Webinar Fetal Education Series

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Children's Mercy Hospital, Kansas City MO

Prenatal Diagnosis of Tetralogy of Fallot

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UMKC School of Medicine

Objectives

- Review the common types of Tetralogy of Fallot
- Review the important findings during a fetal echocardiogram in such cases
- Review important anatomical, clinical and counseling data.

TOF - History

Etienne- Arthur Fallot

- 1672 – Neils Stenson first described the pathological associations
- 1888 – Dr Etienne-Arthur Fallot described the ‘maladie bleu’, that is clinical symptomatology correlating with anatomy
  - Contribution a l’anatomie pathologique de la maladie bleue (cyanose cardiaque)
  - *Mars Med 25, 1888*
- 1924 – Maude Abbot coins the term TOF

TOF - History

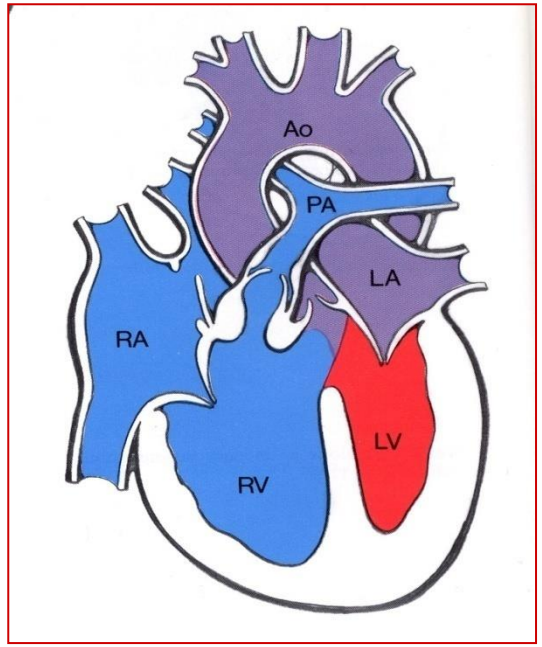
- A. Fallot was the first who understood that TOF was a pathological process at the level of the pulmonary valve and the neighboring infundibulum.

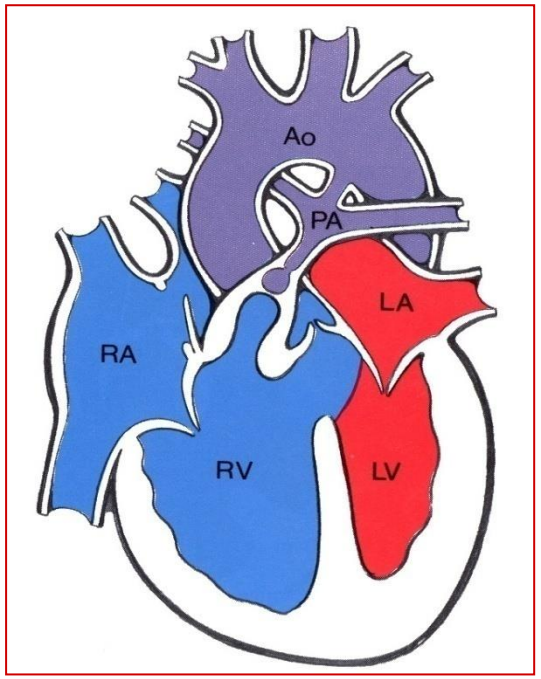
- Almost 80 years later R. Van Praagh reached the same conclusion, that is that Tetralogy of Fallot is essentially a MONOLOGY, the hypoplasia of the subpulmonary conus (infundibulum) due to the anterior deviation of the conal septum – conotruncal malformation.

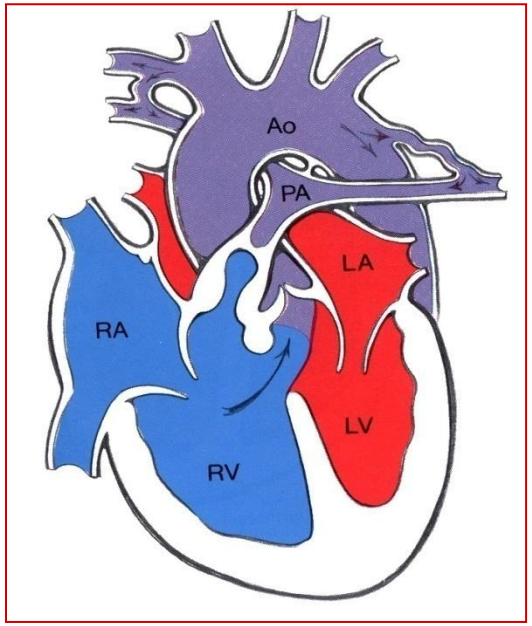
TOF – Anatomical Types

TOF is the most common cyanotic congenital heart disease (incidence of 3.26 in 10,000 live births)

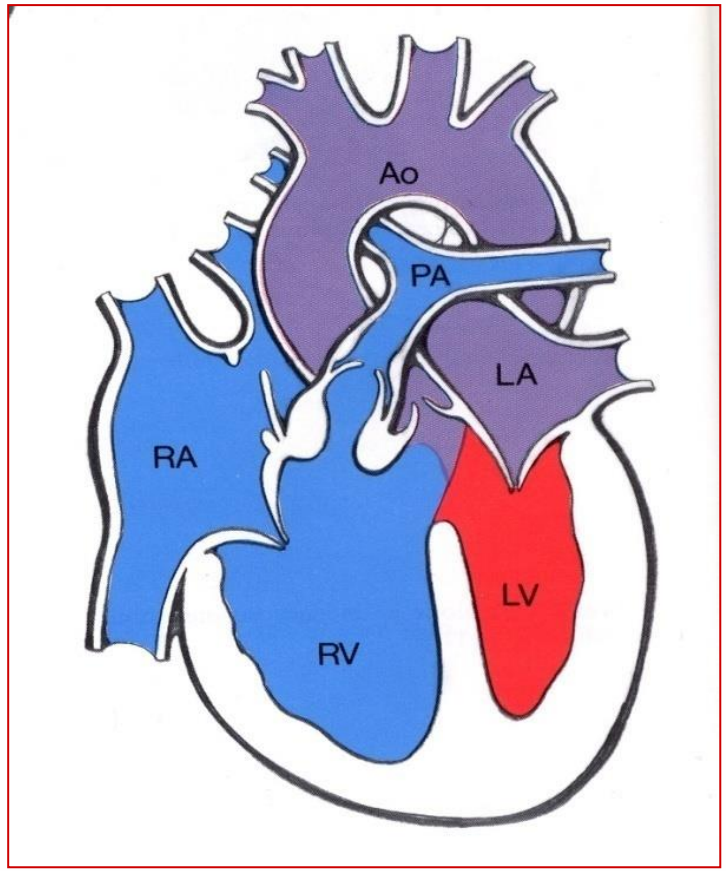
- Simple TOF 61%
- Tetralogy with Pulmonary valve atresia 33%
- Tetralogy with Absent Pulmonary valve 3%
- Tetralogy with Common Atrioventricular Canal 3%





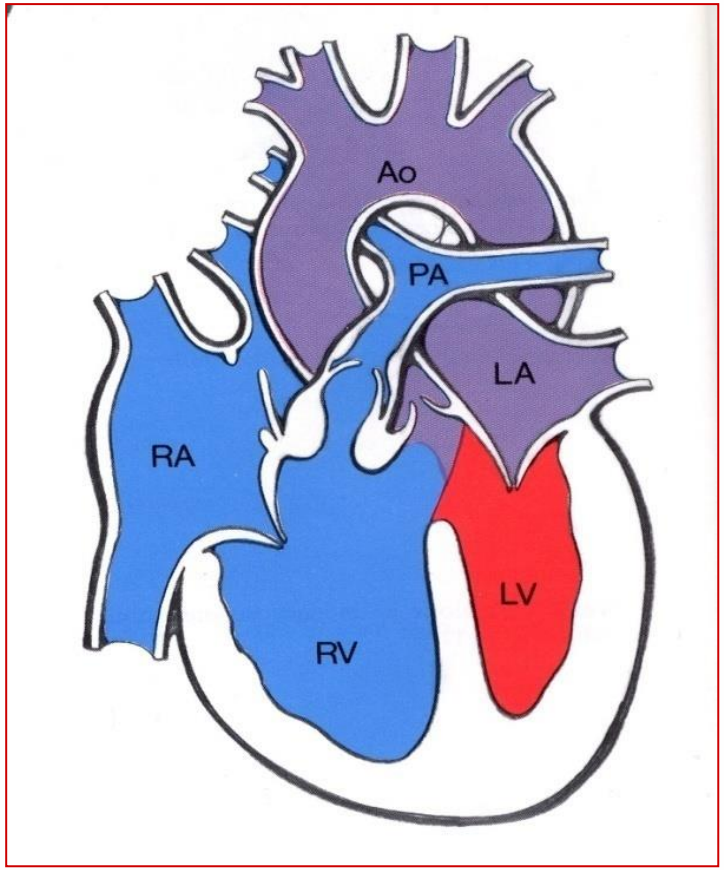


Classic TOF – Frequency, Genetics



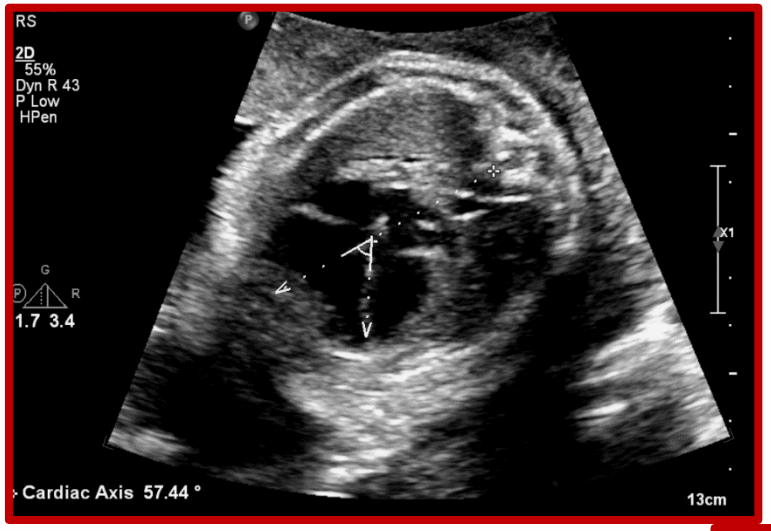
- TOF accounts for 7% of all cyanotic CHD and is the most common cyanotic form, occurring in 0.3-0.4 per 1000 live births.
- Nearly one third of cases have an extracardiac anomaly or chromosomal derangement.
- Microdeletion of chromosome 22q11 is present in 16-18% of all cases of TOF and in almost 50% of patients with TOF and RAA.
- Other genetic associations with TOF are
  - Alagille syndrome
  - VACTERL association
  - CHARGE association
  - Cat eye syndrome
  - Trisomies 13, 18, 21
- There is an association with midline defects (omphalocele, pentalogy of Cantrell)
- CNS, skeletal and renal anomalies may coexist.
- Gene mutations have been linked to the development of TOF
  - *NKX2-5. Tbx 1* (linked to DiGeorge)
  - *NOTCH 1 and 2*, and *JAG1* (linked to Alagille)

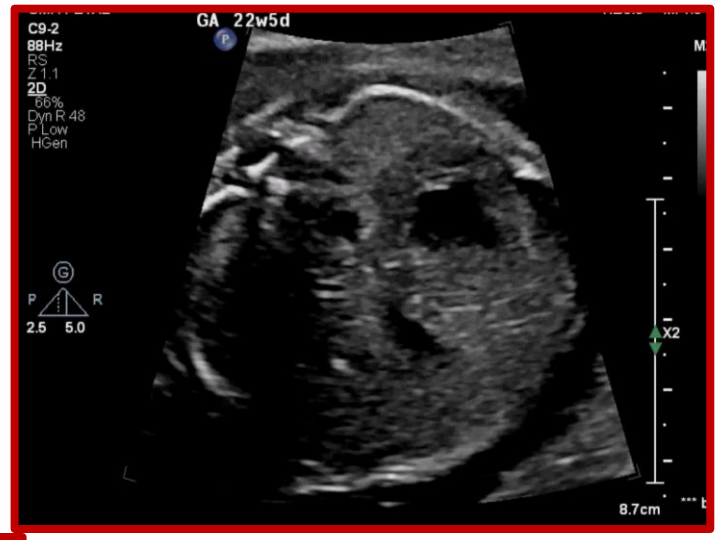
Classic TOF – Anatomical Associations

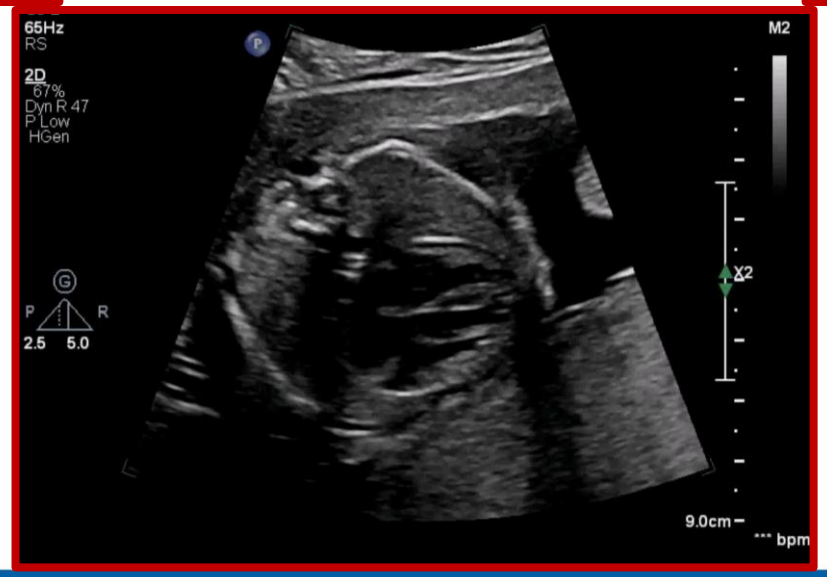


- There might be variable degrees of right ventricular hypoplasia at usually multiple levels subvalvar, valvar and supravalvar.
- The main and branch PAs may also have variable degrees of hypoplasia.
- A right aortic arch may be present in 20-25% of cases and the presence of an aberrant subclavian artery can also occur.
- The ductus arteriosus may be small, tortuous or absent.
- There might be variations of coronary arteries (LAD from RCA).
- Additional muscular VSDs can occur.
- A persistent LSVC occurs as high as 11% of the cases.
- MV anomalies and APVC have also been described.
- The presence of a CAVC is highly associated with trisomy 21.

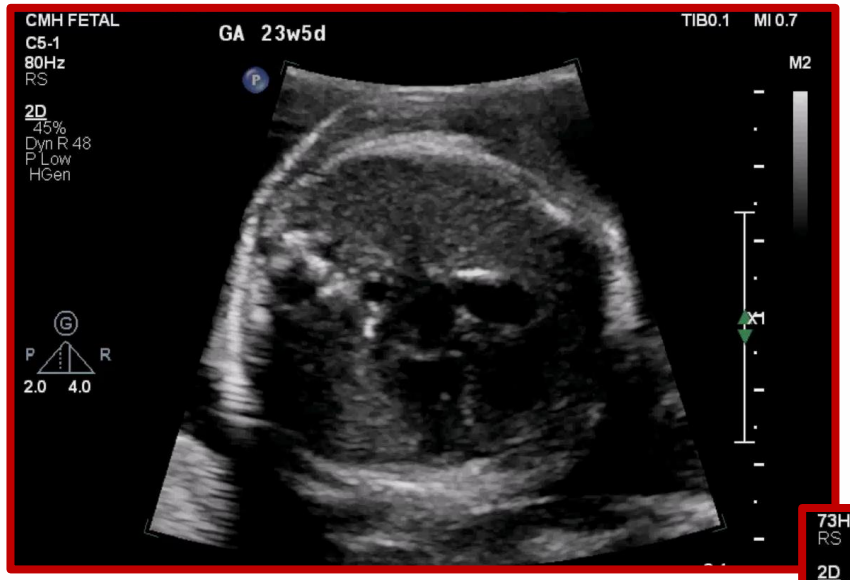
TOF – Fetal echo

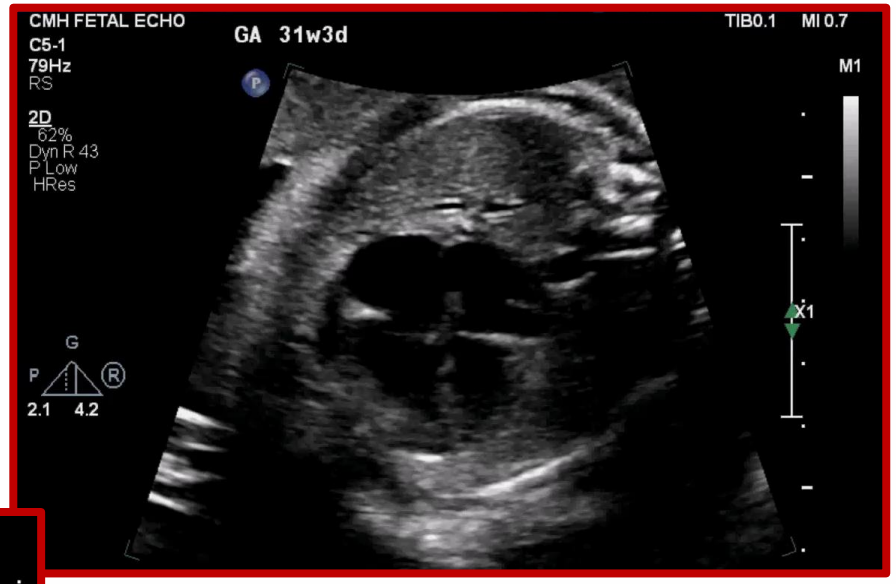


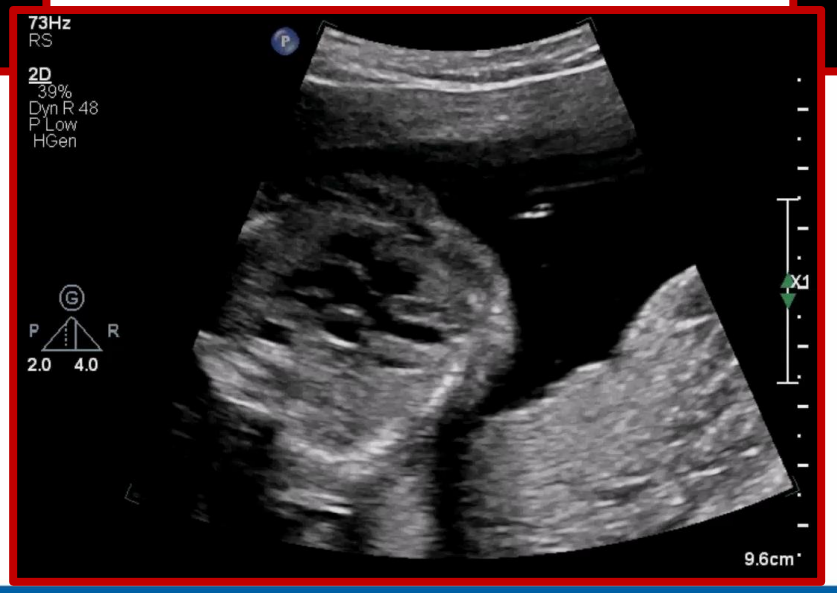




TOF – Fetal echo







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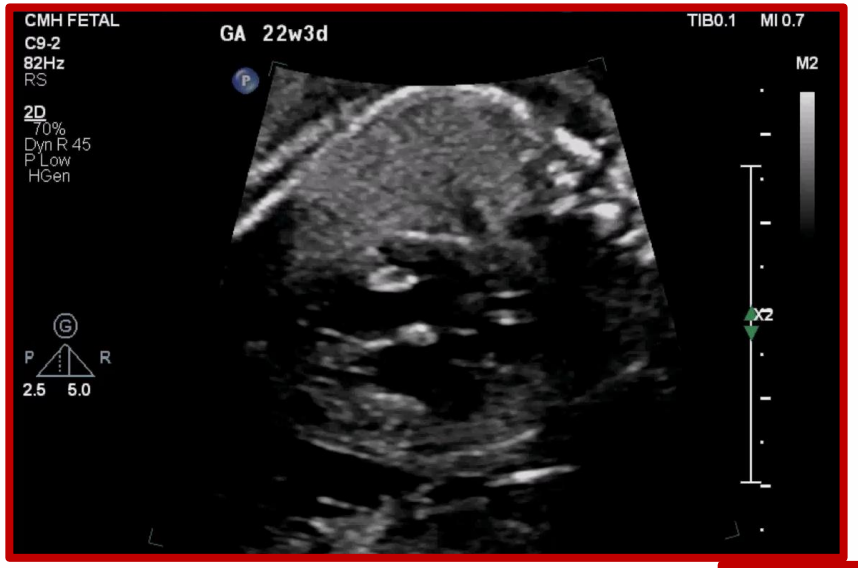

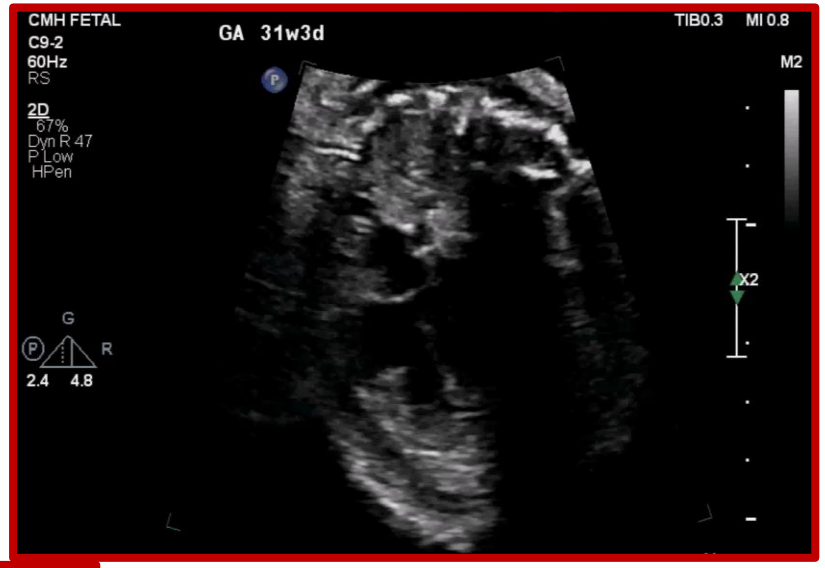

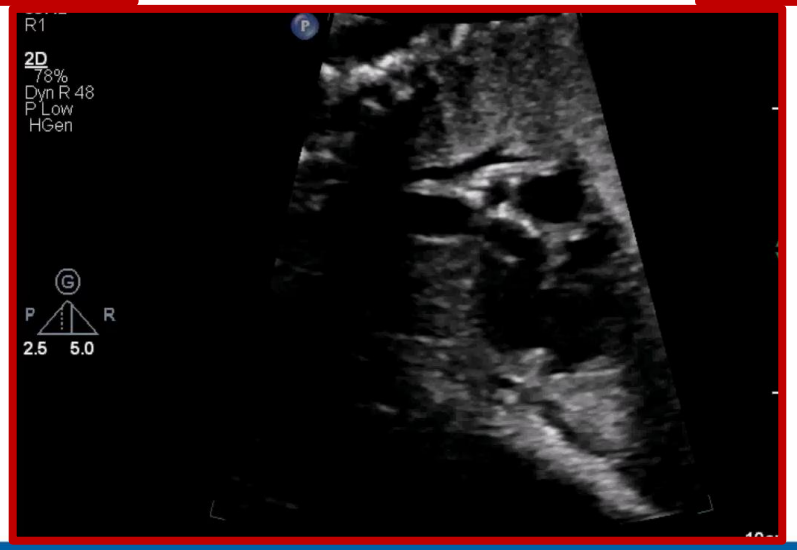

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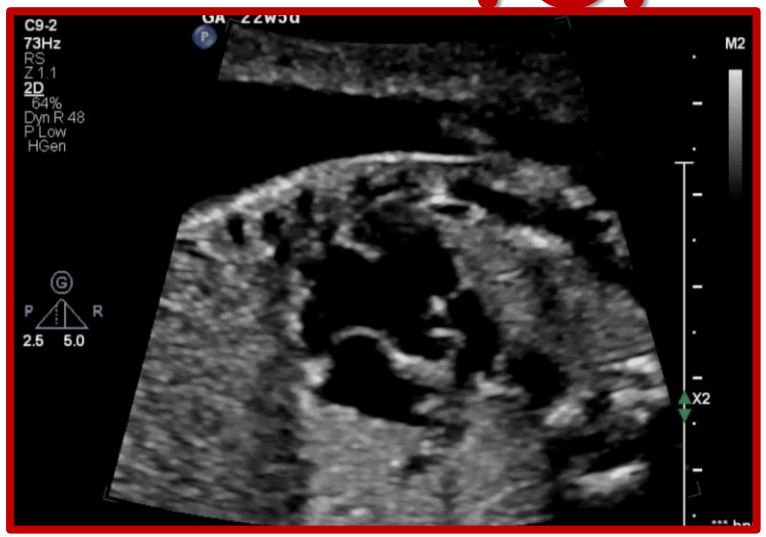

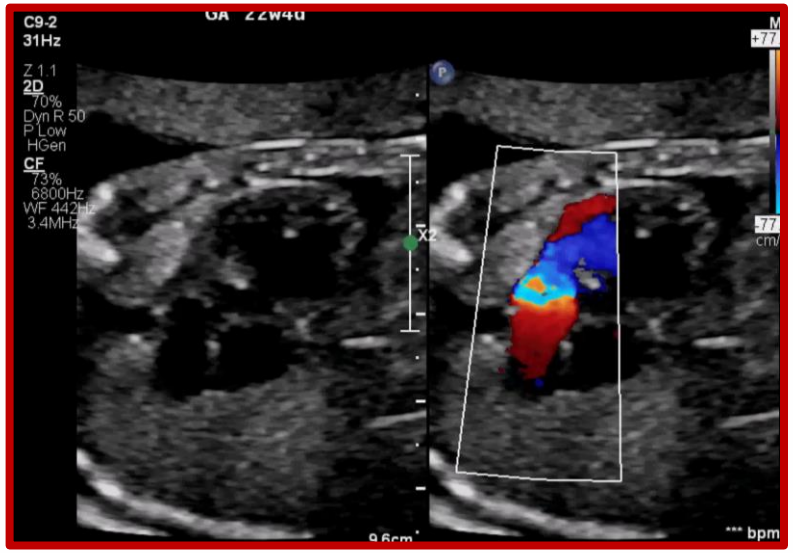

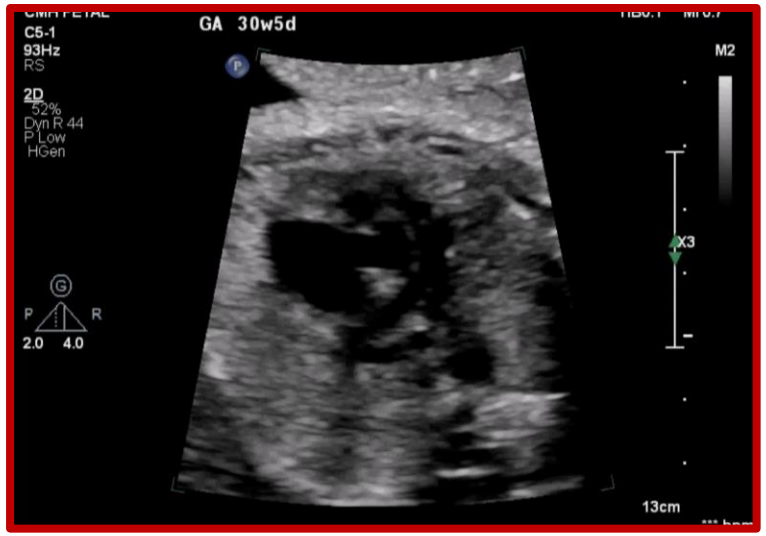

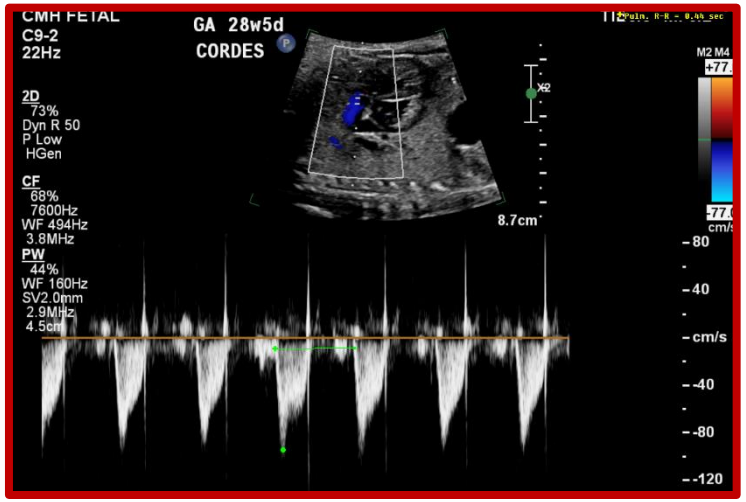

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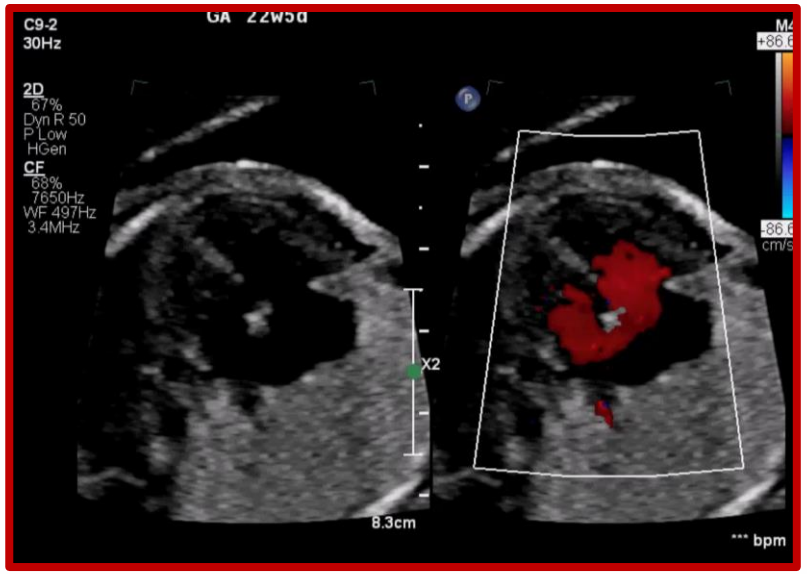
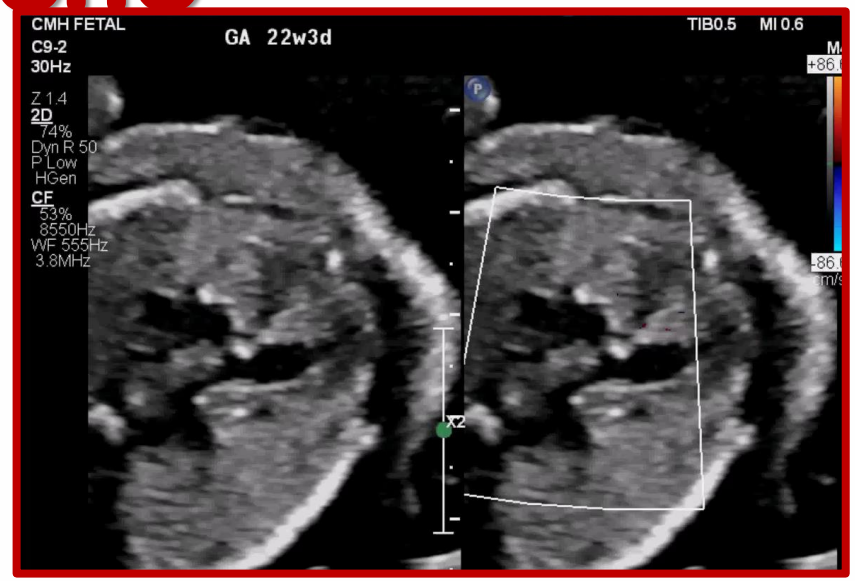
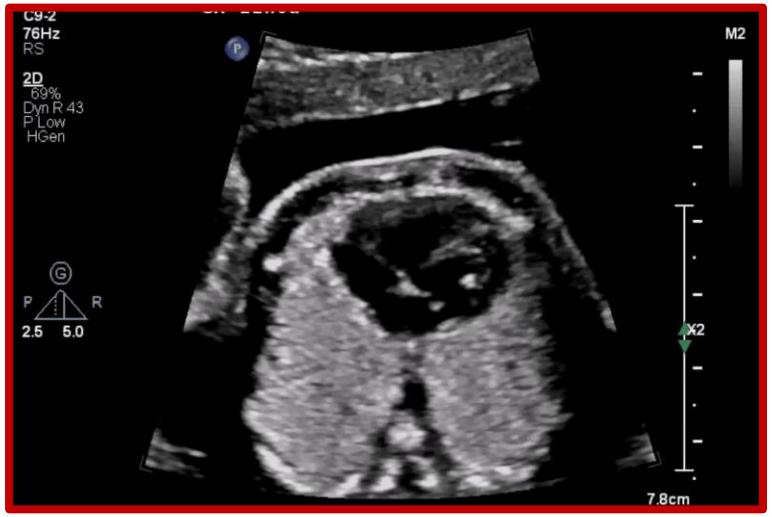
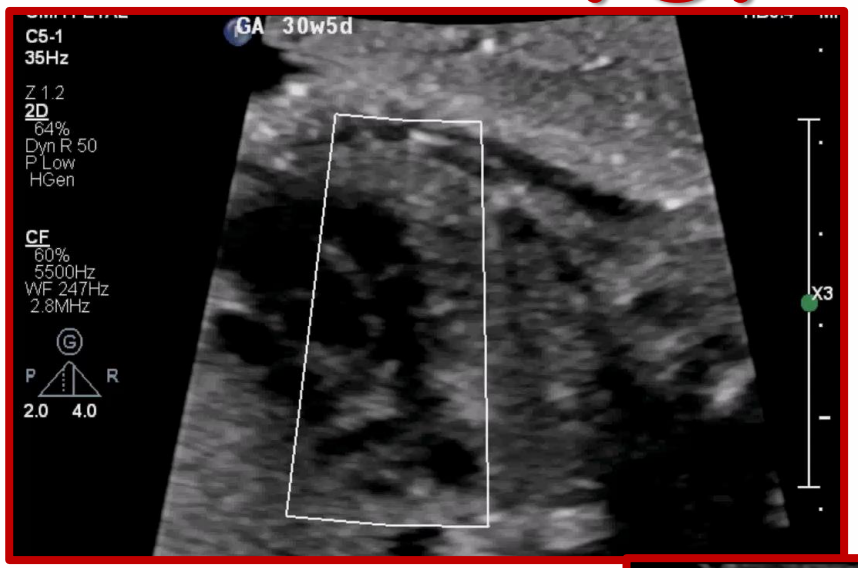
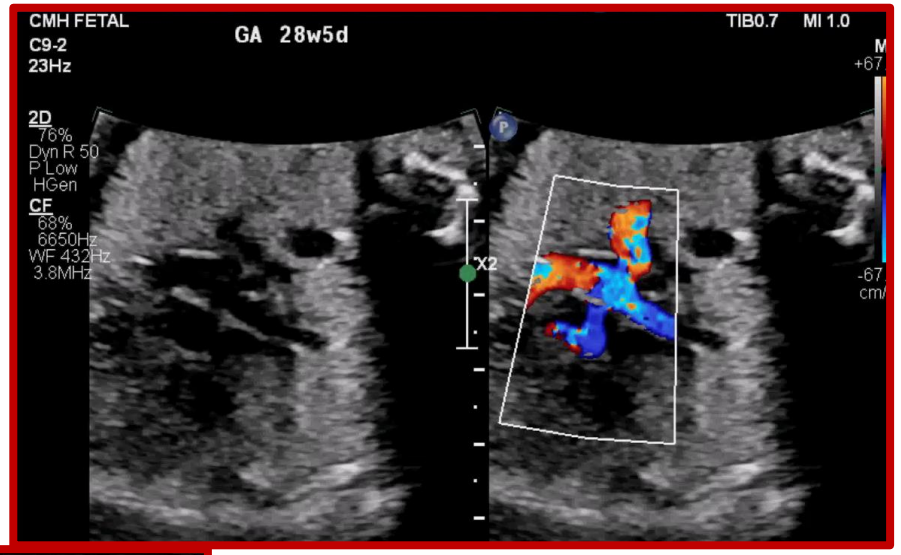


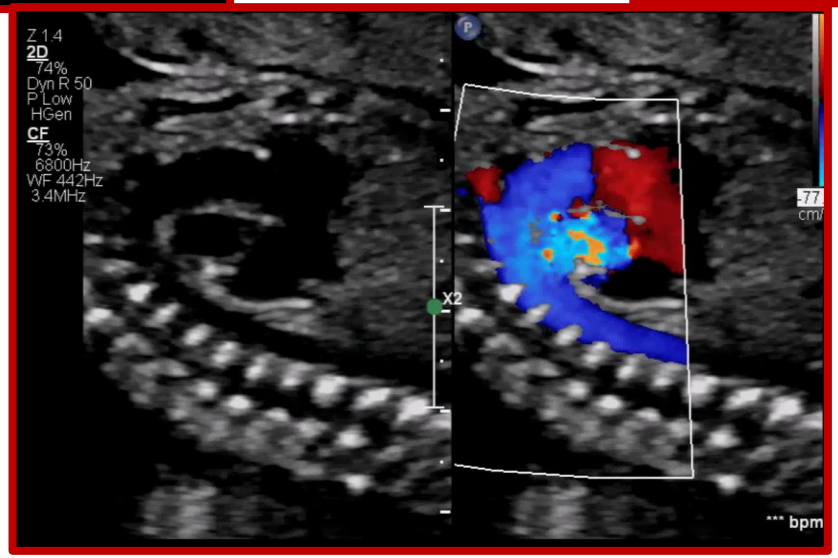




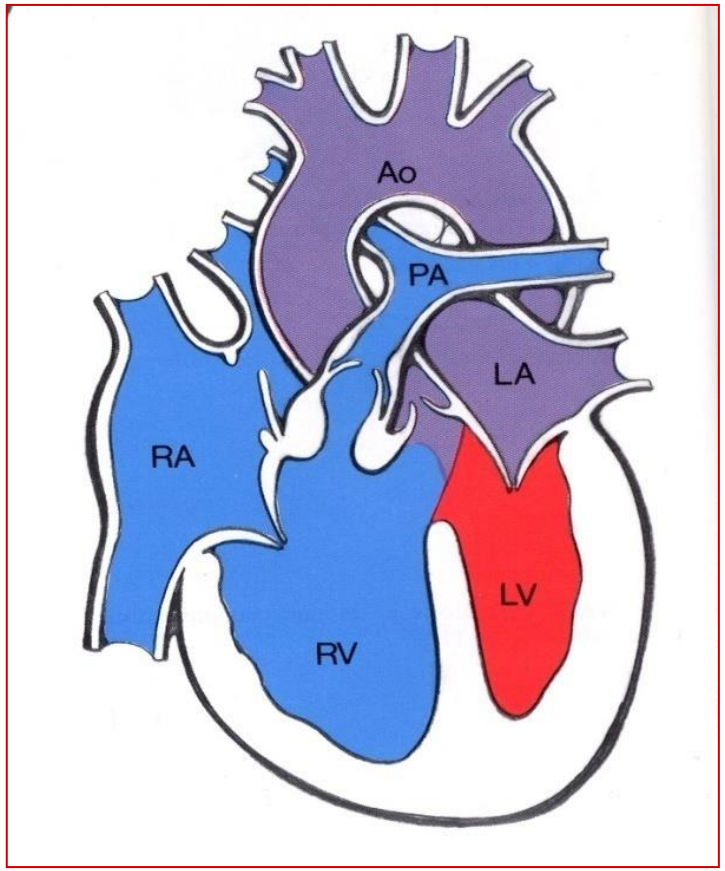
TOF – Fetal echo





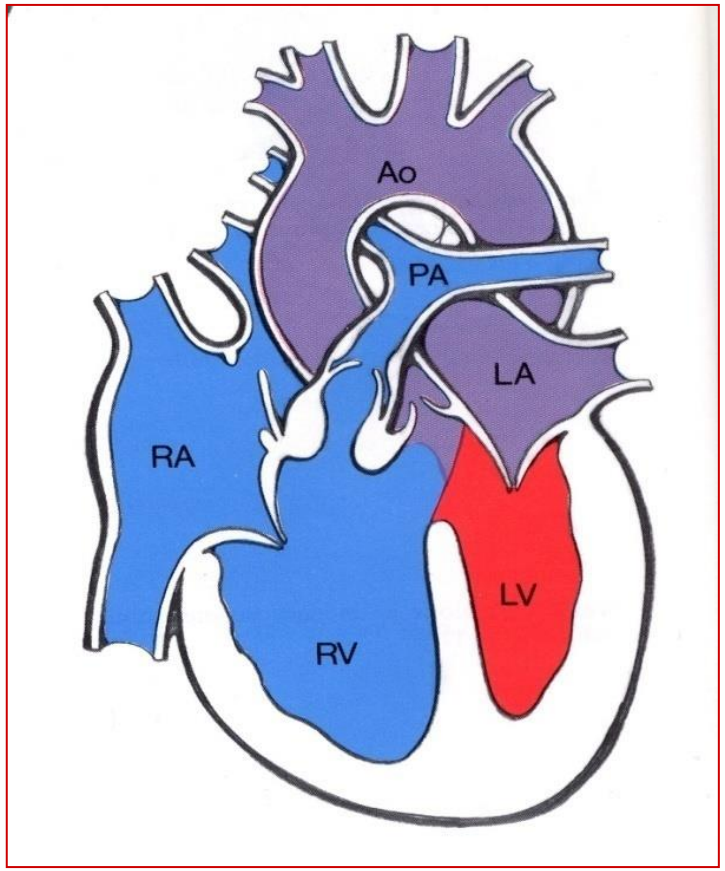


Classic TOF – Echocardiographic features – Imaging tips



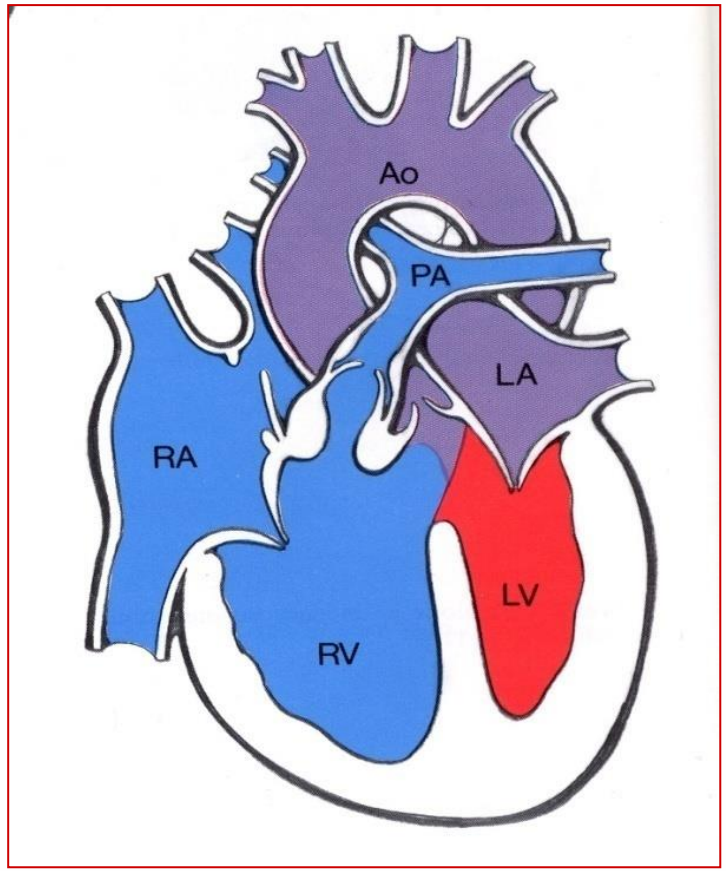
- Identification of the conal septal malalignment.
- Pulmonary valve annulus – comparison to the aortic.
- Large VSD (membranous, paramembranous, muscular)
- Dilated aortic root, overriding the VSD and both ventricles
- Level of RVOT obstruction
- Continuity, confluence and size of the branch PAs.
- Identification of the DA, location, origin and insertion in the branch PAs.
- Direction of flow in the DA
- Aortic arch sidedness and branching (aberrancy of SCVA)

Classic TOF – Echocardiographic features – Imaging tips



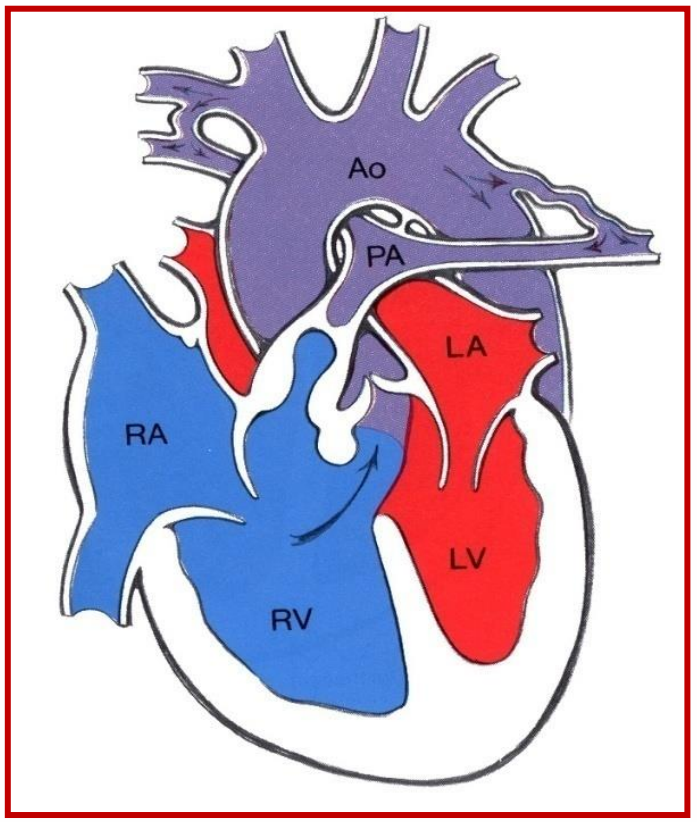
- The aorta is always larger than the PA in TOF.
- Size of the PA less than half the size of the aorta is indicative of significant obstruction (ductal dependent) and more likely to need neonatal repair.
- Document the presence of antegrade flow through the PV with color Doppler imaging.
- Identify the DA and the direction of flow (left to right flow indicated ductal dpendency).
- Identify the thymus (proximity of the great vessels to the anterior chest wall).
- Serial evaluations are of great importance.

Classic TOF – What Do I need to know/check



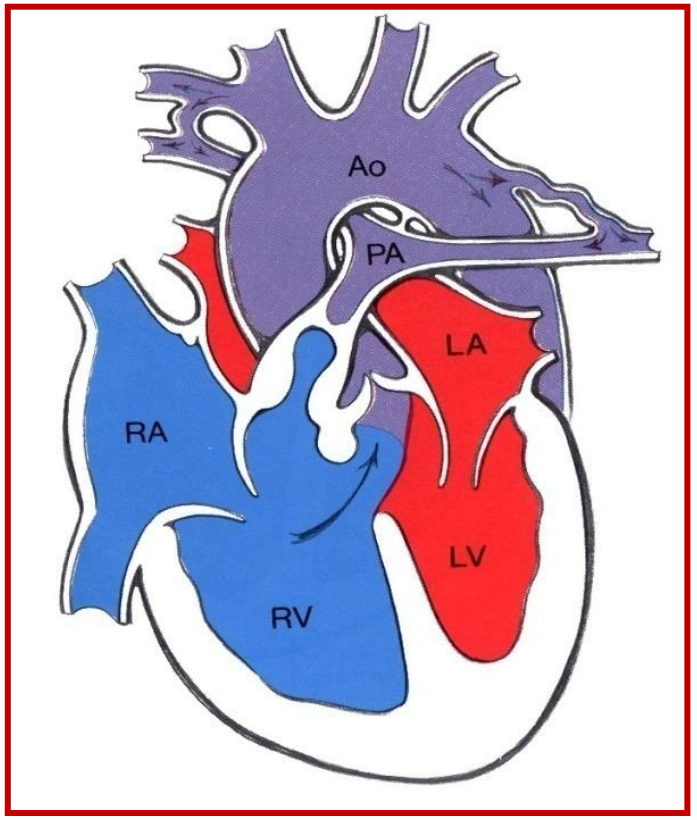
- Assess the degree of RVOT stenosis
- The stenosis is progressive, so serial evaluations are warranted
- Identification of the ductus arteriosus is crucial as is its size and flow
- The pulmonary valve annulus should be compared to the size of the aortic valve
- Comprehensive obstetrical US should be performed
- The absence of a thymus and the presence of a RAA increase the risk of having 22q deletion
- Increased nuchal translucency has been found in 50% of TOFs.
- An amniocentesis should be offered

TOF and Pulmonary Atresia



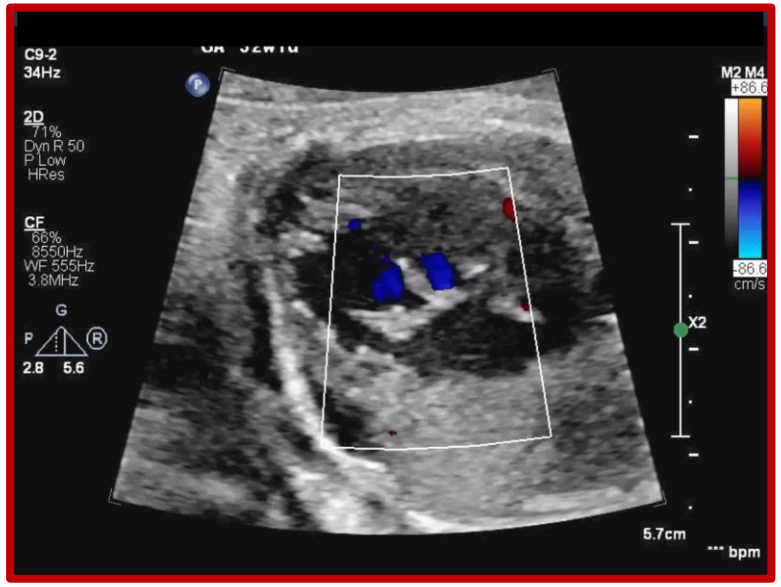
- TOF/PA is the severe form of TOF in which the pathway out of the RV across the pulmonary valve is fully sealed
- There might be plate-like valvar atresia or complete infundibular atresia
- A great variability exists in the origin and distribution of the pulmonary arteries
- They can be supplied by a single DA and mostly they are confluent
- Bilateral ducti can occur (rare)
- Collateral arterial vessels from the aorta to the PAs exist (MAPCAs) – distal aortic arch, thoracic and abdominal aorta or aortic branches.
- Ductal dependent branch PAs and MAPCAs can be present in the same patient.

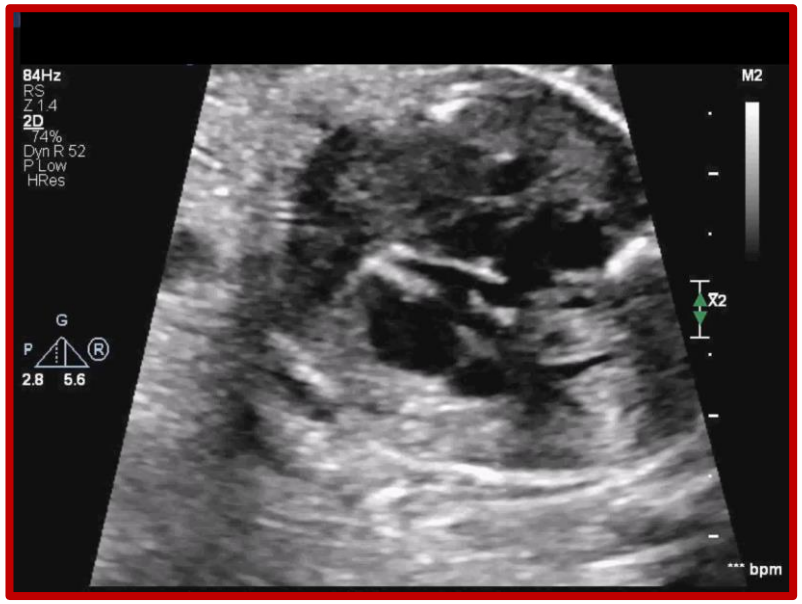
TOF and Pulmonary Atresia
Frequency, Genetics, Development

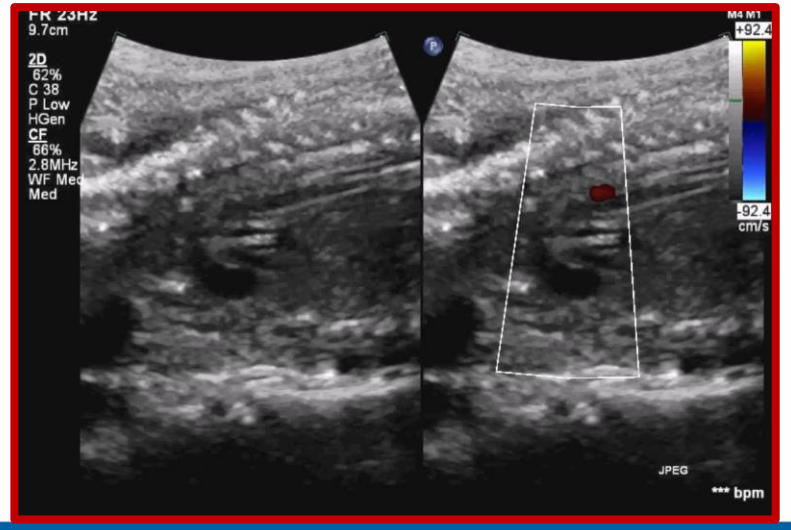


- TOF/PA accounts for 20 -33 % of all forms of TOF and occurs in 0.07 per 1,000 live births
- Extracardiac anomalies occur in ¼-1/2 of all infants with 22q11 del being the most common chromosomal anomaly
- Incidence of 22q11 del in TOF/PA has been reported as high as 40% and is more frequent in the presence of MAPCAs and hypoplastic branch PAs
- Associated thymic aplasia and RAA increases the risk.

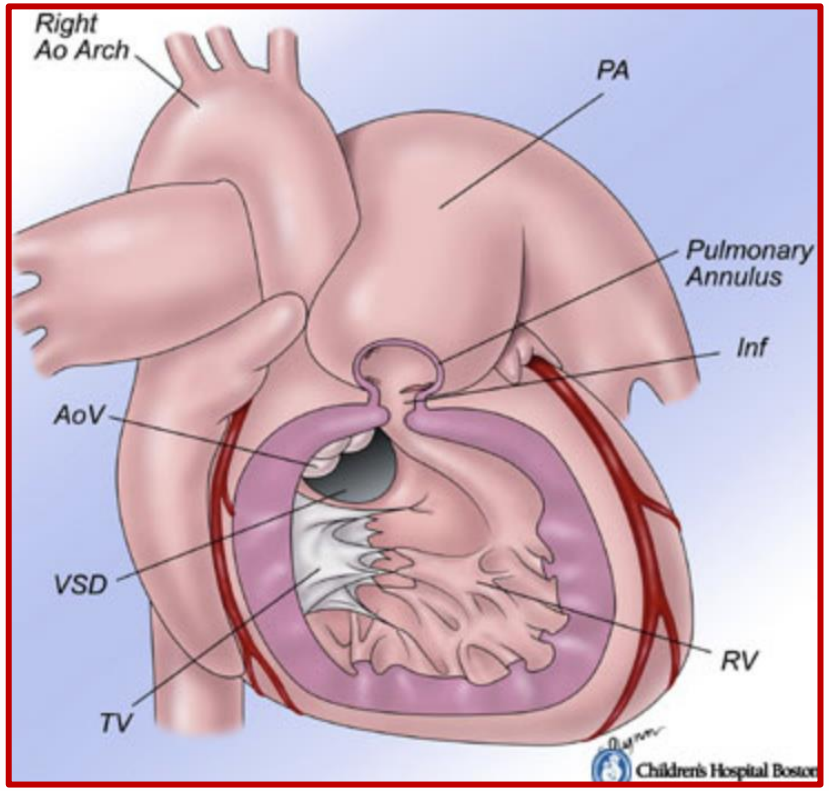
TOF/PA – Fetal echo





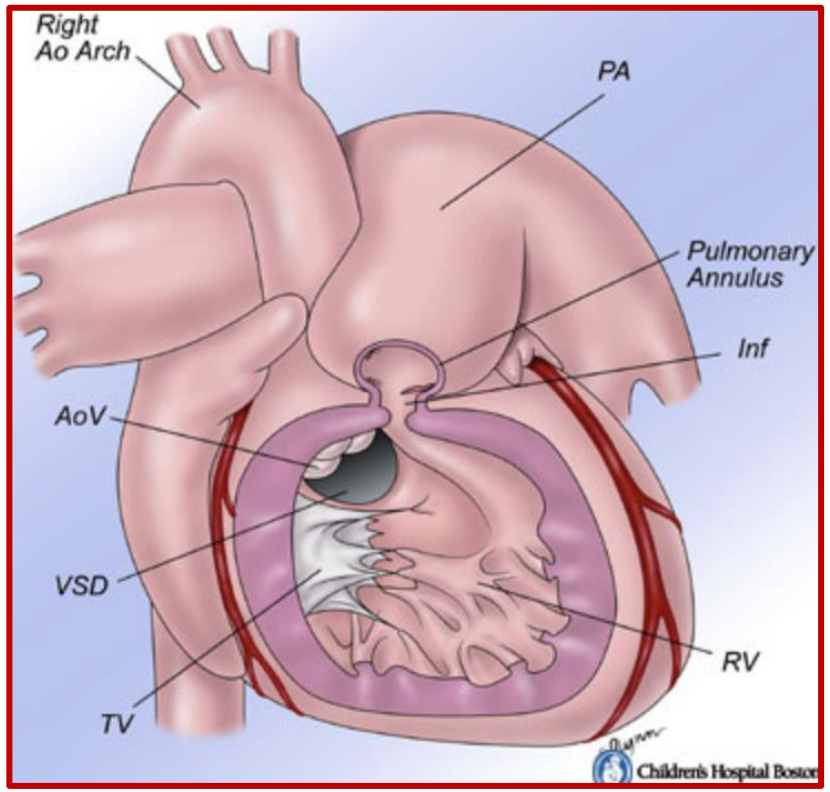


TOF and Absent Pulmonary Valve Syndrome Frequency, Genetics, Development



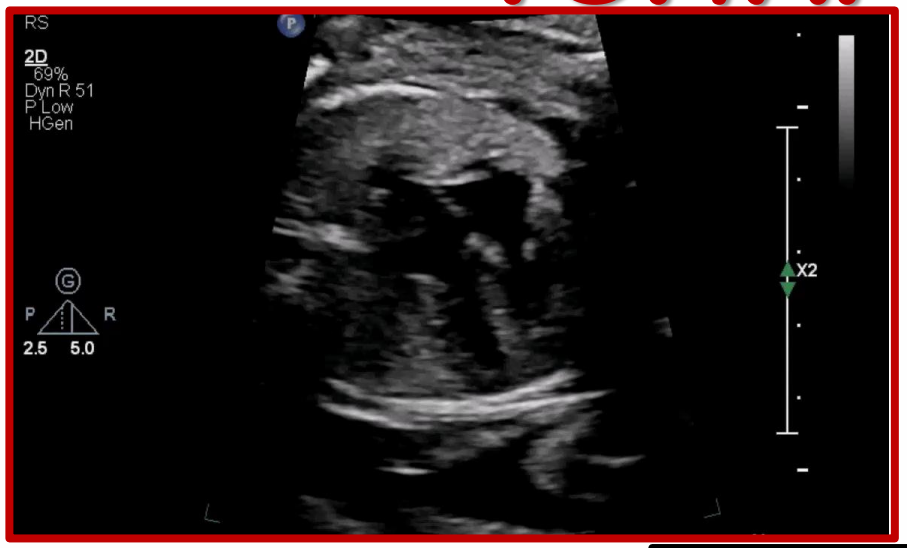
- TOF/APVS is a rare variant of TOF in which the pulmonary valve leaflets are extremely underdeveloped resulting in severe pulmonary insufficiency and dilation of the MPA and branch PAs.
- Usually there is a hypoplastic PV annulus with rudimentary leaflets
- The pulmonary valve is completely incompetent
- The branch PAs being dilated compress the bronchi
- The ductus arteriosus is almost always absent (present when the PAs are discontinuous)
- TOF/APVS accounts for 3-6% of all TOF cases
- TOF/APVS has been associated with anomalous origin of the PAs, coarctation and TAPVC.
- Incidence of 22q11 del in TOF/PA has been reported in 21-38% and is not associated with aortic arch sidedness.

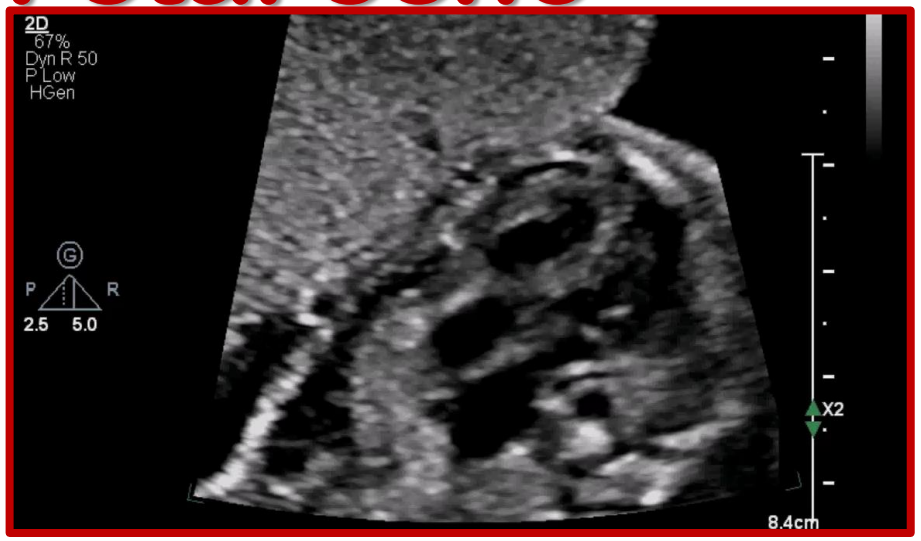
TOF and Absent Pulmonary Valve Syndrome Echocardiographic features – Imaging tips

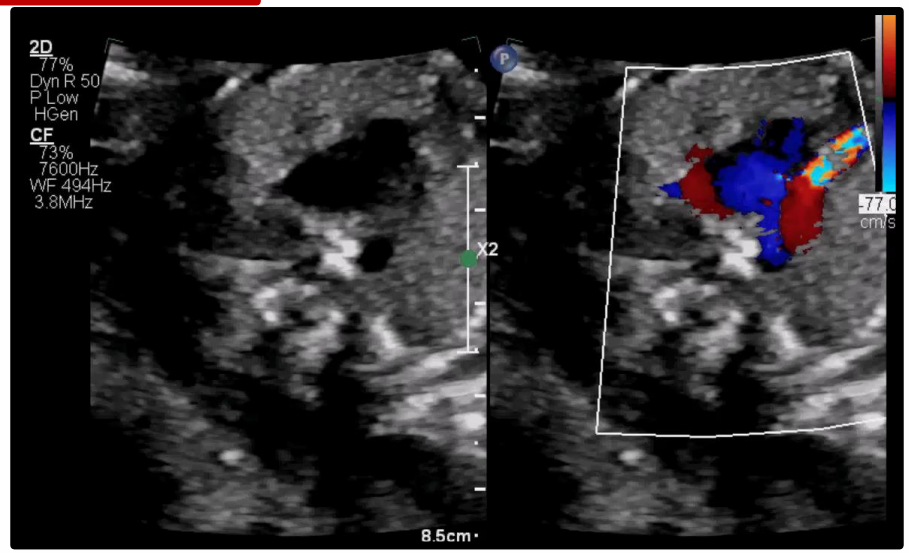


- Large conoventricular VSD
- Large overriding aorta
- Rudimentary PV tissue with both stenosis and regurgitation – PV annulus 'napkin-ring' like
- Massively dilated MPA, branch PAs ('Mickey Mouse' ear sign)
- Dilated RV and RVOT
- Compromised RV systolic function
- Absence of ductus arteriosus

TOF/APVS – Fetal echo







TOF – Postnatal management

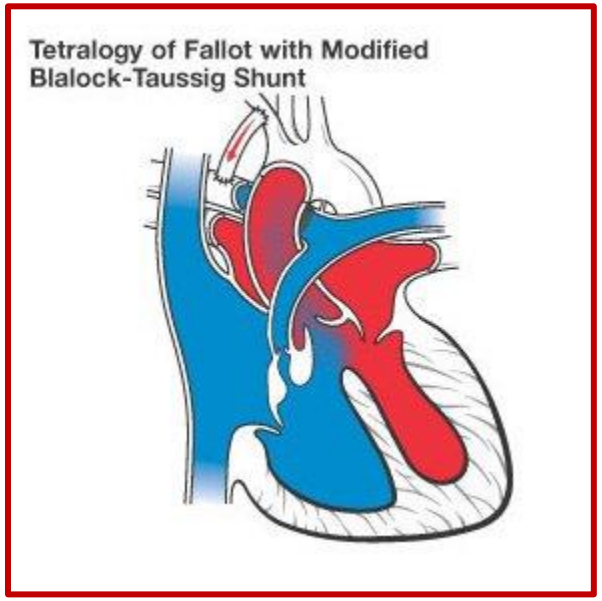
- The postnatal management is dependent upon the degree of hypoxemia as is the timing of intervention
- Crucial to assess the degree of supplemental ductal flow before deciding adequacy of pulmonary flow
- Ideally the operation is scheduled electively between 2-6 months of age
- In neonates with significant hypoxemia PGE infusion should be started and a BTS or complete repair considered
- Ductal stenting is another option.

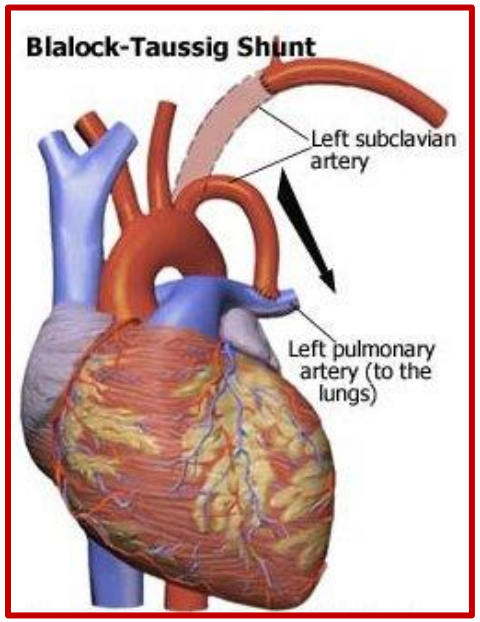
TOF – Surgical management

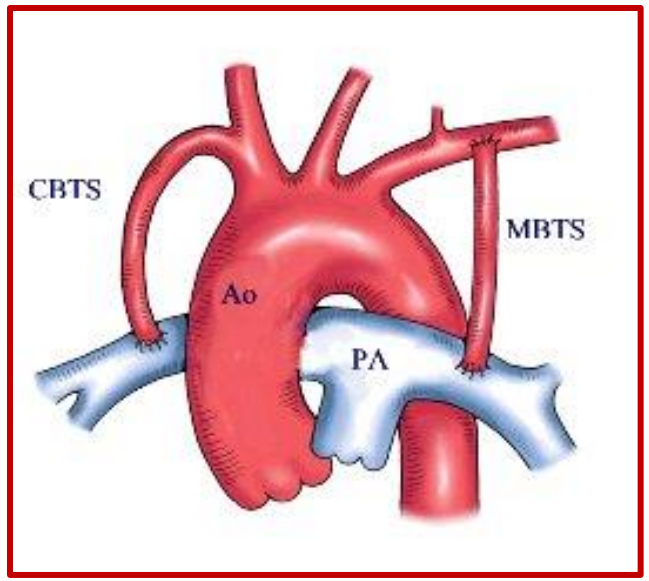
The surgical treatment of malformation of the heart in which there is pulmonary stenosis or pulmonary atresia.

Blalock A, Taussig HB.

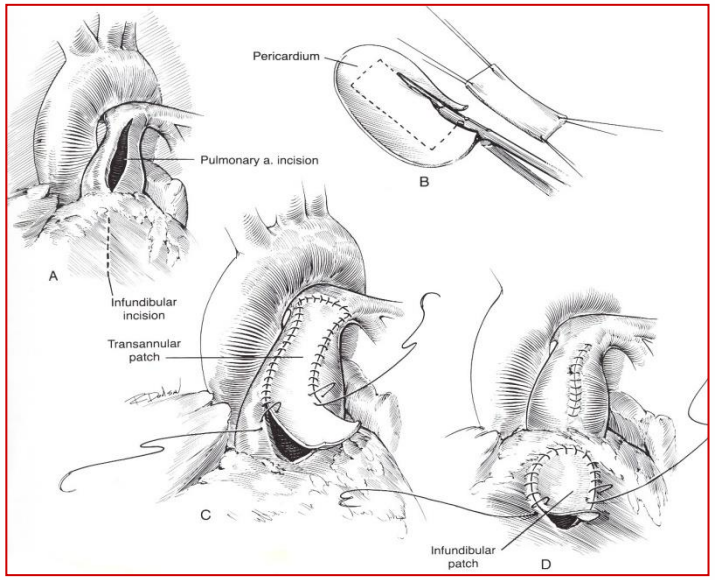
JAMA 1945;128:189-2020

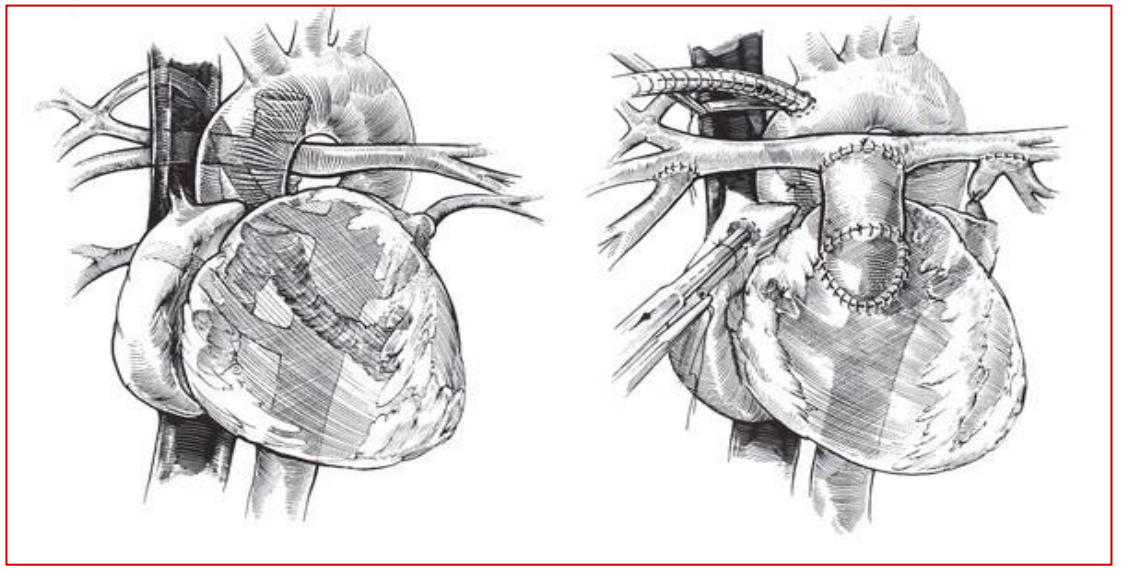


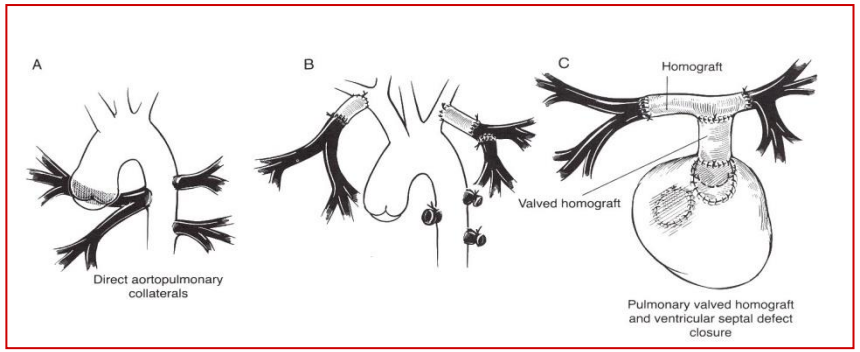




TOF – Surgical management







1945 Blalock- Taussig – Thomas

- First surgical intervention CBTS

1954 Lillehei

- Complete repair

Castaneda Cardiac Surgery of the Neonate and Infant

TOF – Outcomes

Classic TOF

- Overall surgical outcomes for TOF are excellent with a hospital mortality after neonatal complete surgical repair for all types of TOF reported as low as 1-2% in non-syndromic infants.
- Pulmonary insufficiency is the most common residual lesion and that will lead to RV dilation and dysfunction.
- PVR will be needed in the second decade of life.
- Cardiac catheterizations and re-operation is common - Re-intervention is higher in neonatal vs later repair.
- TOF is a lifelong condition

TOF/PA

- TOF with MAPCAs have a 3-year survival of 80% and a 10-year survival of 71%
- Re-intervention is high with over half of the patients having a catheter/surgical intervention within 5 years

TOF/APVS

- Rate of fetal demise is high in this population
- Evidence of RV dilation and dysfunction is associated with respiratory compromise in almost half of those newborns
- Operative mortality in patients with respiratory symptoms is as high as 50%
- The reported overall 10-year survival is 79-87%

Conclusions

- Prenatal diagnosis of TOF is feasible and can give information for most of the anatomic details
- Detailed examination starting with a diaphragmatic to high mediastinal structures
- Short axis view of the cardiac base for delineation of the conal septum and VSD
- Degree of override will determine RVOT stenosis
- Number of great vessels will include – exclude PA
- Delineation of branch Pas
- Aortic arch sidedness
- Presence, size and flow of ductus arteriosus is important
- Interrogate for other anatomic anomalies


LOVE WILL.