



CPN Review: Cardiovascular Conditions

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Objectives

- **Identify** normal structures in fetal circulation
- **Differentiate** between cyanotic, acyanotic and obstructive heart defects
- **Discuss** the plan care for a child with cyanotic, acyanotic and obstructive heart defects
- **List** the acquired cardiovascular disorders commonly seen in children
- **Discuss** vascular access devices
- **Acquire** knowledge to pass the CPN exam!

Statistics on Congenital Heart Disease (CHD)

- The incidence of CHD is 8 per 1000 live births, or about 40,000 children each year
- 2-3 per 100 will be symptomatic in the first year of life
- CHD is a major cause of death in the first year of life (other than prematurity)
- The most common form of CHD is a ventricular septal defect

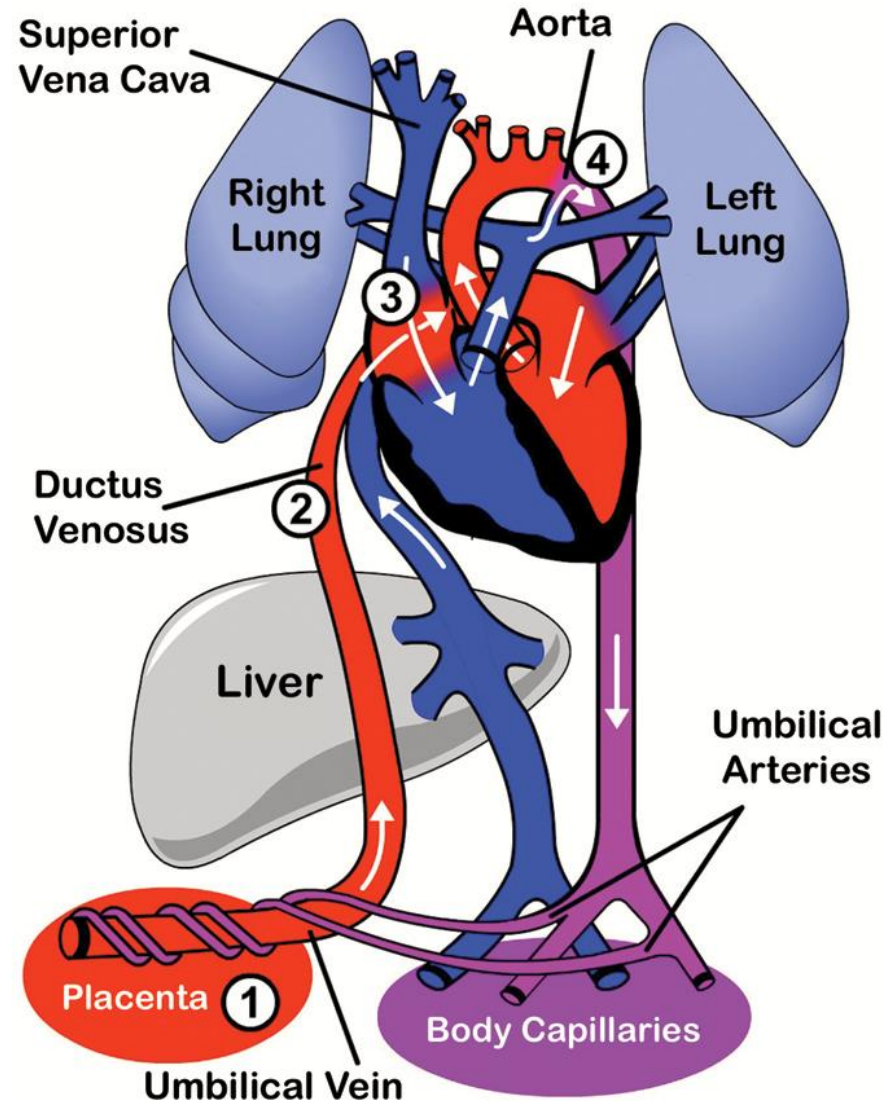
Etiology of CHD

- The exact cause is unknown
- There are some risk factors known to be associated with CHD:
 - Maternal diabetes
 - Maternal exposure to toxins and environmental factors
 - Family history of CHD (parents or siblings)

Fetal Circulation

Structures:

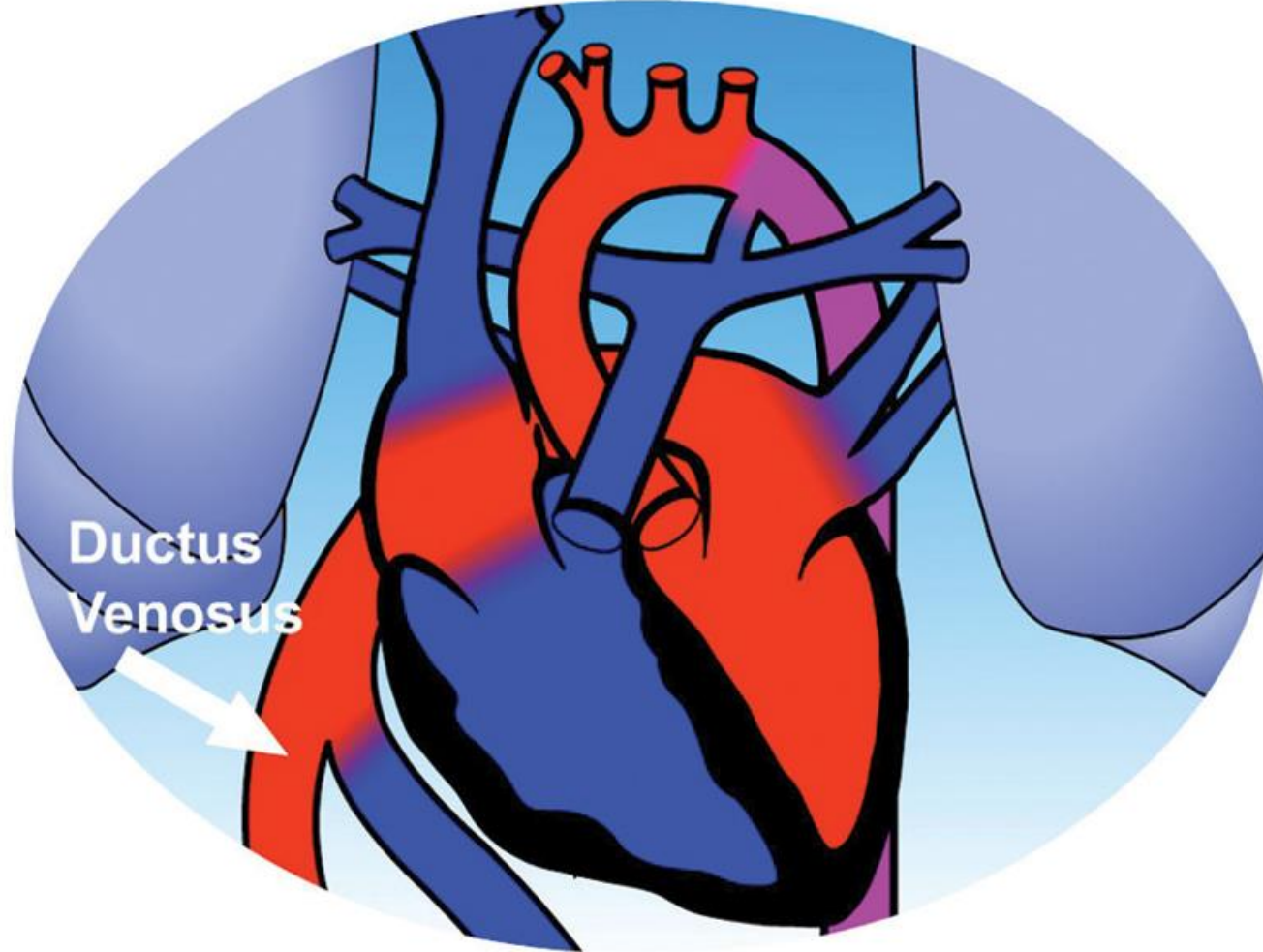
1. Placenta
2. Ductus venosus
3. Foramen ovale
4. Ductus arteriosus



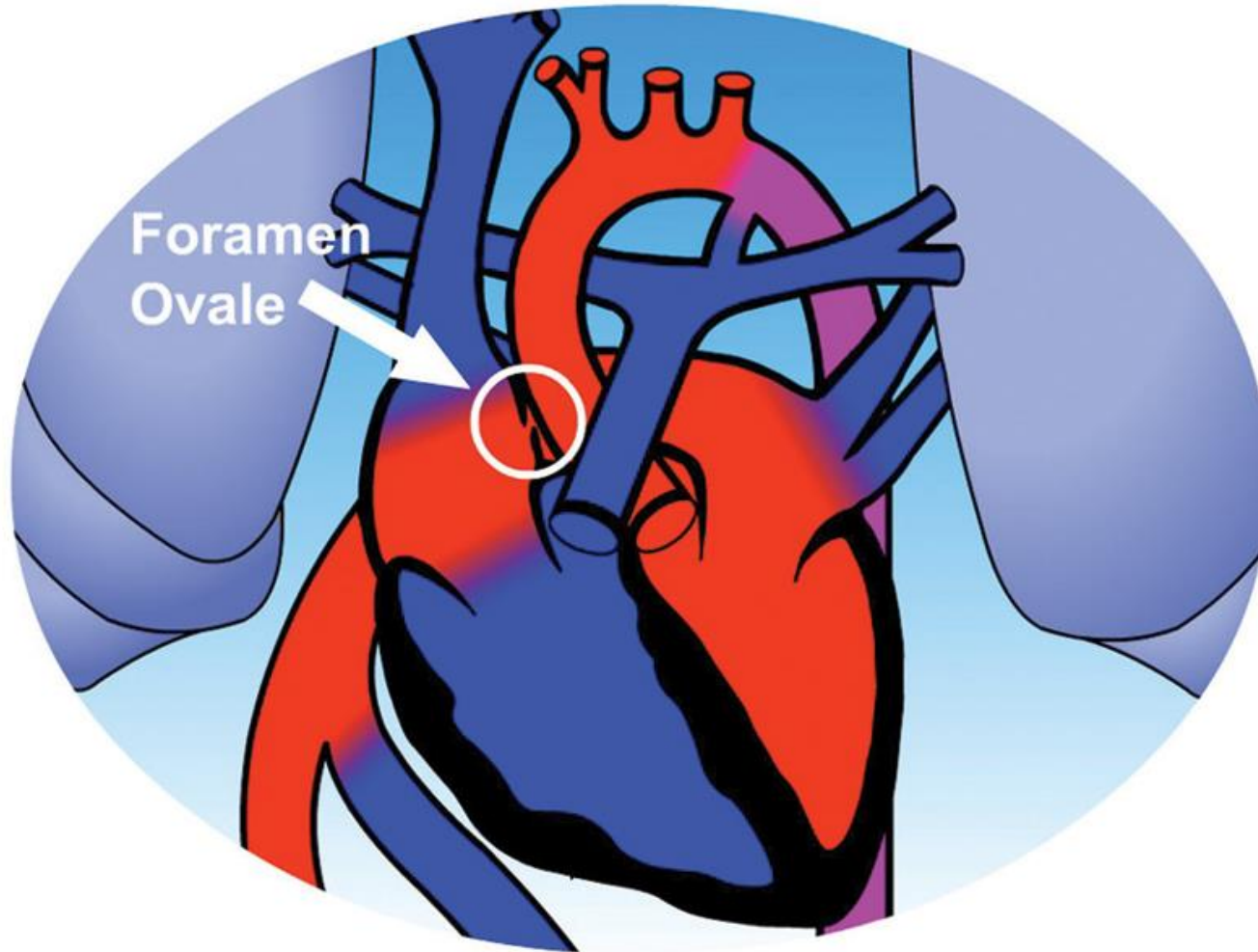
Structures in Fetal Circulation

- **The placenta:** Oxygenates fetal blood
- **Ductus venosus:** A bypass of the fetal liver so oxygenated blood can be quickly distributed to the fetal circulation
- **Foramen ovale:** Allows blood to flow directly from the right atrium to the left atrium (bypassing the lungs). This opening has a one-way flap that closes with the first breath at birth
- **Ductus arteriosus:** Located between the pulmonary artery and the aorta
 - Blood from the right ventricle passes through the pulmonary artery to the ductus arteriosus to the aorta

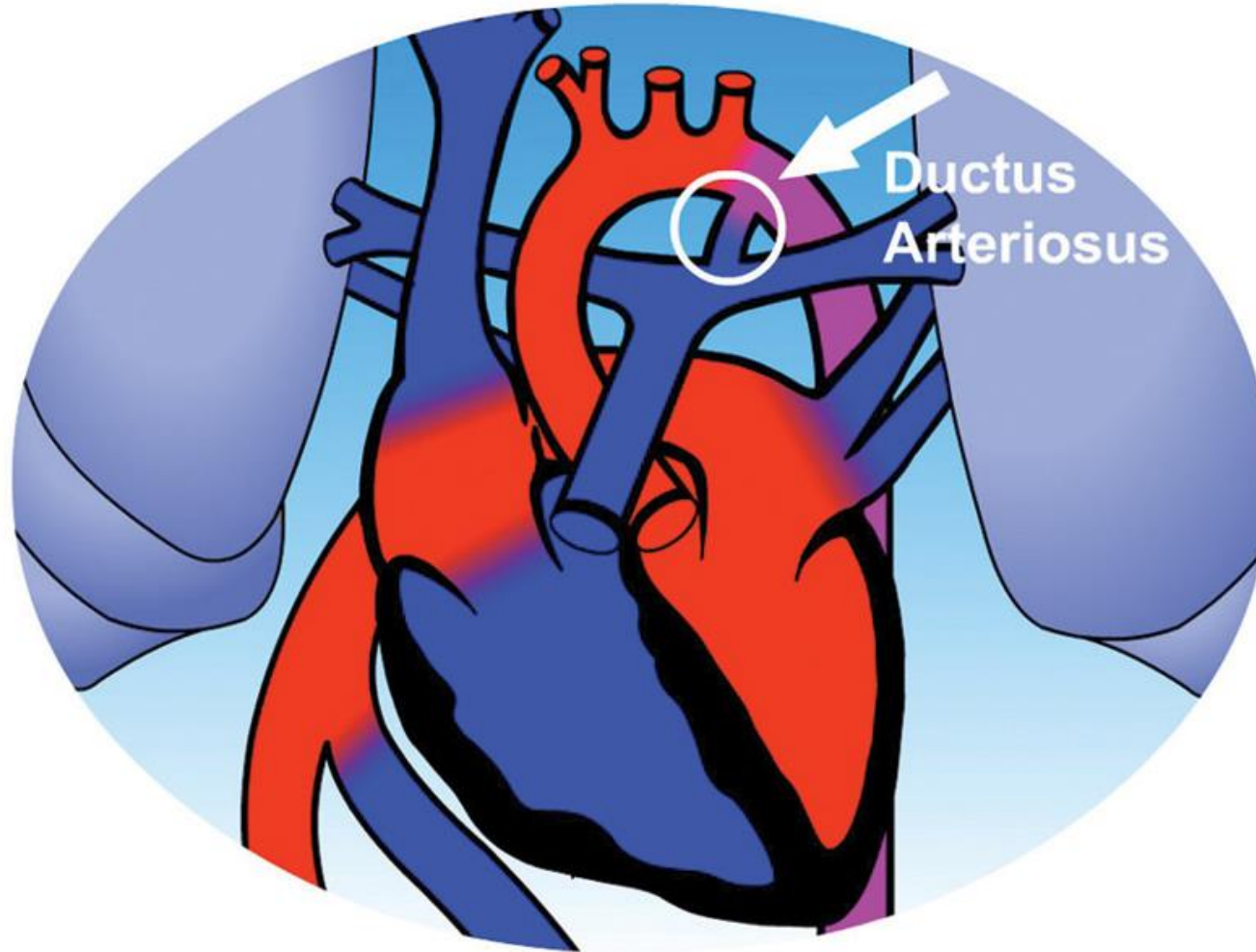
Fetal Heart – Ductus Venosus



Fetal Heart - Foramen Ovale



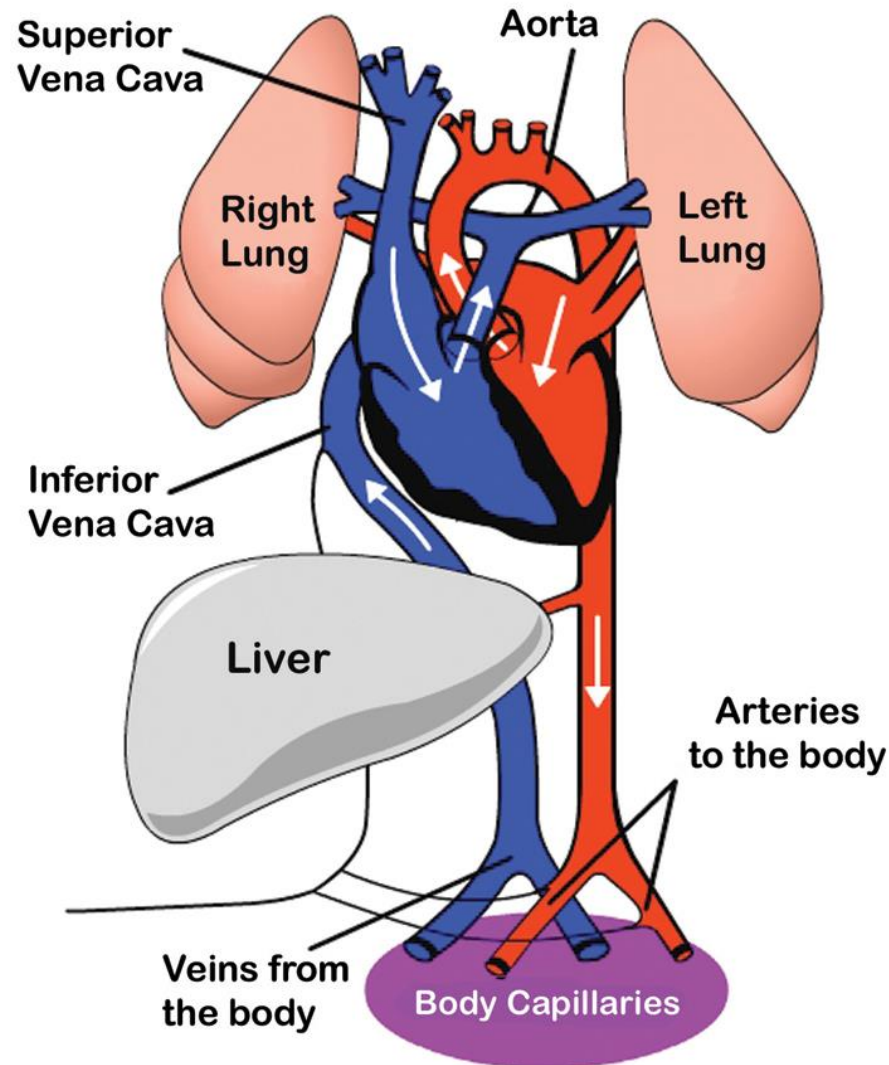
Fetal Heart – Ductus Arteriosus



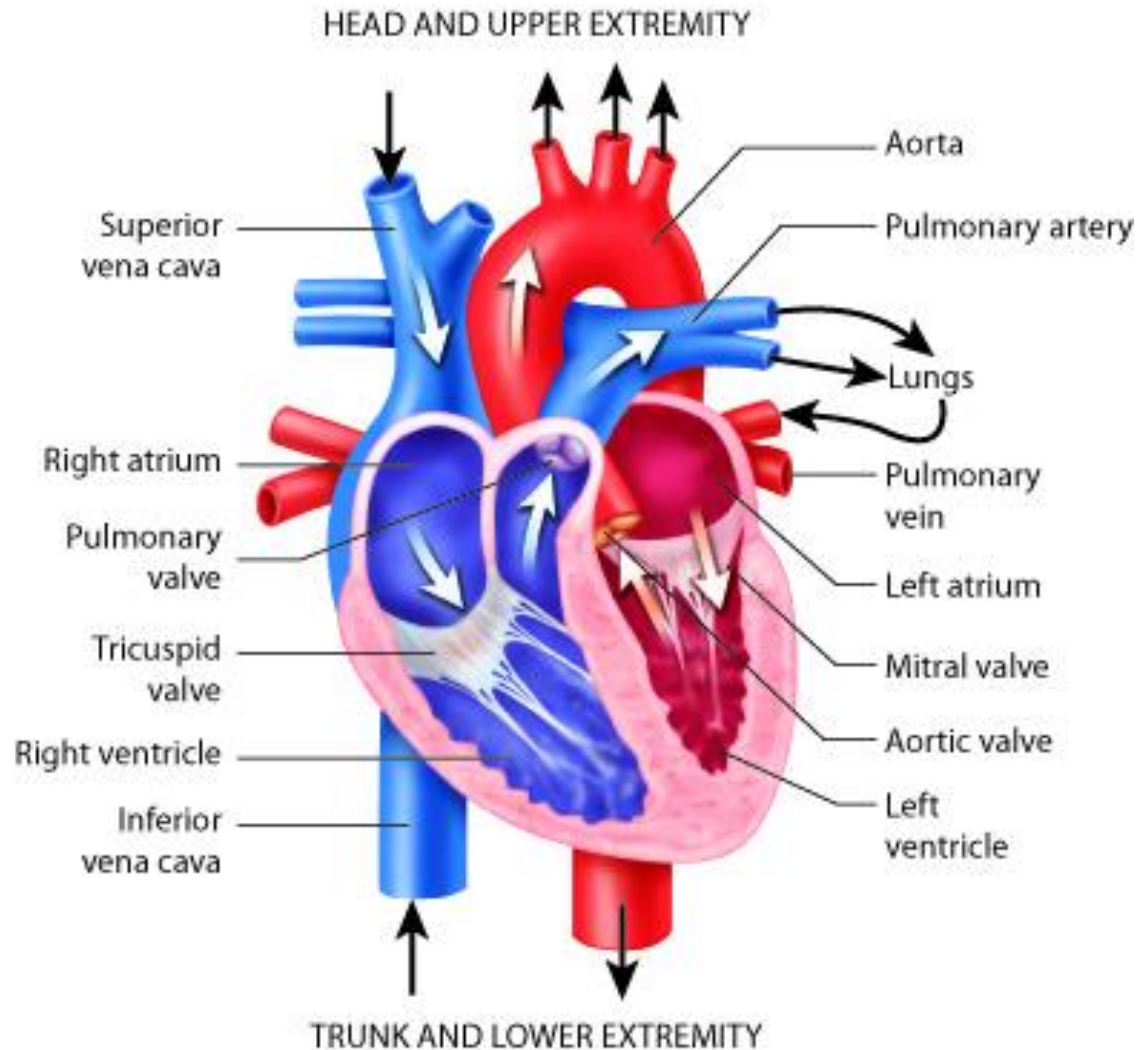
Transition from Fetal Circulation

- At birth, the first breath initiates the relative change in pressures in the heart and lungs
- The foramen ovale closes secondary to the relative pressure change in the lungs vs the body
- The ductus arteriosus closes off in response to higher oxygen saturations in the blood
- The placenta is no longer needed for oxygenation now that the lungs are functioning

Normal Post-Natal Circulation



The Normal Heart

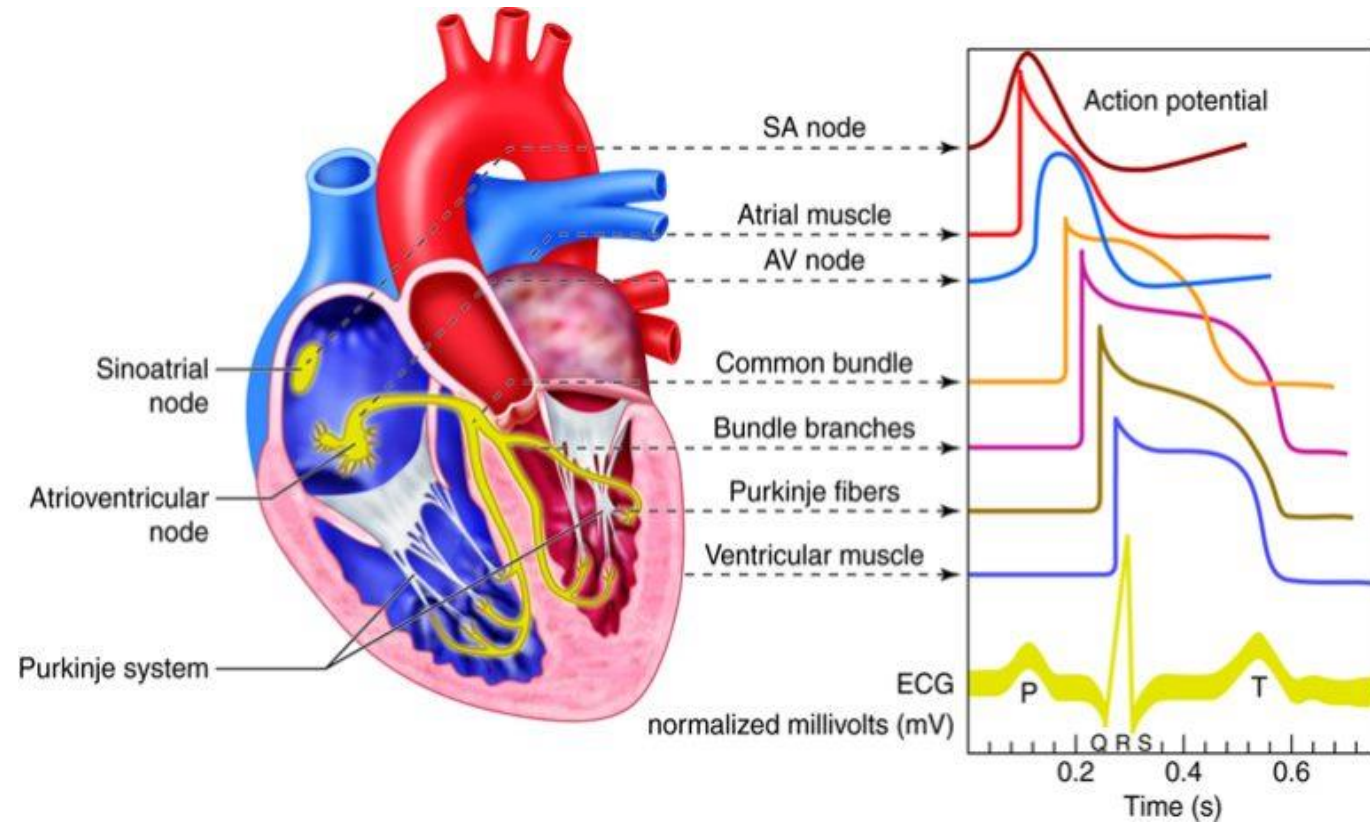


- Contraction of the heart is **systole**
- Relaxation of the heart is **diastole**

Cardiac Pressures

- After birth: pressures on the left side of the heart are higher than on the right side of heart. The highest internal pressure is the LV
- In cardiac defects involving communication **between chambers**, blood flows from areas of high pressure to areas of low pressure
 - This is called L to R shunting
 - Example: In a VSD, blood typically flows from the LV to the RV
- In cardiac defects that **do not** involve chambers, blood will still flow from high to low pressure areas
 - Example: In a PDA, blood flows from aorta to pulmonary artery

Electrical System of the Heart



- The sinoatrial (SA) node is in the right atrium and is the heart's pacemaker
- Charge then spreads to the atrioventricular (AV) node
- Charge then spreads to the bundle of His
- Finally charge reaches the Purkinje fibers which stimulate the ventricles to contract

Diagnostic Evaluation of the Cardiovascular System

- **History and Physical exam**
- **Chest Radiograph:** Identify heart size and pulmonary vascular markings
- **Electrocardiogram:** Identify cavity hypertrophy
- **Echocardiogram:** Gold standard to evaluate anatomy
 - Also useful to evaluate heart function
- **Cardiac Catheterization:** To further delineate anatomy and direct pressure measurements of chambers.
 - Not indicated in all cases

Cardiac Catheterization

- Establish baseline prior to procedure
 - Weight
 - Pulse, blood pressure, temperature and color of extremities
- Post procedure:
 - Keep the extremity of insertion site immobile after cath to prevent hemorrhage. Monitor for blood on dressing or hematoma formation. If bleeding occurs, apply direct pressure and notify interventionalist.
 - Check vitals frequently. Reassess temperature and color of extremities frequently and compare to pre-cath assessment
 - Ensure adequate intake (IV or PO)

History

- Prenatal and postnatal course
- Growth and development
- Exercise tolerance
- Feeding tolerance
- Palpitations
- Chest pain
- Cyanosis
- Syncope
- Wheezing/respiratory problems

Physical Exam

- Heart rate and BP – 4 extremity during 1st visit
- Auscultation – Note regularity of rhythm and assess for presence of murmurs
- Inspection – Assess for heaves, chest shape, location of PMI, cyanosis, clubbing
- Chest Palpation – Assess for thrills
- Quality of pulses – Assess equality and strength
- Capillary refill time and temperature of extremities

Normal Vital Signs

- Heart rate decreases with age. Blood pressure increases with age.

Age	Heart Rate (beats/min)	Blood Pressure (mmHg)
Infant	120-130	80/40
Toddler	80-105	80-100/64
School Age	70-80	94-112/56-76



Acyanotic Heart Defects

Acyanotic Heart Defects

- **A cardiac defect where blood entering the aorta is completely oxygenated**
- These defects include those in the septum that result in left to right shunts
- Any increased blood volume on the right side of the heart causes right-sided hypertrophy and increased blood flow to the lungs
- The pressure difference in the chambers eventually equalizes as the right side of the heart begins to fail in attempt to compensate

Signs of Acyanotic Heart Defects

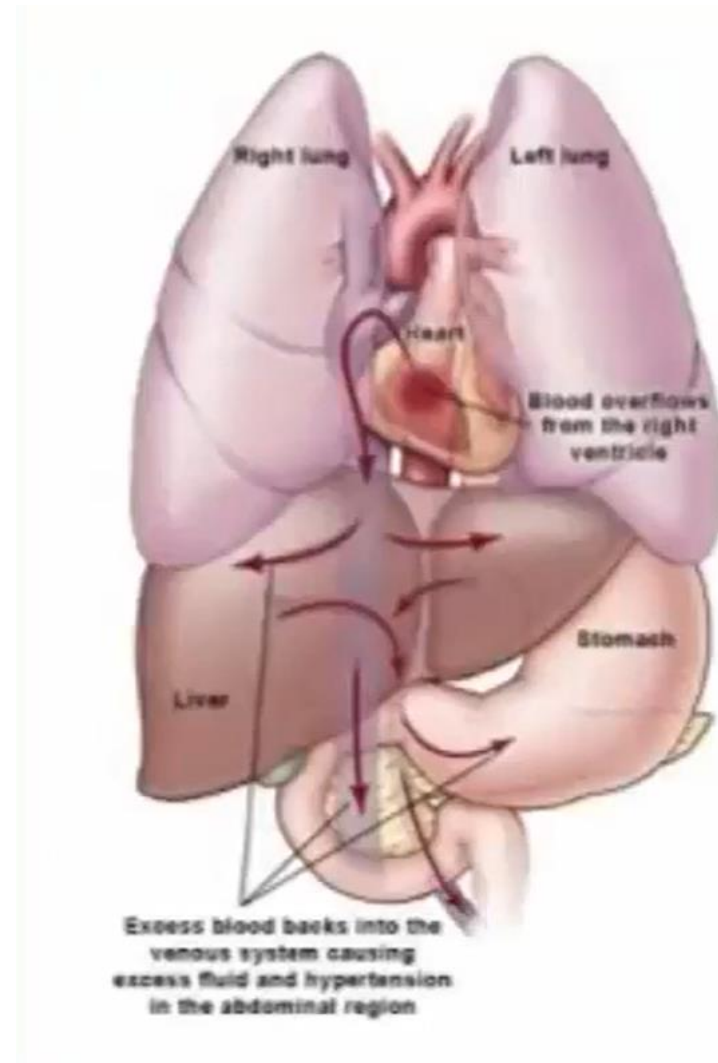
- Tachypnea, congested cough or respiratory distress without an infectious etiology
- Tachycardia
- Diaphoresis
- Mild Cyanosis
- Hepatomegaly
- Poor growth and development (secondary to increased energy expenditure for breathing)
- Fatigue
- Signs of congestive heart failure

Congestive Heart Failure

- Early recognition and treatment of CHF lessens the impact on long-term growth and developmental milestones
- Frequently seen secondary to CHDs where structural abnormalities cause an increased volume load or increased pressure load on the ventricles
- Also seen in defects with increased blood flow to the lungs (those with L to R shunting)

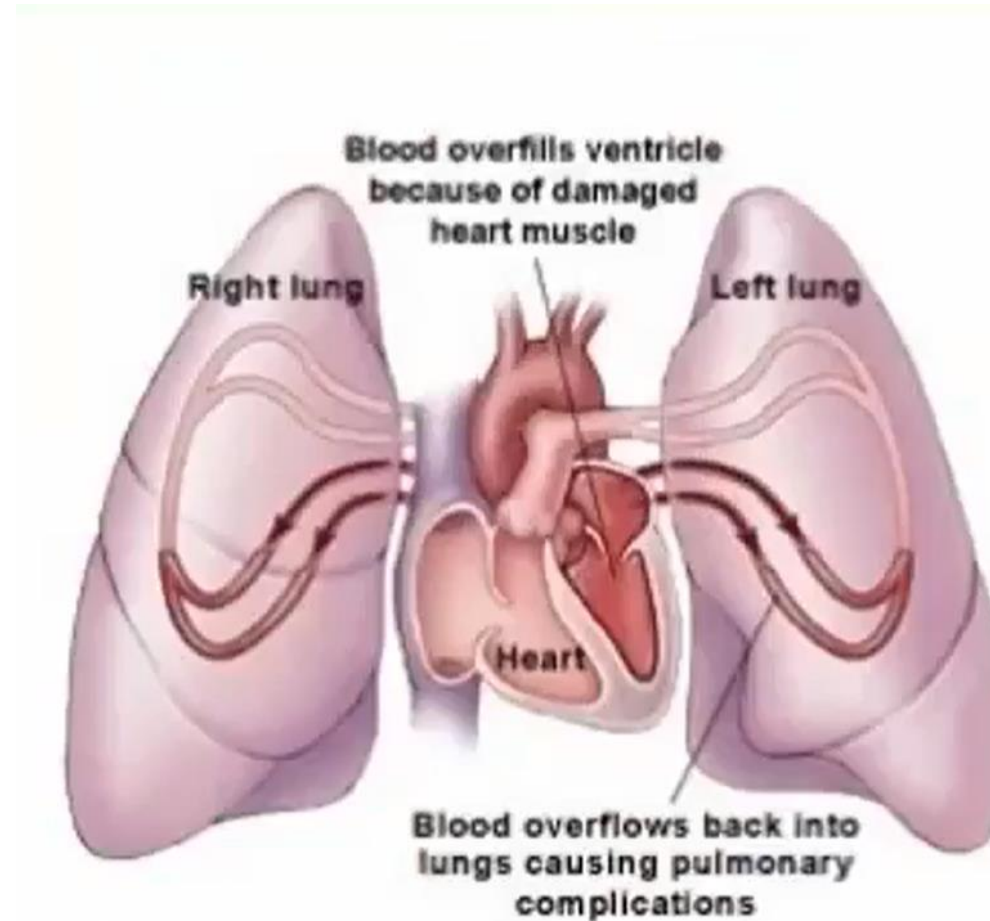
RIGHT-sided Heart Failure

- Hepatomegaly
- Edema (periorbital & facial)
- Ascites
- Weight gain
- Neck vein distention
 - ↑ CVP
 - ↓ CO



LEFT-sided Heart Failure

- Tachycardia
- Decrease pulses
- Tachypnea
- Dyspnea
- Wheezing
- Crackles
- Rales
- Cough
- Pulmonary edema
- Exercise intolerance



Management of CHF

- Anti-congestive therapy:
 - Digoxin
 - Diuretic therapy (Lasix/furosemide): monitor fluid balance closely and observe for potassium loss
- Early involvement with developmental care experts to support achieving milestones (PT/OT/speech/child life)

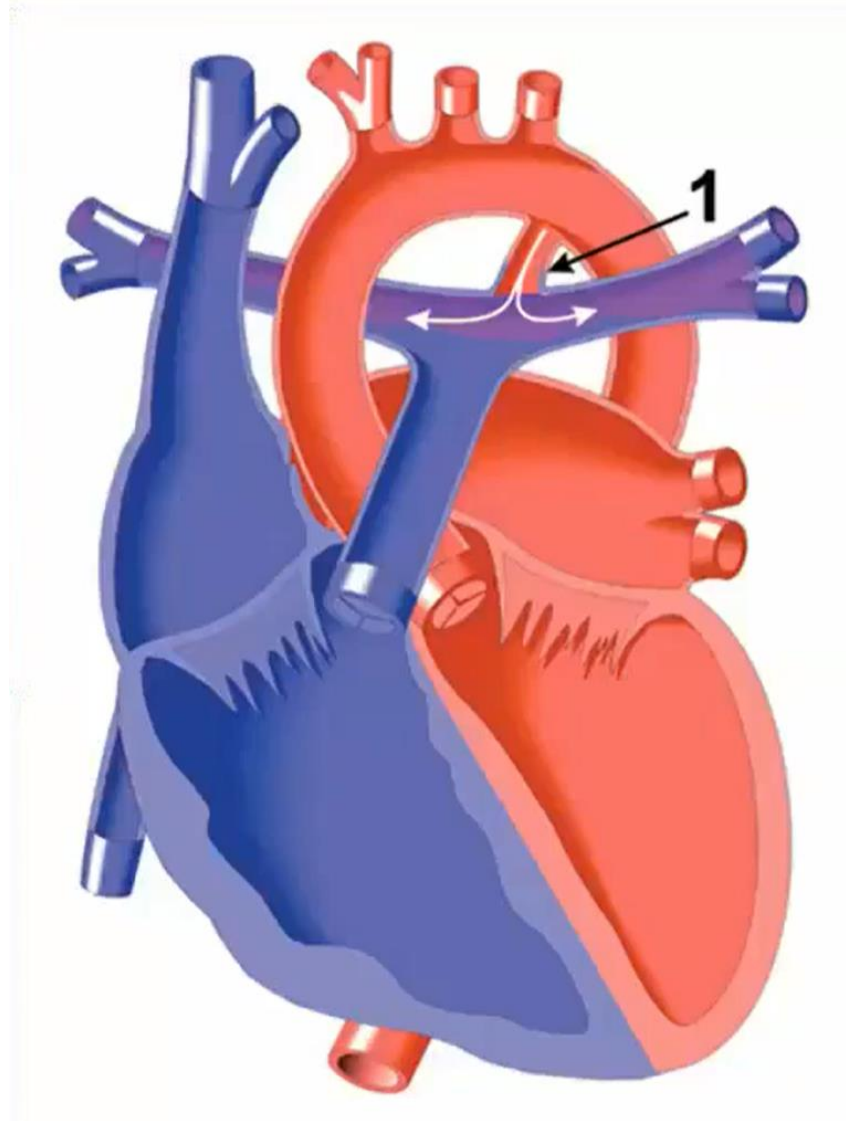
Considerations with Digoxin therapy

- **Action:** To slow the heart rate and strengthen cardiac contractions
- Take apical pulse for 1 minute prior to administration
- Order must specify minimum heart rate for administration
- Medication may be held if patient is experiencing bradycardia
- Digoxin levels will be monitored with routine lab draws to maintain therapeutic window and avoid toxicity

Nursing considerations for CHF

- Assess for a heart murmur
- Monitor fluid status: Daily weight, strict I&O, enforce fluid restrictions
- Reduce oxygen demands by organizing physical care and anticipating child's needs
- Good nutrition with high caloric density foods easy to ingest and digest
- Reduce myocardial demand by maintaining normothermia

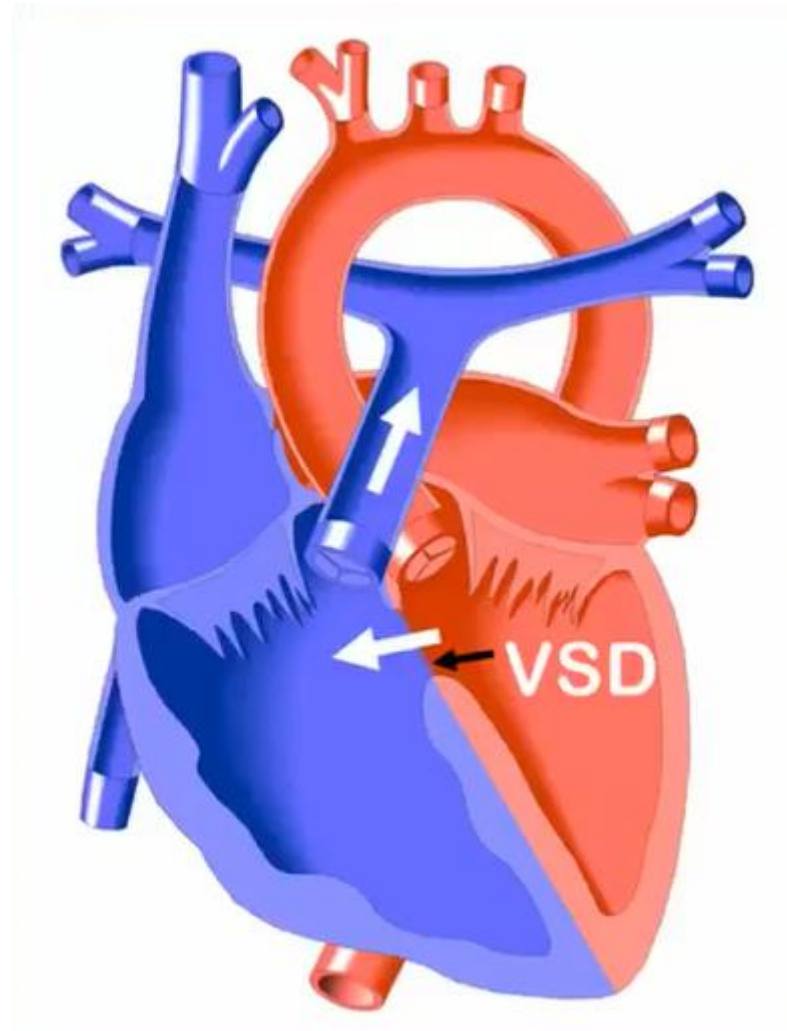
Diagram: PDA



Patent Ductus Arteriosus (PDA)

- Failure of the fetal structure to close. Common in premature infants
- Exhibit signs of congestive heart failure and left ventricular hypertrophy.
- Management:
 - Prepare for possible administration of indomethacin (prostaglandin inhibitor) for pharmacologic closure
 - May be closed via coil occlusion in the cath lab
 - May be surgically clipped or ligated

Diagram: VSD



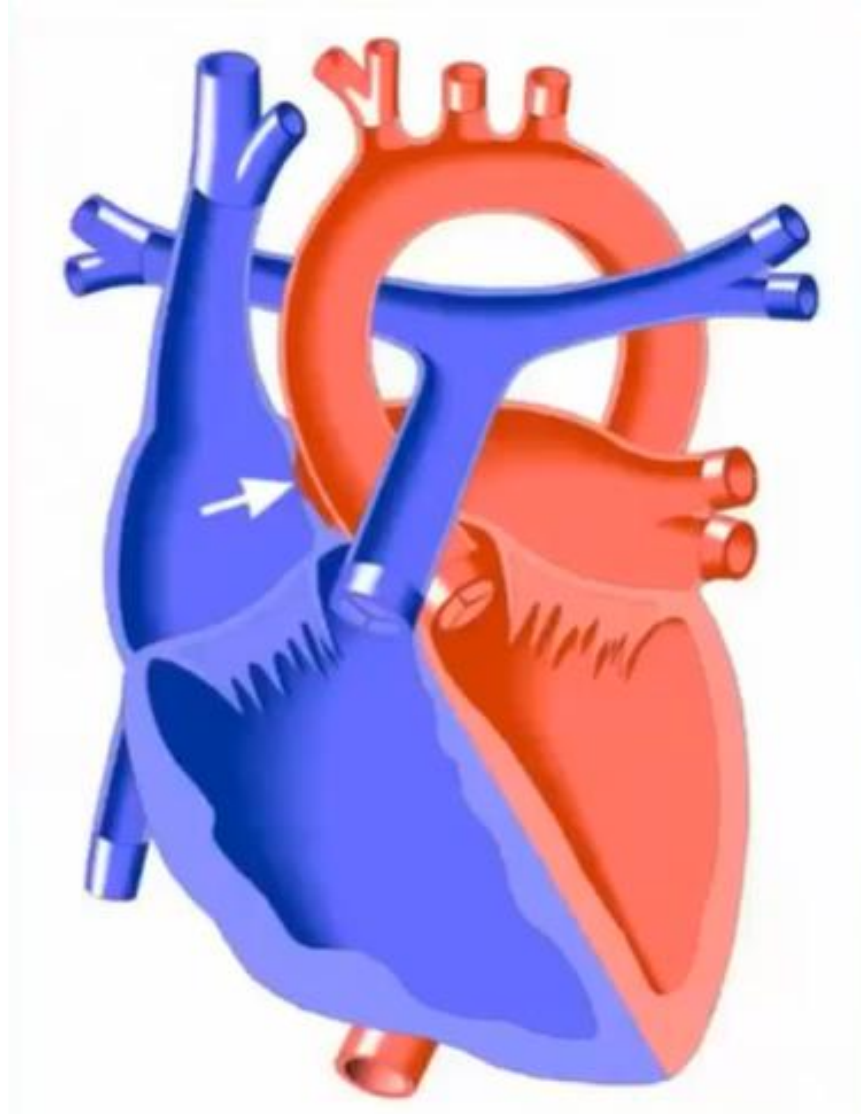
Ventricular Septal Defect (VSD)

- Most common congenital cardiac anomaly
- Failure of the ventricular septum to develop normally resulting in a communication between the ventricles
- Results in a left to right shunt (pressure in the LV >RV, and blood flows from an area of higher pressure to low)
- Assess for signs of CHF with right ventricular hypertrophy
- Assess for failure to thrive and evaluate degree of fatigue

Management of VSD

- Anti-congestive therapy
- Surgical closure of the ventricular septal defect
- The conduction system is located along the ventricular septum, therefore surgical closure may result in heart block
- PA band is a palliative measure
- Some small VSDs can spontaneously close by age 3 years

Diagram: ASD



Atrial Septal Defect (ASD)

- A defect in the atrial septum resulting in a left to right shunt at the atrial level
- May resolve by age 5 years
- Assess for signs and symptoms of CHF. Assess for murmur.
- Management:
 - May be closed with an Amplatzer Septal Occluder Device in the cath lab
 - May be surgically closed depending on size and location of defect



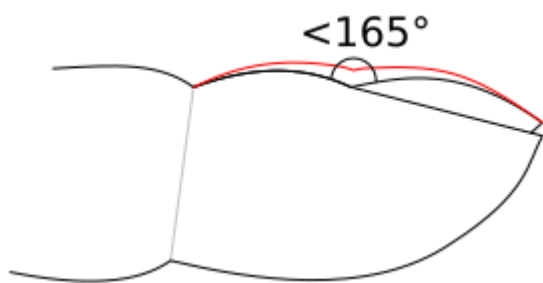
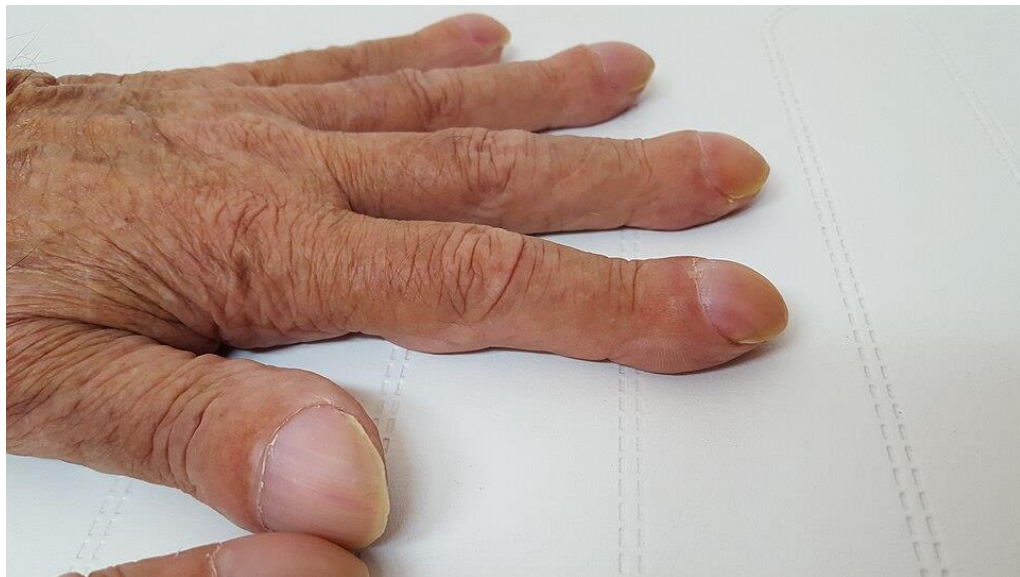
Cyanotic Heart Defects

Cyanotic Heart Defects

- **A cardiac defect that allows oxygenated blood entering the aorta (and eventually systemic circulation) to be mixed with deoxygenated blood**
- It can result from any condition that increases pulmonary vascular resistance or from a structural defect that allows the aorta to receive blood from the right side of the heart
- It can lead to left-sided heart failure, decreased oxygen supply to the body, and the development of collateral circulation

Signs of Cyanotic Heart Disease

- May have a comfortable respiratory pattern but persistent cyanosis despite institution of supplemental oxygen
- Polycythemia (secondary to chronic hypoxemia)
- Activity/Feeding Intolerance (or irritability with feeds)
- Squatting position (to increase venous return)
- Failure to thrive
- Dyspnea
- Clubbing (seen with chronic hypoxemia)

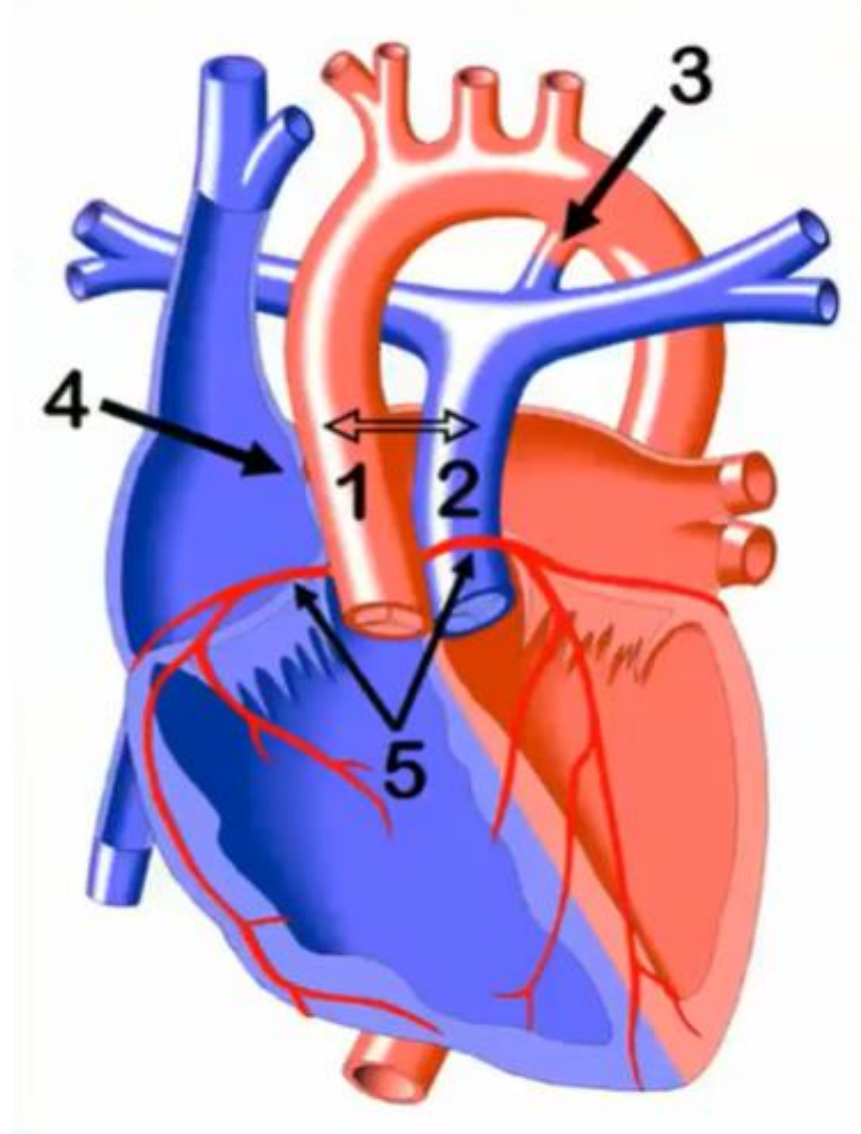


Nursing Interventions:

When Caring for a Child with Cyanotic Heart Disease

- May provide supplemental oxygen...but NOT in all cases!!
- Decrease oxygen demands by organizing physical care and anticipating the child's demands
- Provide appropriate hydration, especially in cases when polycythemia is present
- May need prophylaxis for infective endocarditis
- Note for alterations in ABCs
- Assess strict intake and output; output should be at least 1-2 ml/kg/hr (neonates: 0.5-1ml/kg/hr)

Diagram: Transposition of the Great Arteries



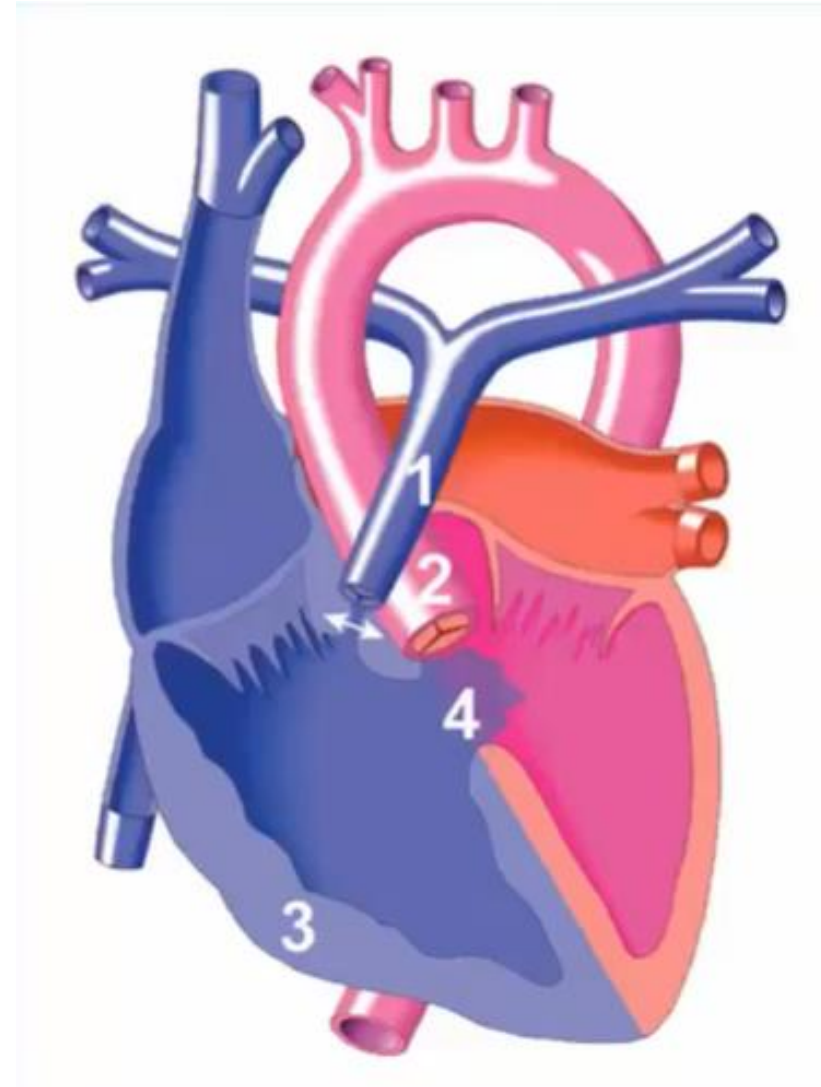
Transposition of the Great Arteries

- The Aorta arises from the right ventricle and the Pulmonary artery arises from the left ventricle resulting in parallel circuits
- Often present as cyanotic at birth with a comfortable respiratory effort
- Note increasing cyanosis as the PFO or PDA closes
- **Must have mixing at the level of the atria, ventricle or ductus arteriosus to survive**

Interventions/Nursing Considerations

- Anticipate the initiation of PGE₁ Infusion. (This provides mixing at the level of the ductus arteriosus)
- May need palliation initially with a balloon atrial septostomy. This is performed in the catheterization lab. (This procedure provides mixing at the atrial level)
- Surgical repair is the Arterial Switch Procedure. The goal is to associate the great arteries with their appropriate ventricles. This is done within the first week of life.

Diagram: Tetralogy of Fallot



Tetralogy of Fallot

- Components:
 - Ventricular Septal Defect (VSD)
 - Pulmonary artery stenosis
 - Overriding Aorta
 - Right ventricular hypertrophy

Tetralogy of Fallot

- There is increased pressure in the right ventricle due to pulmonary stenosis, resulting in a right to left shunt
- Cyanosis may or may not be present depending on the degree of pulmonary stenosis

Signs with Tetralogy of Fallot

- Cyanosis and symptoms of cyanotic heart disease
 - Clubbing, dyspnea, failure to thrive, exercise intolerance, polycythemia
- Posturing such as squatting position or knee chest position
 - Do not interfere with this position if the child appears comfortable
- Hyper-cyanotic spells or “Tet Spells”

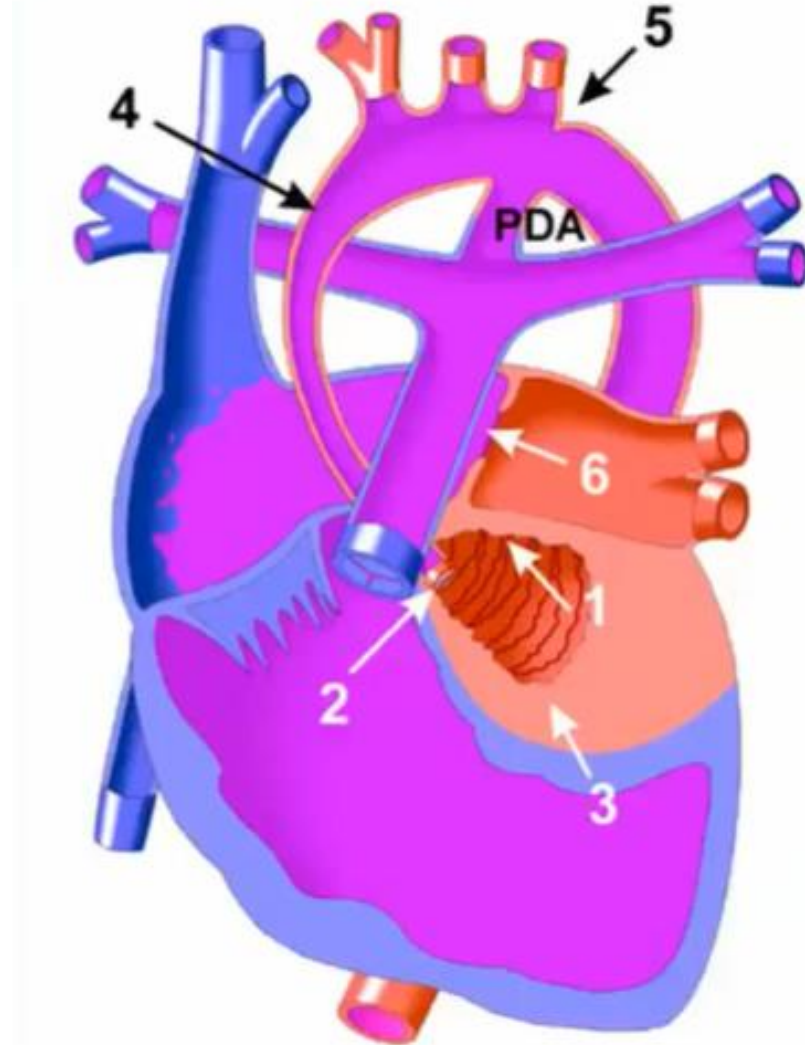
“Tet Spells”

- Increasing cyanosis and hypoxemia leading to decreased oxygen to the brain and short periods of loss of consciousness
- **Interventions:**
 - Morphine for the infundibular spasm
 - Provide supplemental oxygen
 - Place child in a knee-to-chest position

Interventions for ToF:

- PGE₁ infusion for ductal-dependent circulation
- Palliative treatment to increase pulmonary blood flow
- Surgical repair: Close the VSD and augment the pulmonary outflow tract

Diagram: Hypoplastic Left Heart Syndrome



Hypoplastic Left Heart Syndrome (HLHS)

- **Components consist of small or hypoplastic left-sided structures of the heart**
 - Aortic Valve atresia, mitral valve atresia and hypoplastic left ventricle, and severe hypoplasia of the ascending aorta and aortic arch
- **Important Principle:** Vessels and chambers grow around the volume of blood passing through them (William I. Norwood, MD)

Blood flow in HLHS

- **The mixed blood in the right atrium → tricuspid valve → right ventricle → pulmonary valve → pulmonary artery**
 - Some of the blood goes through the branch pulmonary arteries to the lungs for oxygenation
 - Some of the blood travels “right to left” through the ductus arteriosus to the aorta then to the body
- **The distribution of blood depends upon systemic and pulmonary pressures**

Signs of HLHS

- Cyanosis, dyspnea, tachypnea
- Decreased pulses, decreased perfusion
- Low cardiac output
- **This circulation is DEPENDENT on a patent ductus arteriosus and a wide open atrial communication**
- The child may appear normal at birth

Intervention

- PGE₁ infusion
- Possible atrial septostomy in the cath lab (to open the atrial communication)
- Surgical intervention consists of Staged Palliation:
 - Stage I : Norwood Procedure (newborn period)
 - Stage II: Hemi Fontan (6 months of age)
 - Stage III: Fontan (1 year of age)
- Cardiac Transplantation

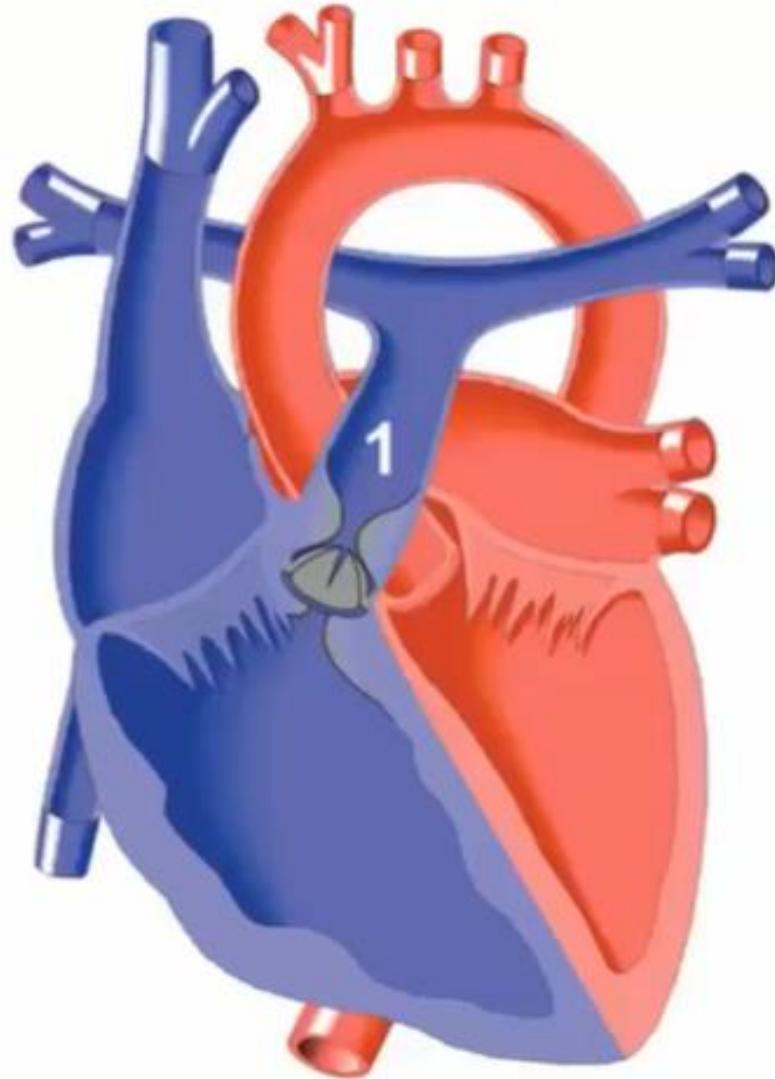
Realities of HLHS

- Death will occur in early infancy without surgery
- The childhood mortality rate is 25% with surgery



Obstructive Defects

Diagram: Pulmonary Stenosis



Pulmonic Stenosis (PS)

- Narrowing of the pulmonary valves at the entrance of the pulmonary artery interfering with right ventricular outflow
- May result in right ventricular hypertrophy and right-sided heart failure

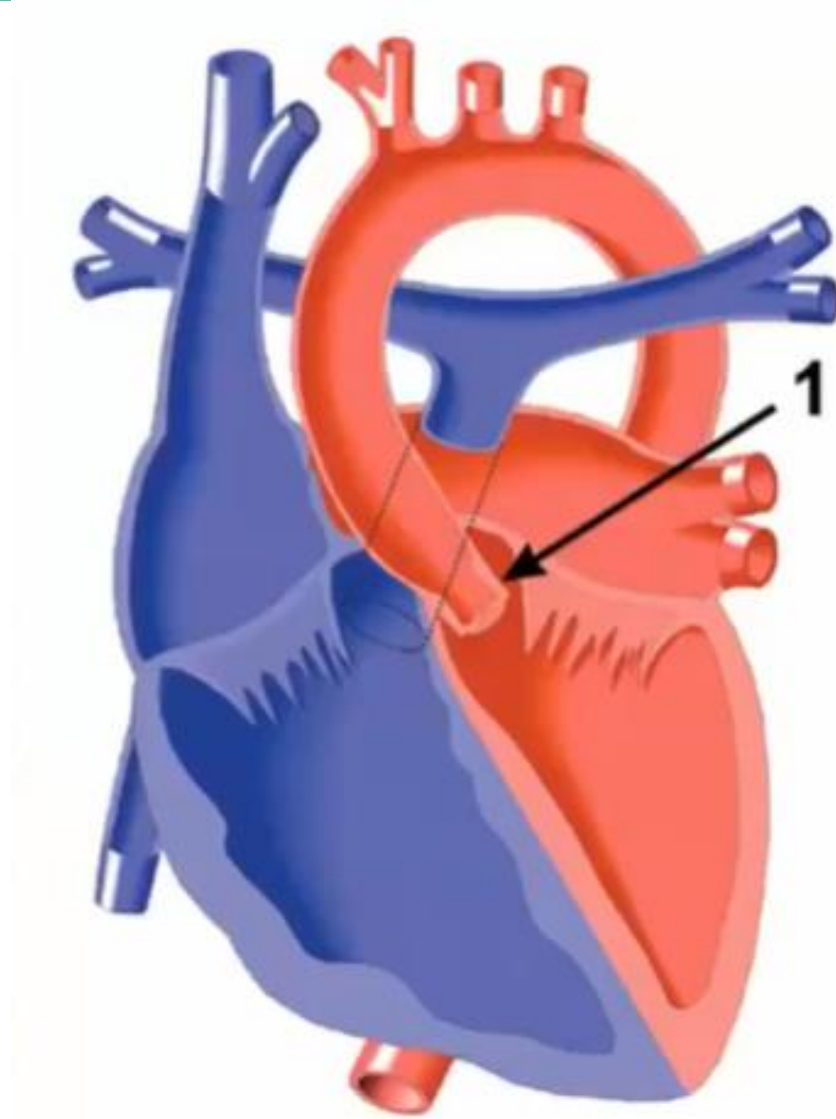
Signs of Pulmonary Stenosis

- Review history for exertional fatigue
 - Feeding difficulty
 - CP with exercise
 - Cyanosis with exercise
- The degree of cyanosis will depend on the degree of pulmonary stenosis or obstruction
- Systolic murmur

Interventions for PS

- Pulmonary balloon valve angioplasty in the Cardiac Catheterization Lab
- Surgical valvotomy or commissurotomy
- Child will have a permanent residual murmur
- May recur in adulthood

Diagram: Aortic Stenosis



Aortic Stenosis (AS)

- Narrowing of the aortic valve interfering with left ventricular outflow
- May result in left ventricular hypertrophy, left-sided heart failure and pulmonary congestion

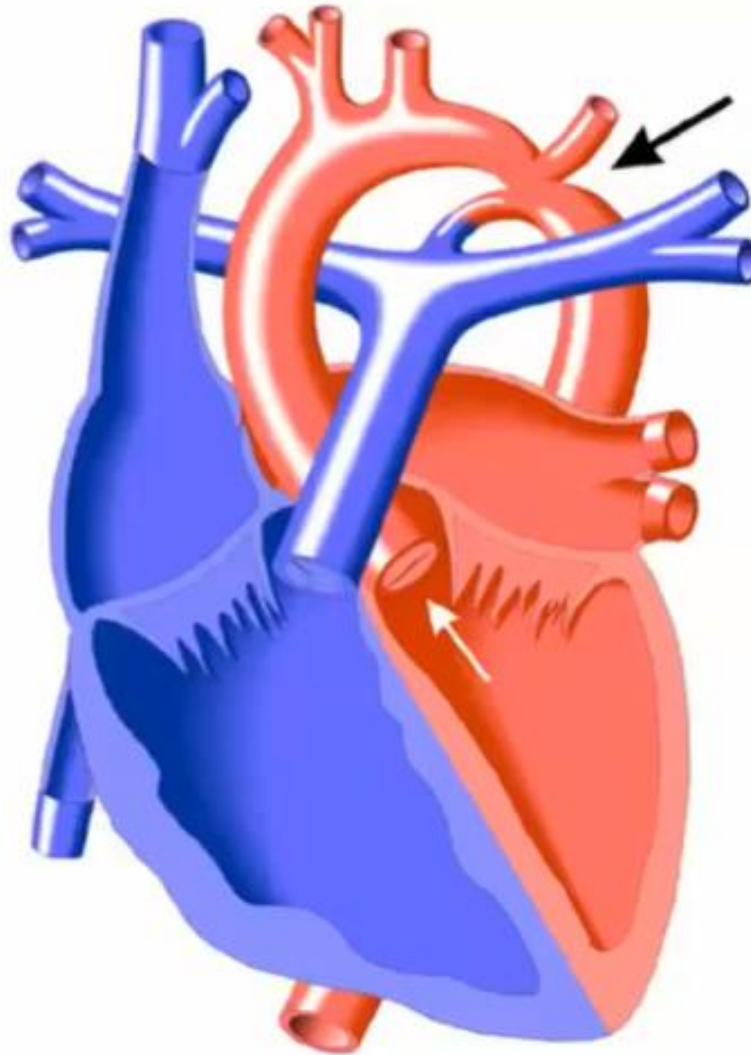
Signs of Aortic Stenosis

- Syncope, dizziness
- History of chest pain / angina
- May present as irritability with feeding in an infant
- Ask if activities increase symptoms

Interventions in AS

- Aortic balloon valve angioplasty
- Surgical valvuloplasty or commissurotomy
- Aortic Valve replacement
- May recur in adulthood

Diagram: Coarctation of the Aorta



Coarctation of the Aorta

- Narrowing of the aortic arch
- Depending on the location of the narrowing, the child may be dependent on blood flow through the ductus arteriosus
- It decreases blood flow to the trunk and lower body
- This condition predisposes the child to a cerebrovascular accident

Signs of Coarctation of the Aorta

- Decreased or non palpable pulses in the lower extremities, as compared to the upper extremities
- Cool lower extremities
- **At least a 10 to 20mmHg BP gradient** between the upper and lower extremities (UE>LE)
- Review history for nosebleeds, headaches, dizziness, leg cramps and lack of energy
- Assess for CHF

Interventions

- Balloon angioplasty of the area of coarctation
- Surgical repair:
 - Aortic arch augmentation
 - Resection of the coarctation with end-end anastomosis



Acquired Heart Conditions

Rheumatic Fever

- Acquired autoimmune immune-complex disorder occurring 1-6 weeks after a strep infection
- The strep infection is not present in the heart
- The antibodies attack the heart valves because of the similarities in their antigenic markers
- RF results in antigen-antibody complexes that initiate complement formation and heart destruction
- AHA states to diagnose RF - 1 major and 2 minor symptoms (known as the Jones Criteria) must be present

Jones Criteria

- **Major**

- Carditis
- Polyarthrititis
- Chorea
- Subcutaneous nodules
- Erythema marginatum

- **Minor**

- History of previous strep infection
- History of fever and arthralgia
- Elevated ESR
- Elevated ASO titer
- EKG with prolonged P-R interval

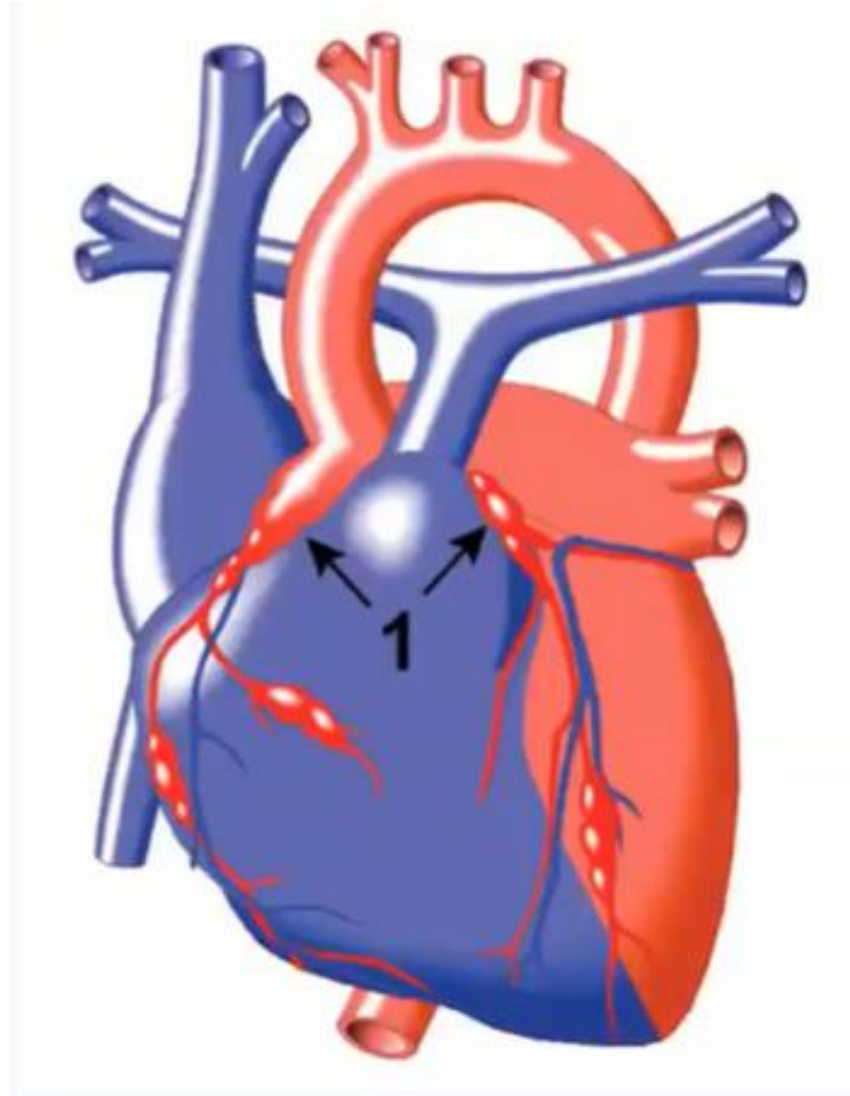
Management

- Monthly long acting PCN for 5 years (or until age 21)
- Anti-inflammatory agents: administer for arthritis pain
- Provide bedrest until the sedimentation rate normalizes
- Treat signs of congestive heart failure

Kawasaki Syndrome

- Results from a vasculitis of small and medium sized blood vessels. The coronary arteries are most at risk
- The leading cause of acquired heart disease in children
- Etiology is unknown
- Assess for fever for 5 days or more with:
 - Swelling of the conjunctivae without drainage
 - Strawberry tongue
 - Rash
 - Swollen red palms of hands and soles of feet
 - Cervical lymphadenopathy

Kawasaki Disease



Interventions

- Administer IVIG to reduce the risk of coronary artery abnormalities
 - Greatest therapeutic effect if given within 10 days of infection/symptoms
- Administer salicylates (ASA)
 - First given as an anti-inflammatory dose, then lowered to an anti-platelet dose
- Administer fluids as needed
- Minimize skin discomfort

Infective Endocarditis

- An infection of the valves and inner lining of the heart, usually from a blood stream infection
- Those at risk include anyone with a prosthetic device in the heart and anyone with abnormal blood flow in the heart, especially due to congenital anomalies

Signs of Infective Endocarditis

- Fever
- Fatigue
- Weight loss
- Pallor
- New or changes to an existing heart murmur

Interventions

- IV antibiotics for 6 weeks
- Prevention for those at risk
 - Antibiotic therapy with dental/oral procedures



Vascular Access

Vascular Access Devices

- **Peripheral Catheters**

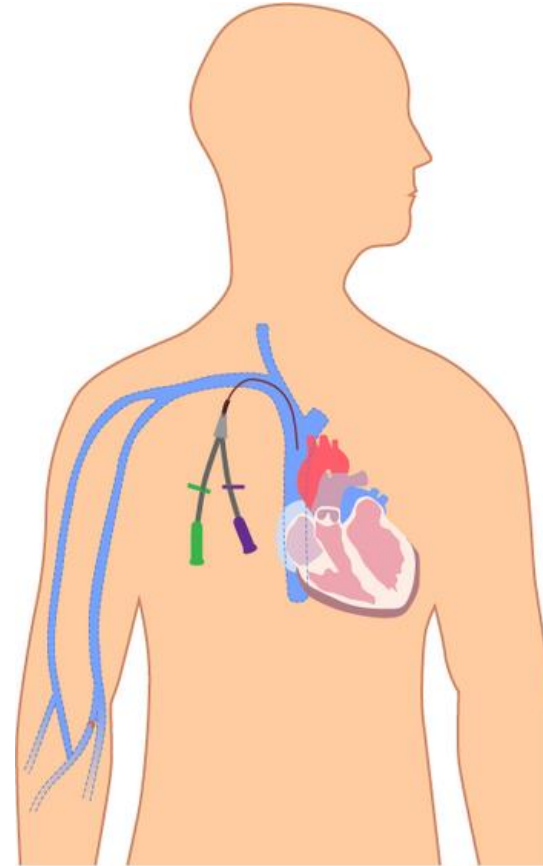
- Use local topical anesthetic prior to insertion
- Change tubing q96h or when contaminated
- Change dressing when soiled, damp or loose



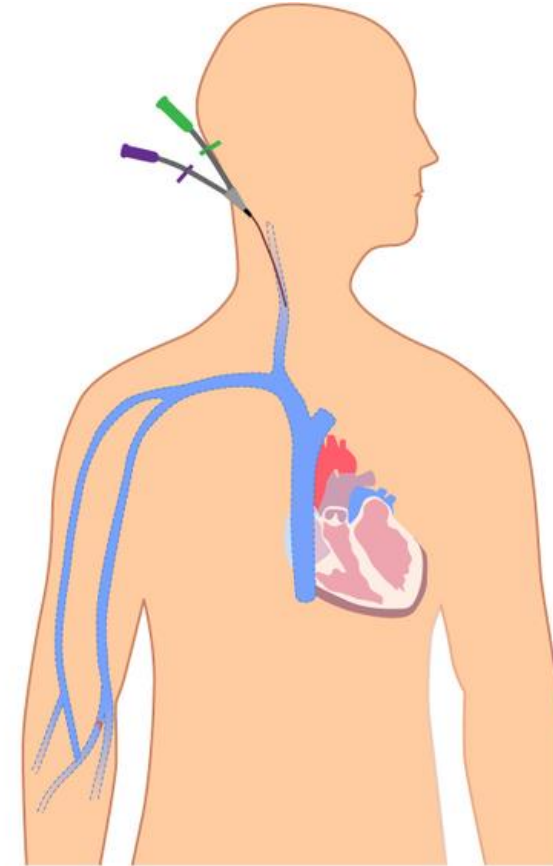
Vascular Access Devices

- **Peripherally Inserted Central Catheters (PICC) and Central Line Catheters**

- Indicated for long-term IV access
- Contraindications: bleeding disorders, trauma involving extremity, severe burns
- Limb alert for extremity with PICC
- Use CVL precautions: aseptic technique and line securement practices



Subclavian vein insertion



Internal jugular vein insertion



Practice Questions

The nurse is reviewing the anatomy and physiology of the heart. All of the following statements are true except:

- A. Prior to birth the pressure is highest on the right side of the heart
- B. The area of highest pressure in the heart of a healthy child is the left ventricle
- C. Blood flows from areas of low pressure to high pressures, this is called left-to-right shunting
- D. Relaxation of the heart is called diastole

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The nurse is reviewing telemetry for a patient and notices an arrhythmia. The nurse knows the ____ is the pacemaker of the heart:

- A. Atrioventricular node (AV node)
- B. Bundle of His
- C. Ventricular Septum
- D. Sinoatrial Node (SA node)

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The nurse is caring for Ben, a 4-year-old with an unrepaired VSD. The nurse would expect to find all of the following except:

- A. Tachypnea with a congested cough
- B. Tachycardia
- C. Height for age at 5th percentile
- D. Small liver that is difficult to assess

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A child is admitted with a possible congenital heart defect. When your assessment reveals a bounding radial pulse with a weak femoral pulse, what do you suspect?

- A. Patent ductus arteriosus
- B. Coarctation of the aorta
- C. Ventricular septal defect
- D. Truncus arteriosus

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A 10-month-old with Tetralogy of Fallot experiences a hyper-cyanotic episode of “Tet spell.” To improve oxygenation during the episode, the nurse should place the infant in which position?

- A. Knee-to-chest
- B. Fowler’s
- C. Trendelenburg’s
- D. Prone

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A 3-week-old is admitted with congestive heart failure secondary to an atrial septal defect (ASD). Her plan of care should include:

- A. Monitor strict intake and output, weigh all diapers, and weigh patient weekly
- B. Cluster all care so that oxygen demands are decreased
- C. Provide high calorie formula and allow patient to feed slowly over an hour
- D. Allow patient to cry to encourage expansion and clearing of lung fields

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A child with suspected rheumatic fever is admitted to the pediatric unit. When obtaining the child's history, the nurse considers which information to be most important?

- A. A fever that started 3 days ago
- B. Lack of interest in food
- C. A recent episode of pharyngitis
- D. Vomiting for 2 days

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Pharmacologic management to achieve closure of a patent ductus arteriosus (PDA) would be which of the following:

- A. Prostaglandin
- B. Indomethacin
- C. Digoxin
- D. Milrinone

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Normally a child's blood pressure increases with age.

- A. True
- B. False

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A. True

B. False

In the newborn nursery you note that a baby is cyanotic after the bath but breathing comfortably in room air. Oxygen 100% fiO_2 is applied with unchanged oxygen saturations of 76%. Which of the following measures do you anticipate?

- A. Bag-mask ventilation
- B. Administration of indomethacin
- C. Cardiology consult
- D. Pulmonary consult

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# Best of Luck on Your Exam!

