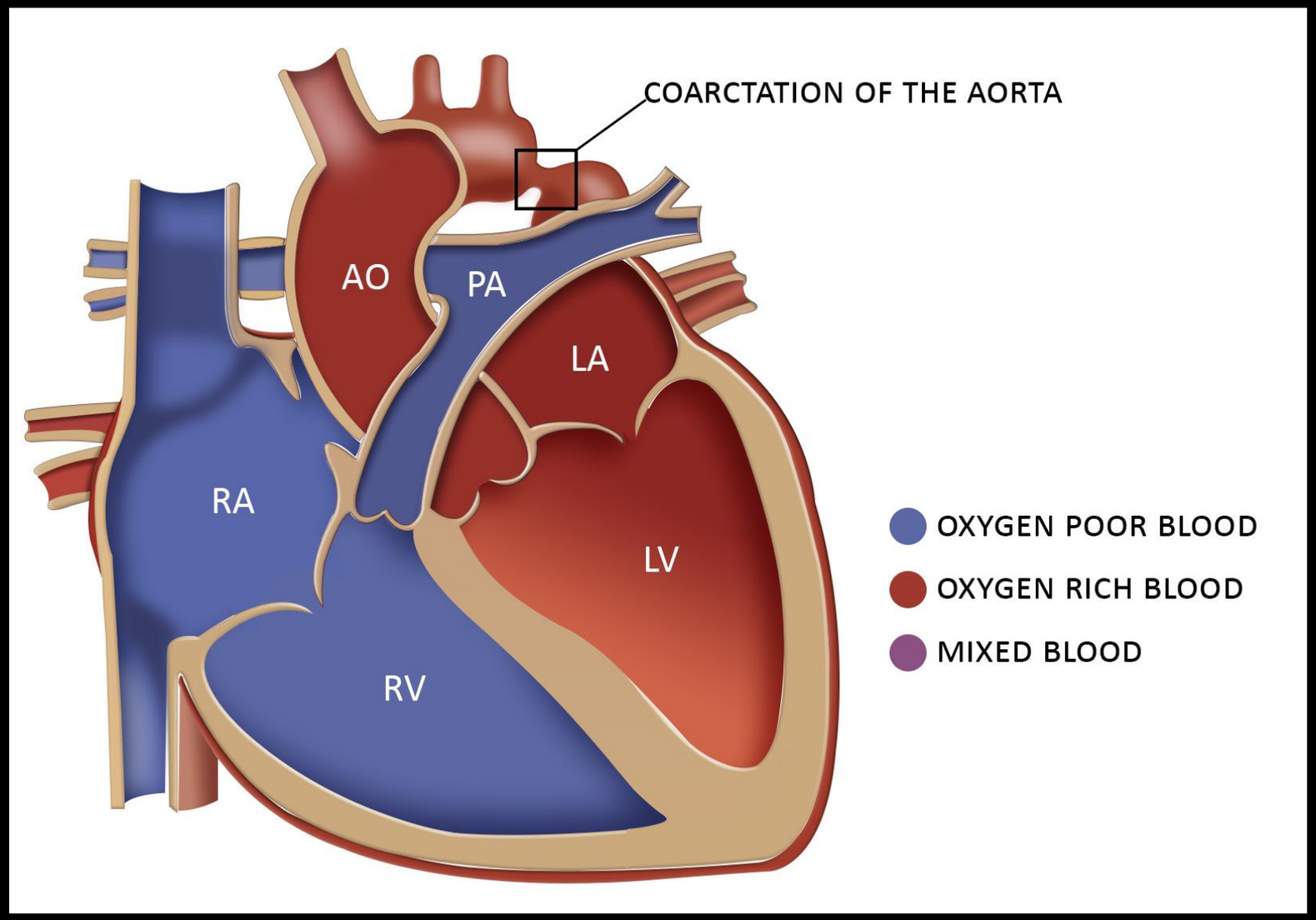
Coarctation of Aorta



AO = aorta, LA = left atrium, LV = left ventricle, PA = pulmonary artery, RA = right atrium, RV = right ventricle

- Narrowing of the aortic lumen, incidence: approximately 1 in 2500 births, more common in males
- Two types: infantile: long-segment narrowing proximal to the ductus arteriosus; adult: short-segment narrowing distal to the ductus arteriosus
- Collateral vessels would not be seen in infantile-type coarctation; it takes time for the collateral vessels to form.
- May occur as an isolated defect or in association with various other lesions, most commonly bicuspid aortic valve and ventricular septal defect

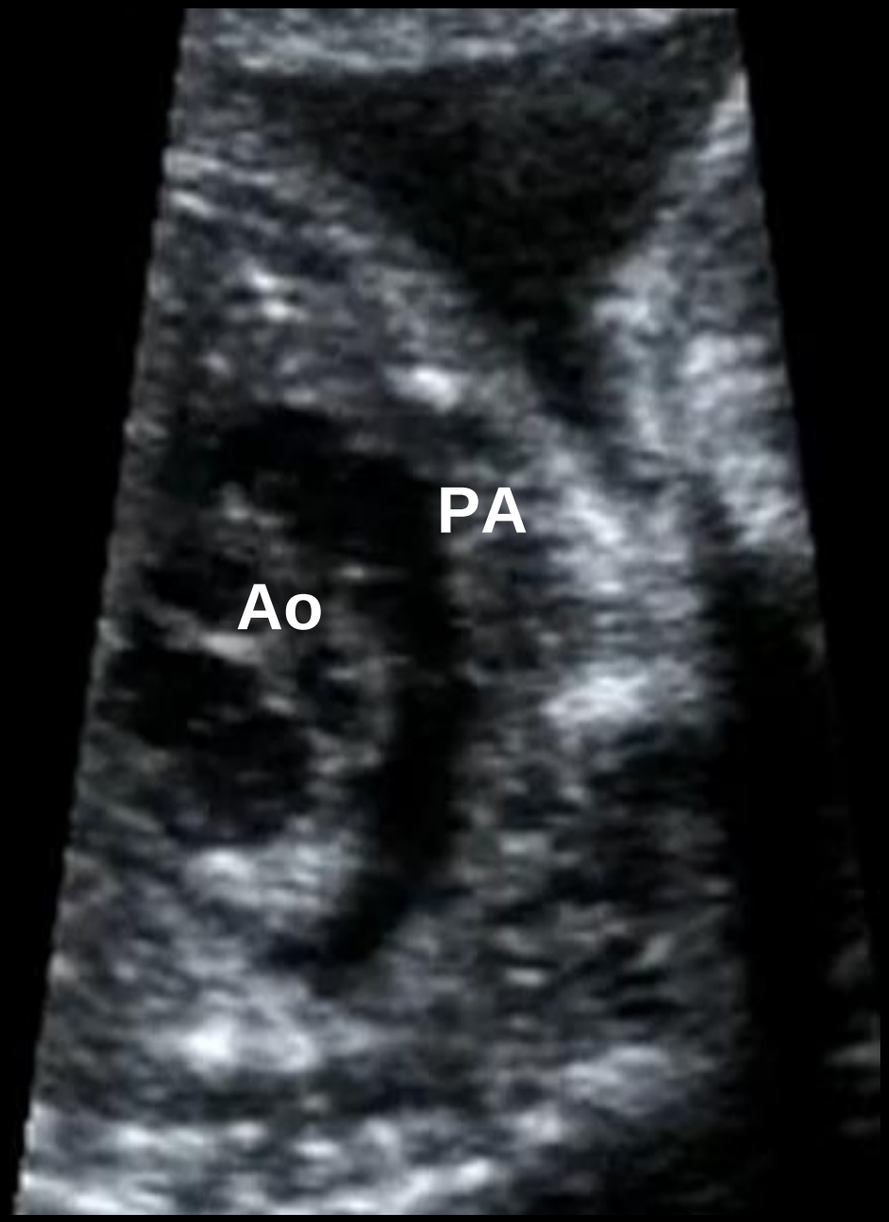
Coarctation of Aorta



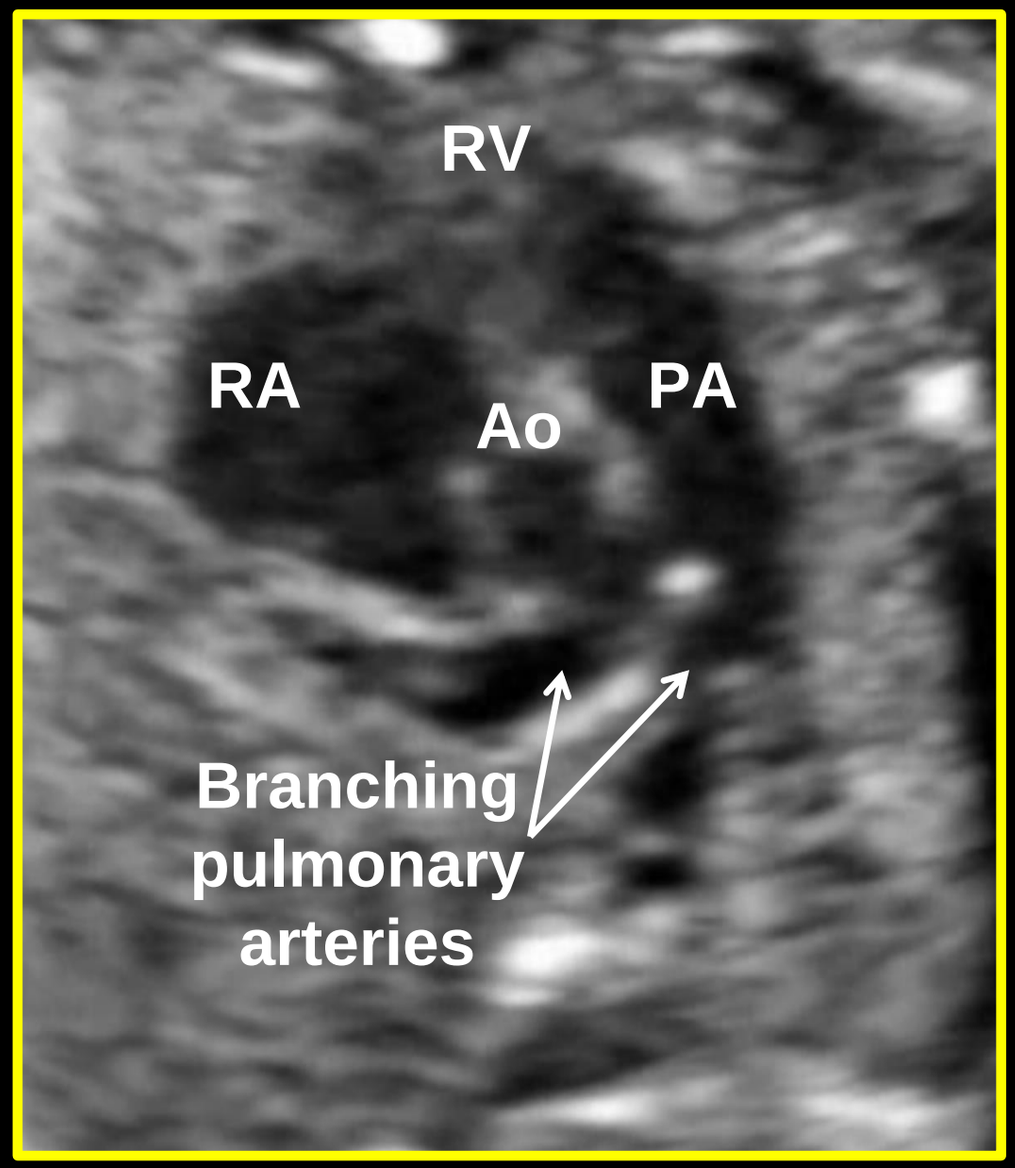
AO = aorta, LA = left atrium, LV = left ventricle, PA = pulmonary artery, RA = right atrium, RV = right ventricle

- The most commonly associated defects include patent ductus arteriosus, bicuspid aortic valve, ventricular septal defect, and aortic stenosis.
- May manifest as a complicating feature of a more complex cyanotic heart defect, such as transposition of the great arteries, Taussig-Bing anomaly, double-inlet left ventricle, tricuspid atresia with transposition of the great arteries, and hypoplastic left heart syndrome

Coarctation: RVOT



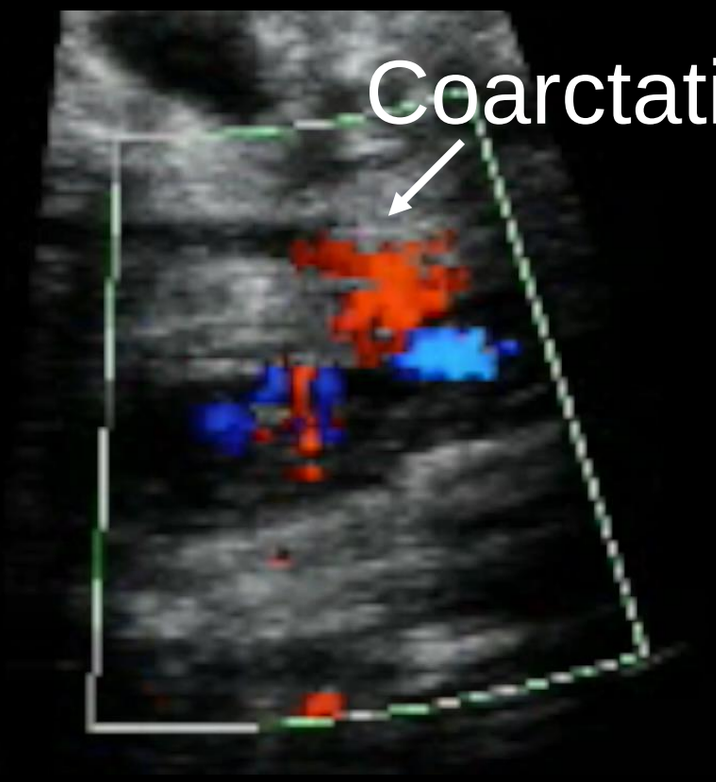
Normal RVOT

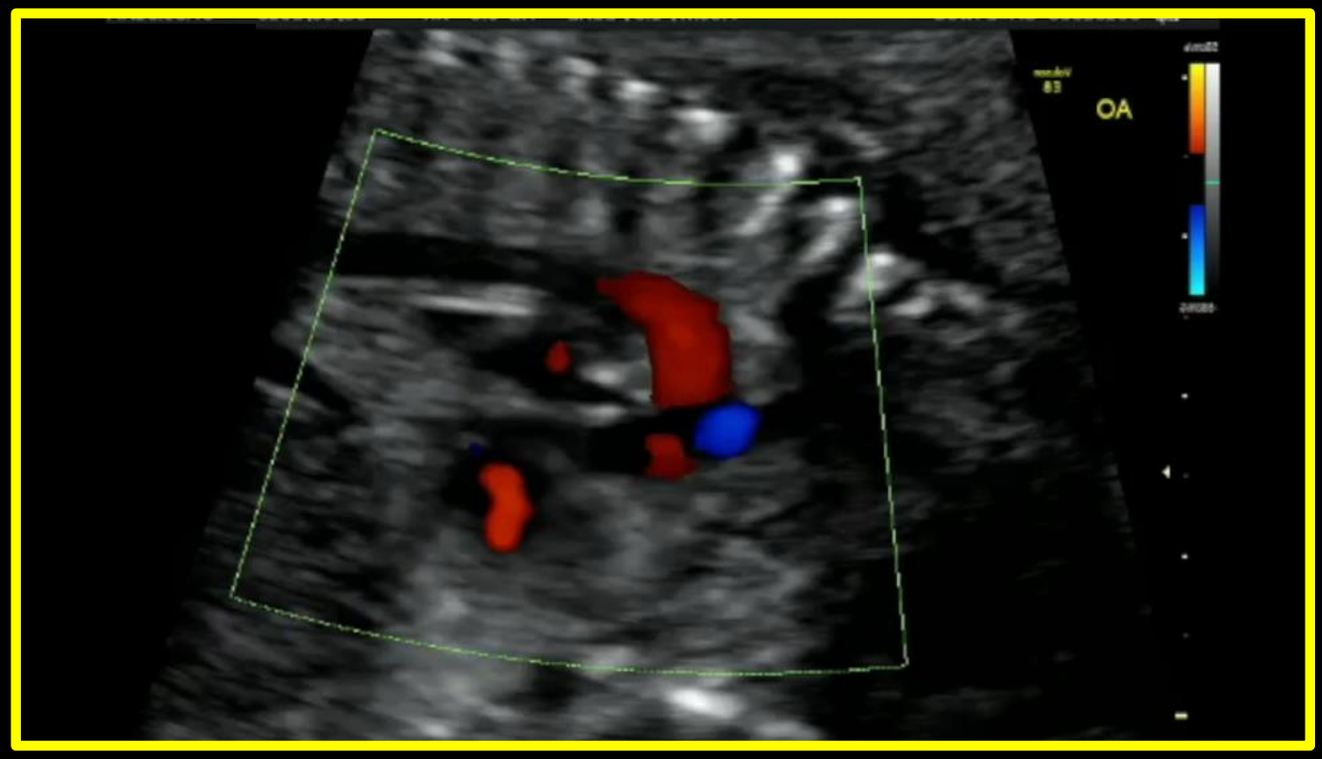


In coarctation, the pulmonary artery can be relatively enlarged compared with the aorta.

Ao = aorta, PA = pulmonary artery, RA = right atrium, RV = right ventricle

Coarctation of Aorta



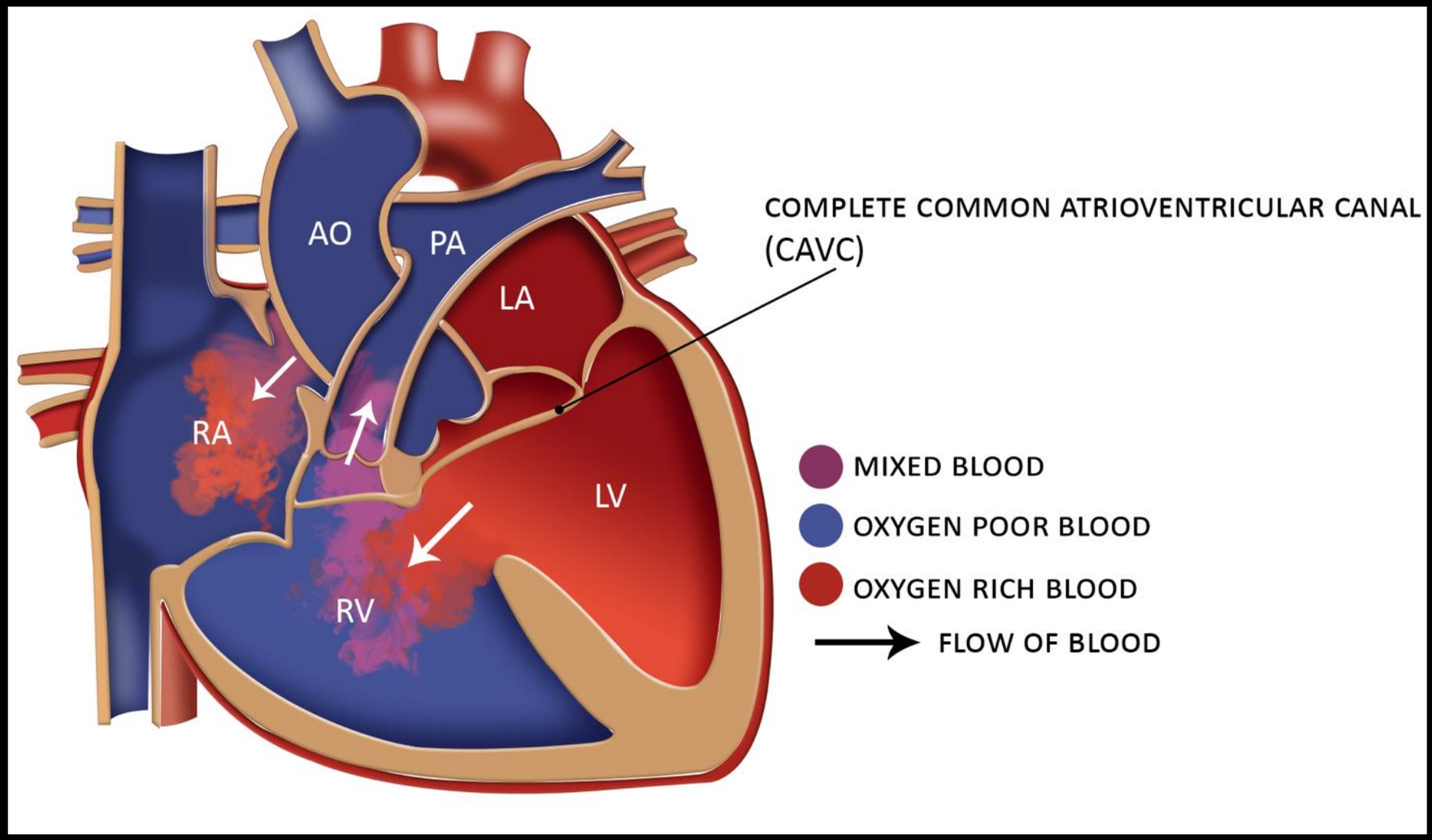


Abnormal aortic arch view

Normal aortic arch view

Coarctation can involve a discrete or long segment of the aortic arch. Color Doppler flow imaging can be helpful to identify this abnormality.

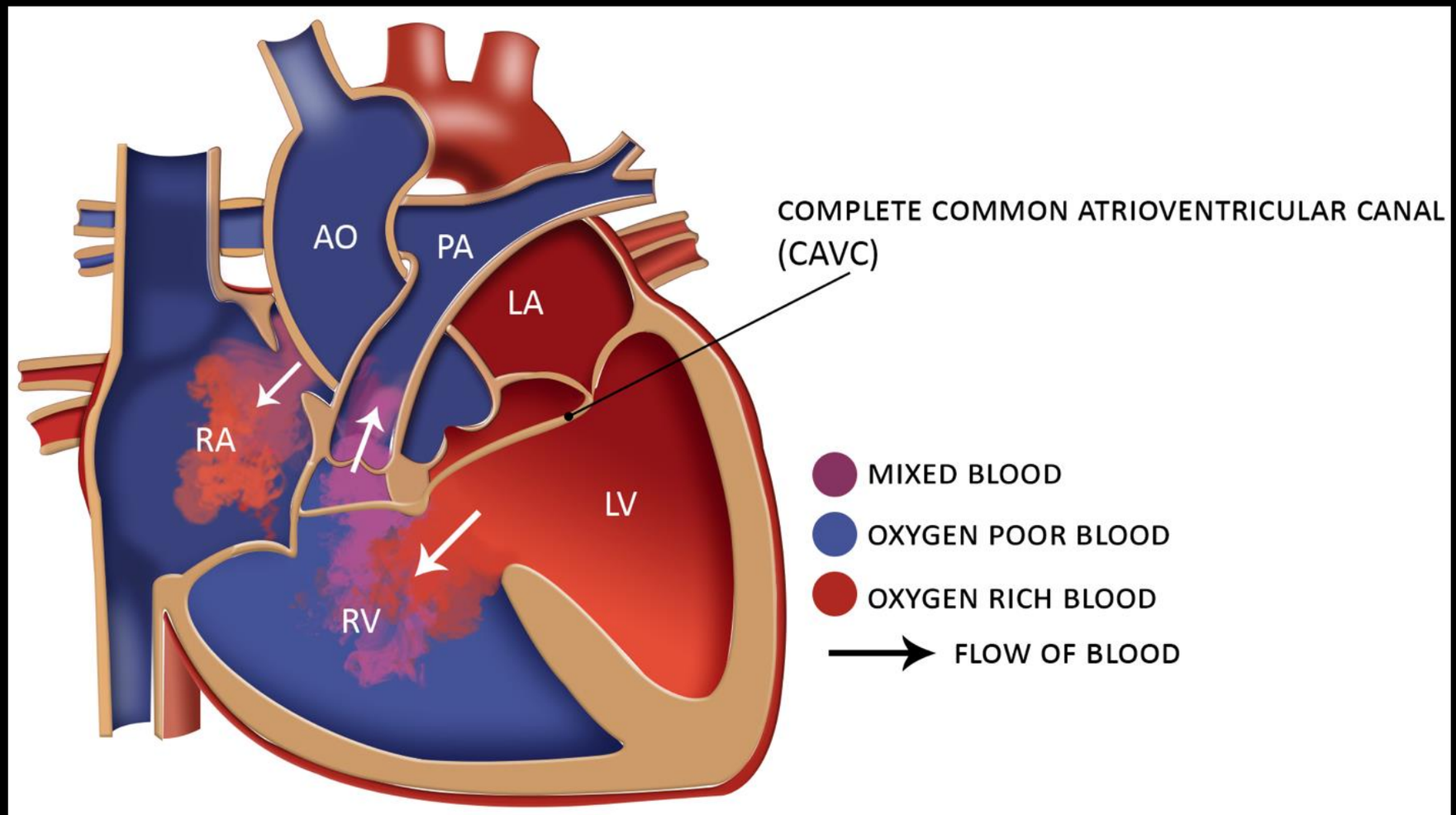
Atrioventricular Septal Defect



AO = aorta, LA = left atrium, LV = left ventricle, PA = pulmonary artery, RA = right atrium, RV = right ventricle

- Incidence: approximately 1 in 4000 births, associated with trisomy 21, less commonly trisomy 13 and 18, heterotaxy syndromes
- Common synonyms: atrioventricular canal defect or endocardial cushion defect
- Associated cardiac anomalies include tetralogy of Fallot, right aortic arch, and double outlet right ventricle.
- Can be associated with anomalies of the systemic and pulmonary veins, mainly when associated with heterotaxy syndromes

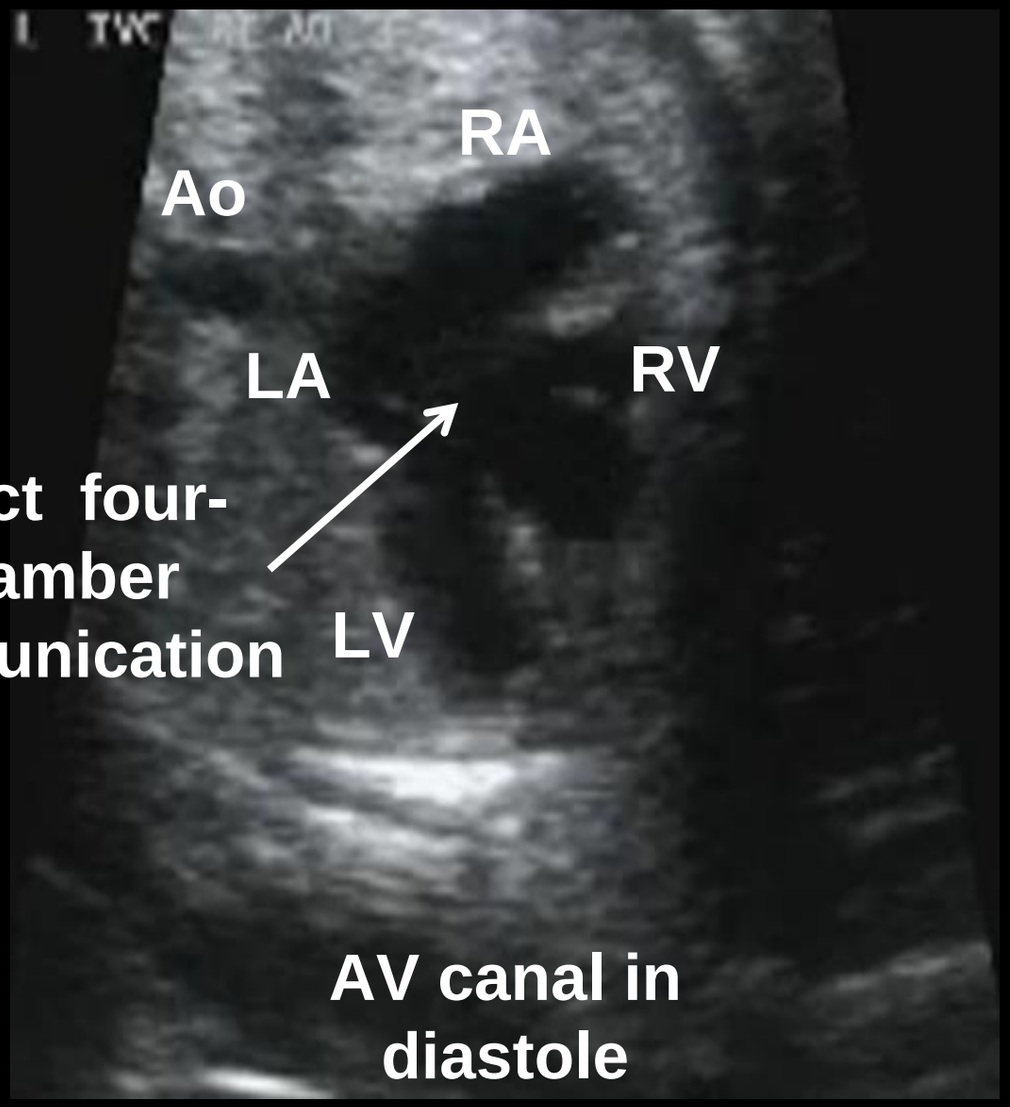
Atrioventricular Septal Defect

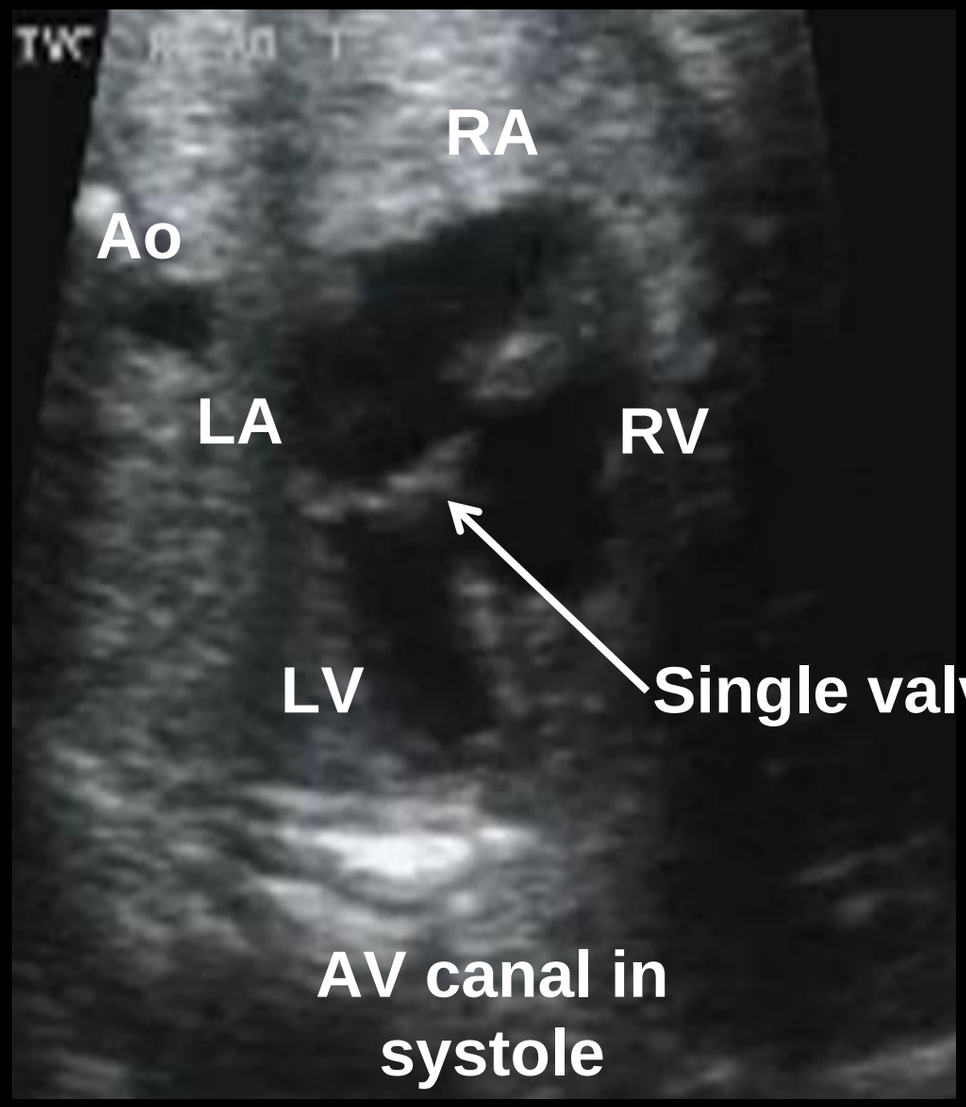


AO = aorta, LA = left atrium, LV = left ventricle, PA = pulmonary artery, RA = right atrium, RV = right ventricle

- Represents a group of congenital abnormalities bound by a variable deficiency of the atrioventricular septum immediately above and below the atrioventricular valves
- Defects range from incomplete atrioventricular septal defects, which have a deficiency in only the inferior portion of the atrial septum immediately superior to the atrioventricular valves, to complete atrioventricular septal defects, with both atrial and ventricular septal defects and a single common atrioventricular valve.
- Unbalanced atrioventricular septal defect results in ventricular disproportion and can result in single-ventricle physiology.

Atrioventricular Septal Defect: Four-Chamber View

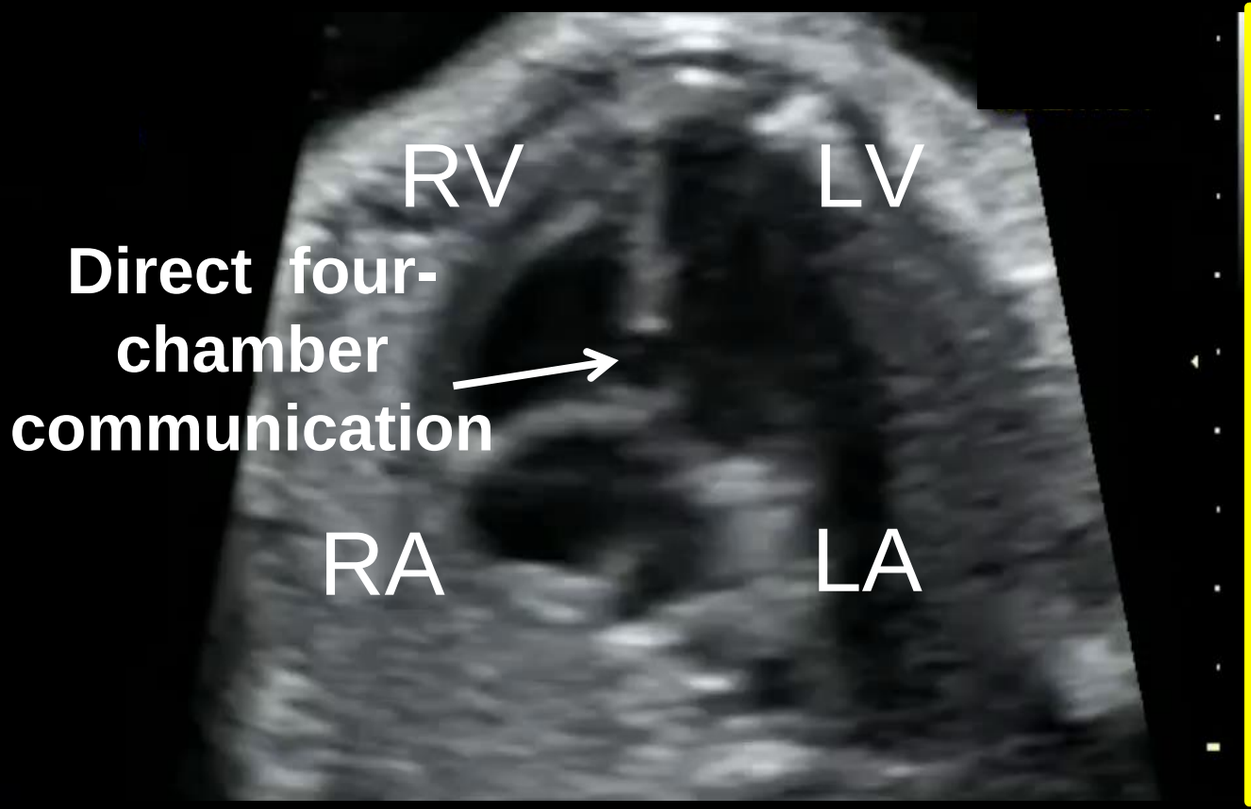


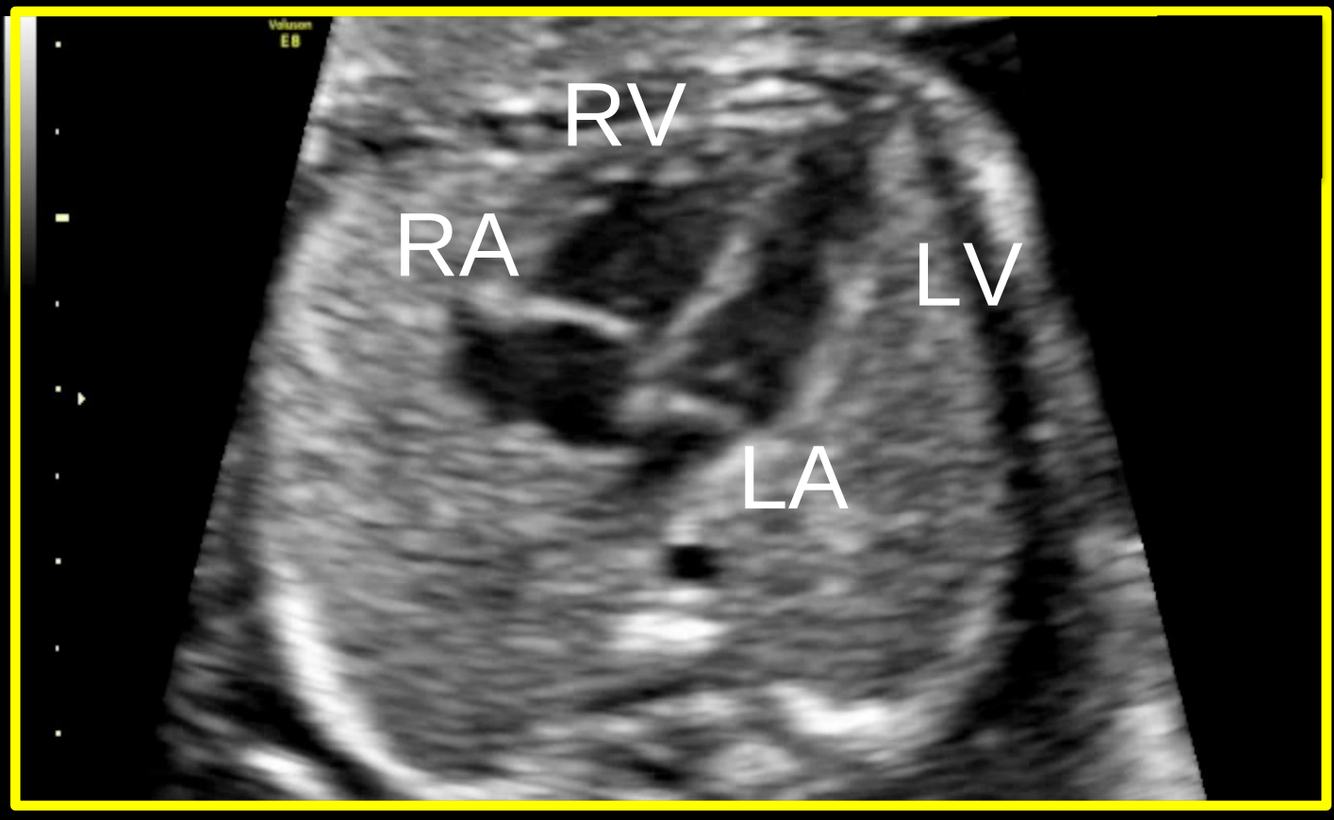


In atrioventricular septal defect, a common abnormal valve distributes blood flow to the right and left ventricles.

Ao = aorta, AV = atrioventricular, LA = left atrium, LV = left ventricle, RA = right atrium, RV = right ventricle

Atrioventricular Septal Defect: Four-Chamber View



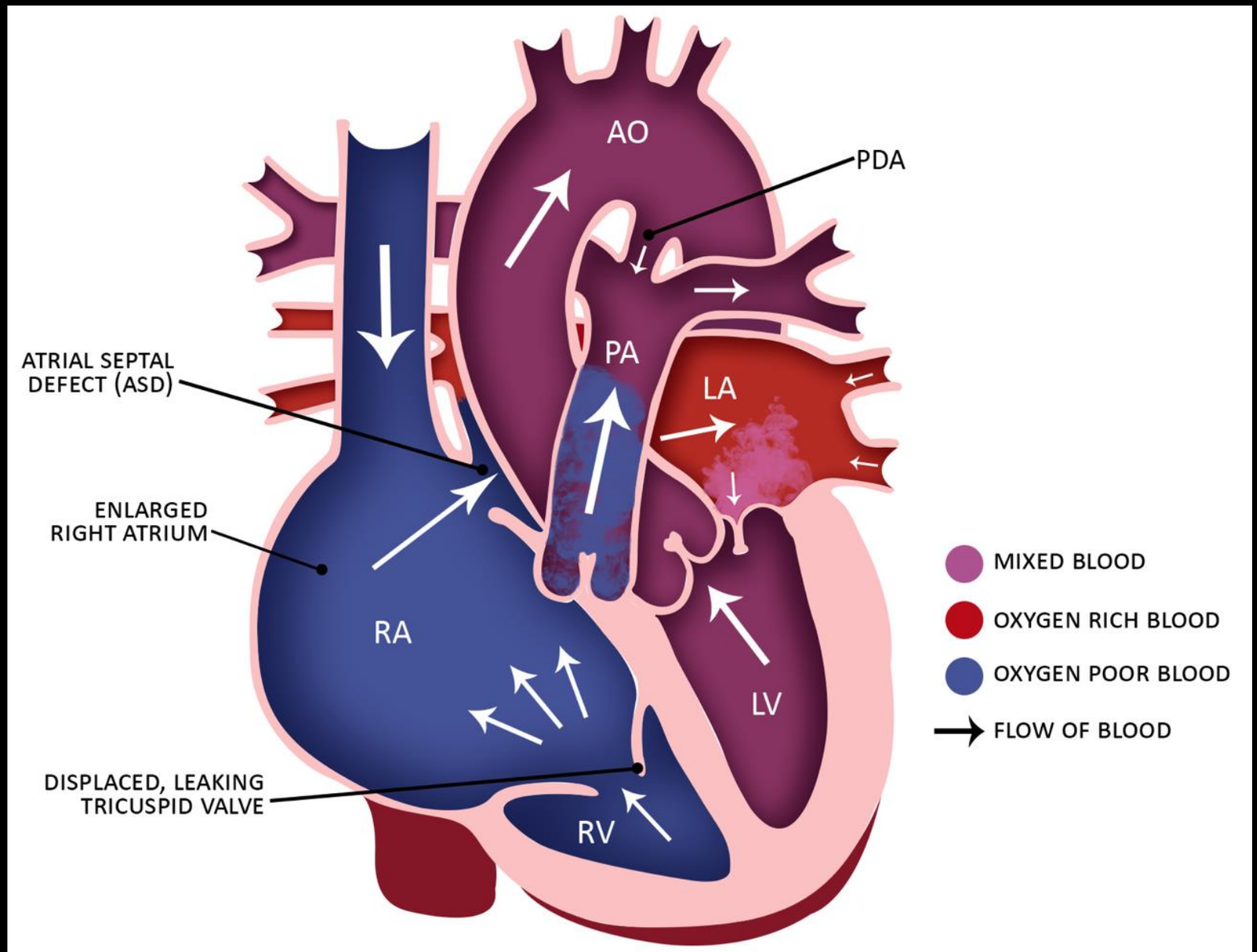


Normal four-chamber finding

In atrioventricular septal defect, a common abnormal valve distributes blood flow to the right and left ventricles.
Atrioventricular septal defect may be more easily seen by slowing down the cine loop and viewing during diastole when the atrioventricular valves are open.

LA = left atrium, LV = left ventricle, RA = right atrium, RV = right ventricle

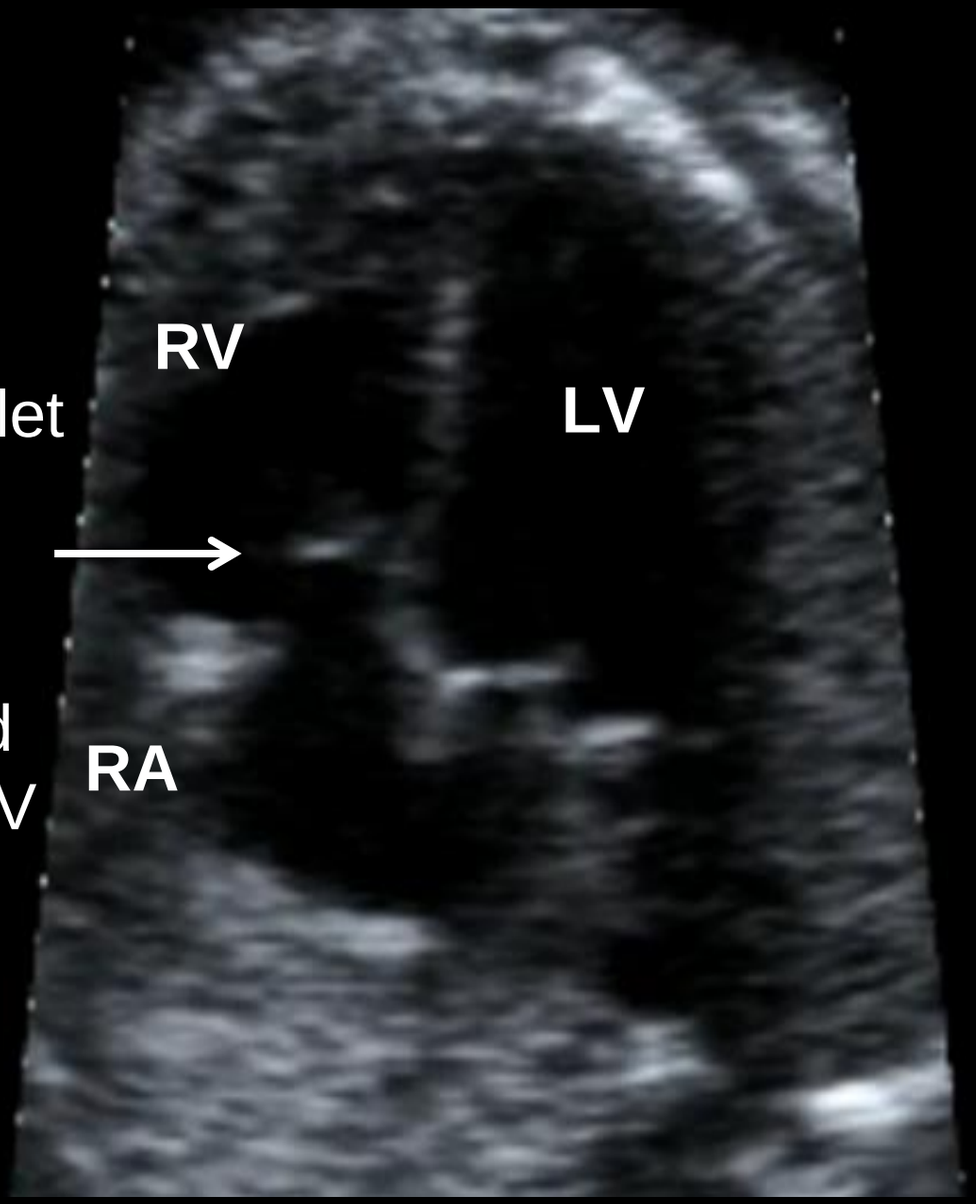
Ebstein Anomaly



AO = aorta, LA = left atrium, LV = left ventricle, PA = pulmonary artery, PDA = patent ductus arteriosus, RA = right atrium, RV = right ventricle

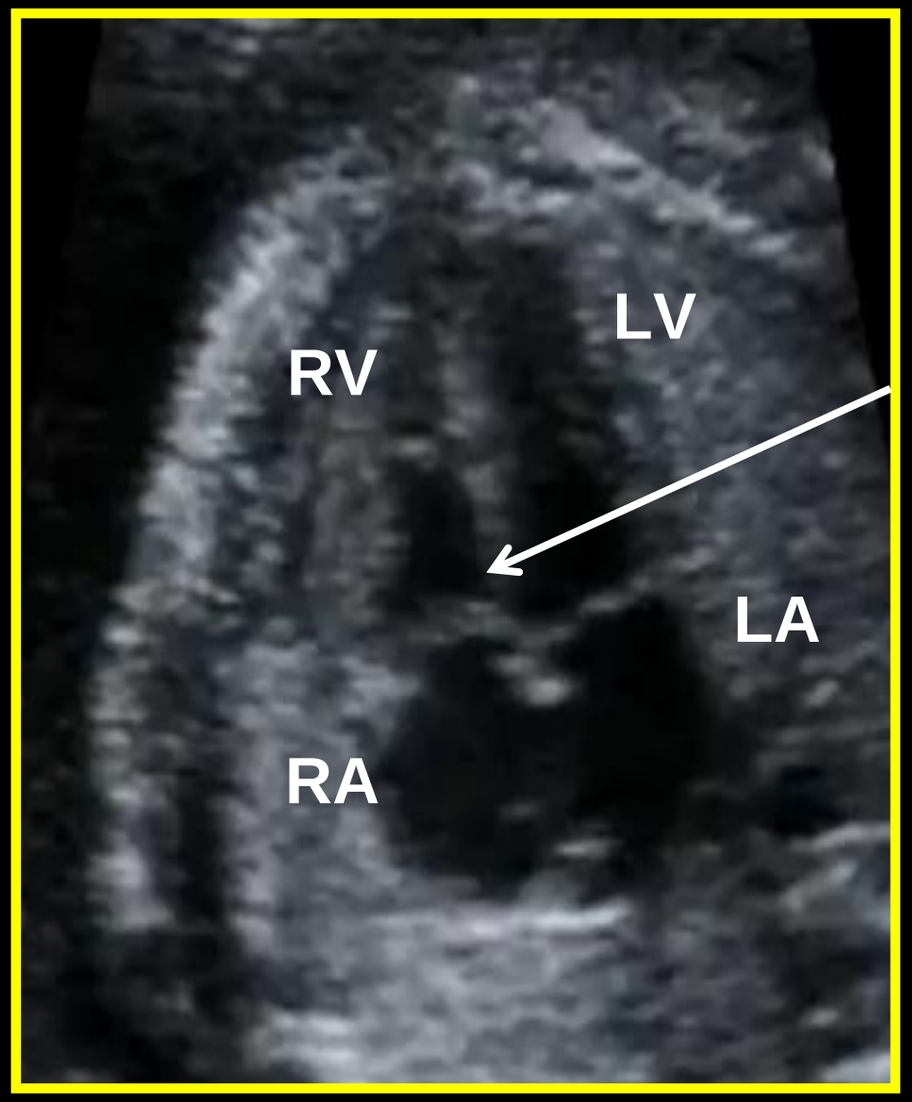
- Approximately 1 in 200,000 births; known associations with maternal use of lithium or benzodiazepines
- Displacement of the tricuspid valve leaflets into the right ventricle (septal > posterior) -> right atrial dilatation -> severe cases can eventually lead to atrialization of right ventricle
- Spectrum of the disease varies from mild to severe. Mild cases are characterized by mild displacement of the tricuspid valve and tricuspid regurgitation. Severe cases show atrialization of the right ventricle except for a small infundibular component.

Ebstein Anomaly: Four-Chamber View



Septal leaflet of the tricuspid valve displaced into the RV

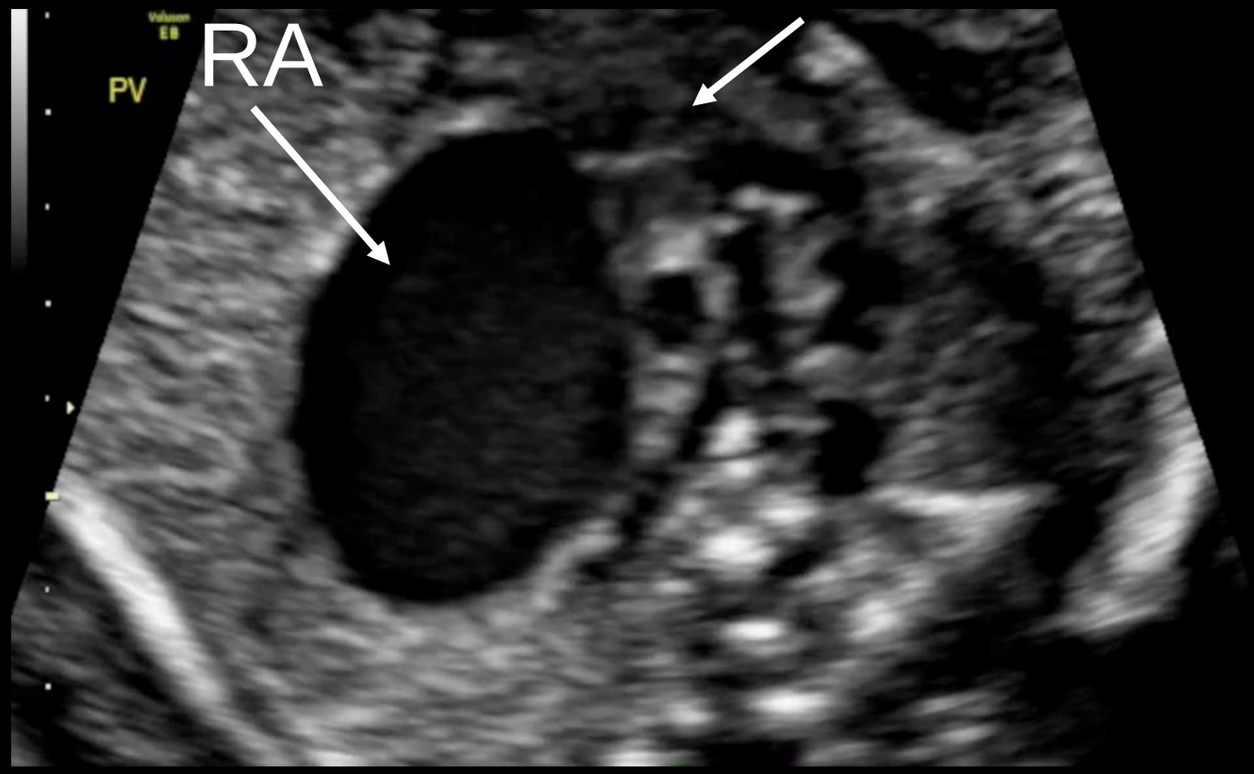
Normal four-chamber view



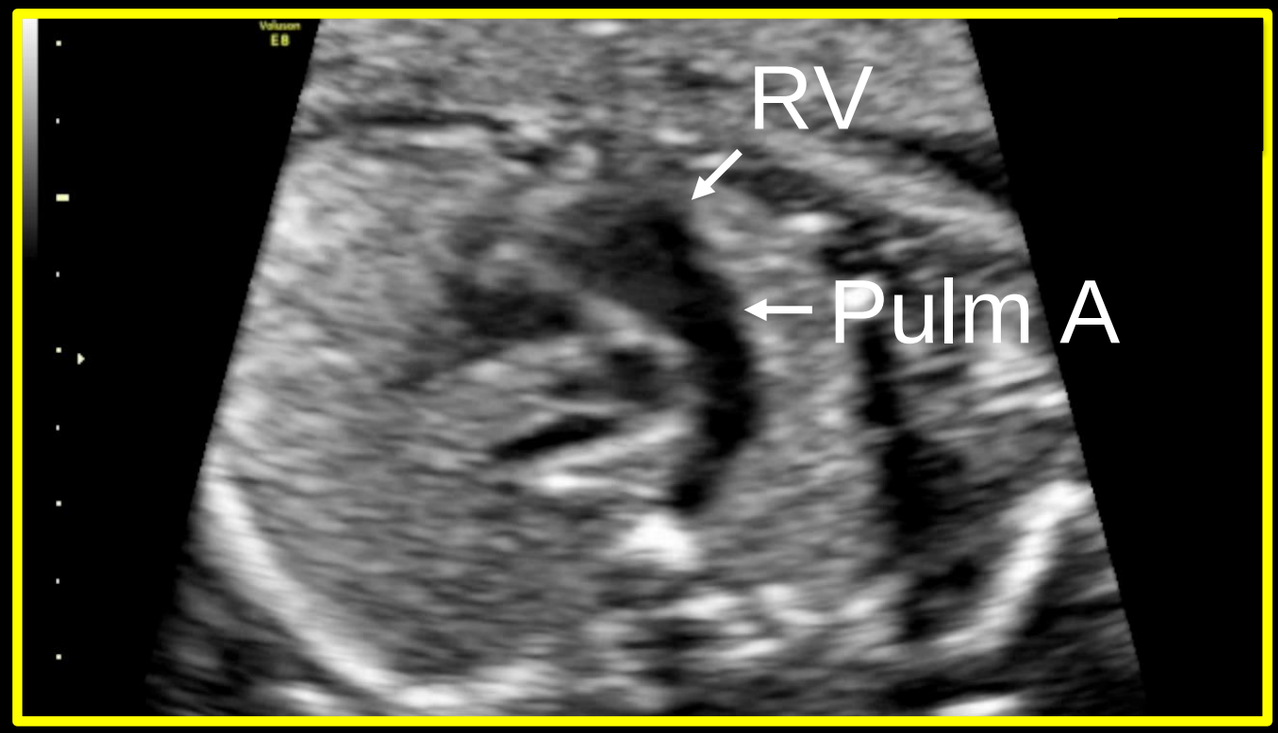
Normal tricuspid valve

In this example of mild Ebstein anomaly, the septal tricuspid valve leaflet is displaced apically into the right ventricle, with minimal secondary right atrial dilatation. LA = left atrium, LV = left ventricle, RA = right atrium, RV = right ventricle

Ebstein Anomoly: Right Outflow Tract



Abnormal RVOT



Normal RVOT

In this example of severe Ebstein anomaly, the right atrium is markedly dilated secondary to severe tricuspid regurgitation.

Pulm A = pulmonary artery, RA = right atrium, RV = right ventricle

Summary

- In conclusion, we presented the three required cardiac views (four-chamber, LVOT, and RVOT) for fetal cardiac screening sonography included in the latest 2013 American Institute of Ultrasound in Medicine guidelines and an optional three-vessel view.

- We listed the important normal cardiac structures in each view to assist in obtaining ideal still frame and cine loops.

- We described a new methodology for acquiring screening cardiac images by using maneuvers such as turning the transducer with the sonographer’s thumb as the focal point of rotation, created after surveying and observing sonographers at our institution.

- We discussed a few common congenital heart defects and anomalies, with the help of hand-drawn figures, interactive cines, and concise text.

Suggested Readings

American College of Radiology Guidelines and Standards Committee. ACR-ACOG-AIUM-SRU practice parameter for the performance of obstetrical ultrasound. Am Coll Radiol 2013;1–14. http://www.acr.org/~/media/ACR/Documents/PGTS/guidelines/US_Obstetrical.pdf

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