

Pediatric Cardiovascular Physiology

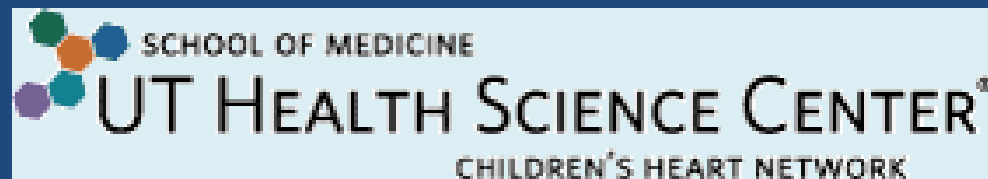
S. Adil Husain, MD

Associate Professor - Cardiothoracic Surgery

Chief of Pediatric Cardiothoracic Surgery

Univ. of Texas Health Science Center

San Antonio



Objectives

- **Fetal Circulation**
 - Role of the placenta
 - Sites of shunting
- **Transitional Circulation**
 - Changes occurring at birth
 - Abnormalities in Translational Circulation
- **Neonatal Myocardial Physiology**
 - Cardiac Output / Heart Rate
 - Autonomic Nervous System
 - Role of Catecholamines / Impact of Inotropes
- **Importance of Pulmonary Vascular Resistance**

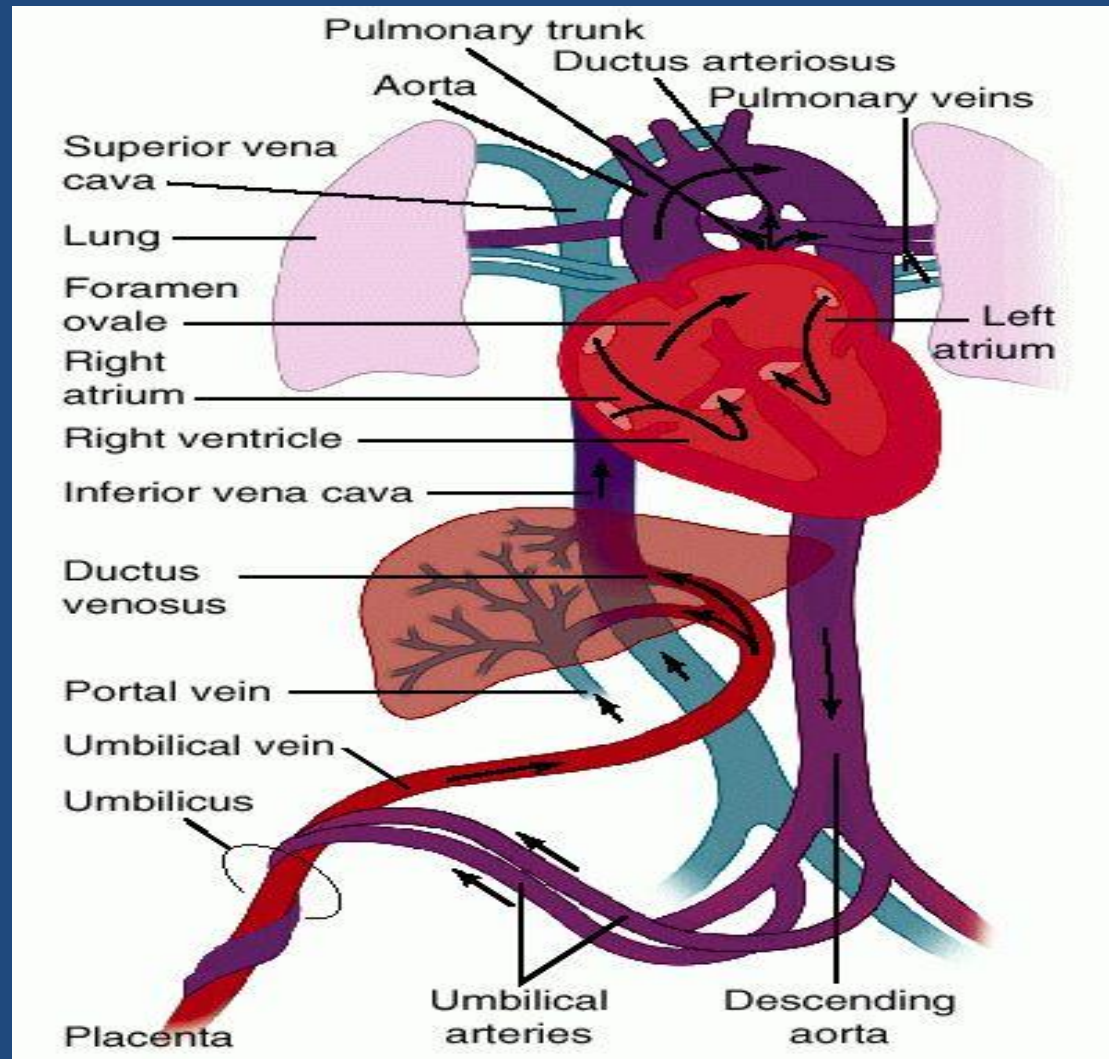


Fetal Circulation

- Parallel Circulation
 - Organs receive blood supply from both R and L ventricles
- Role of the Placenta – oxygen exchange
- Sites of Shunting
 - Ductus venosus
 - Foramen ovale
 - Ductus arteriosus
- Circulatory Pathways



Fetal Circulatory Pathway

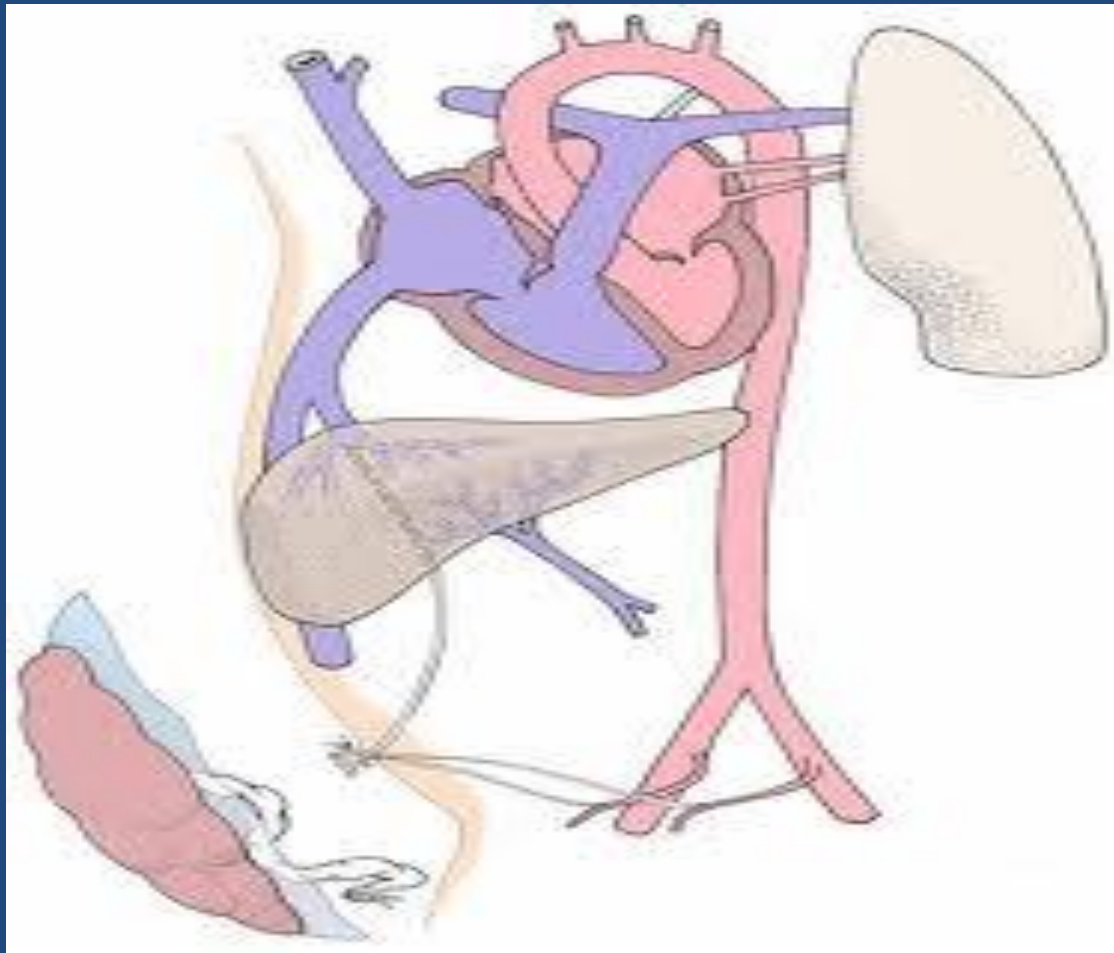


Transitional Circulation

- Immediate post natal events
- “Transfer of Responsibilities” – Placenta to Lungs
- Fetal to post natal circulation
- Development of a normal in series circulation
- Clamping of umbilical cord
- Infants first respirations



Transitional Circulation



Abnormalities in Transitional Circulation

- Persistent Fetal Circulation
 - Perinatal Distress
 - Hypoxia
 - Hypercarbia
 - Acidosis
 - Clinical Examples
 - Diaphragmatic Hernia
 - Meconium Aspiration
 - Sepsis
- Anatomic abnormalities
 - Atrial Septal Defect
 - Patent Ductus Arteriosus



Pathophysiology of Persistent Fetal Circulation

- Elevated pulmonary vascular resistance
- Increased right atrial pressures
- Right to left intra-cardiac shunting
 - Patent Foramen Ovale
- Persistent and further hypoxia
- Continued extra-cardiac shunting
 - Patent Ductus Arteriosus
- Progressive and continued pulmonary hypertension



Treatment Options for Persistent Fetal Circulation

- Mechanical Ventilation
- Correction of acid / base abnormalities
- Inotropic Support
- Antibiotic Regimen
- Extra Corporeal Membrane Oxygenator (ECMO) Therapy

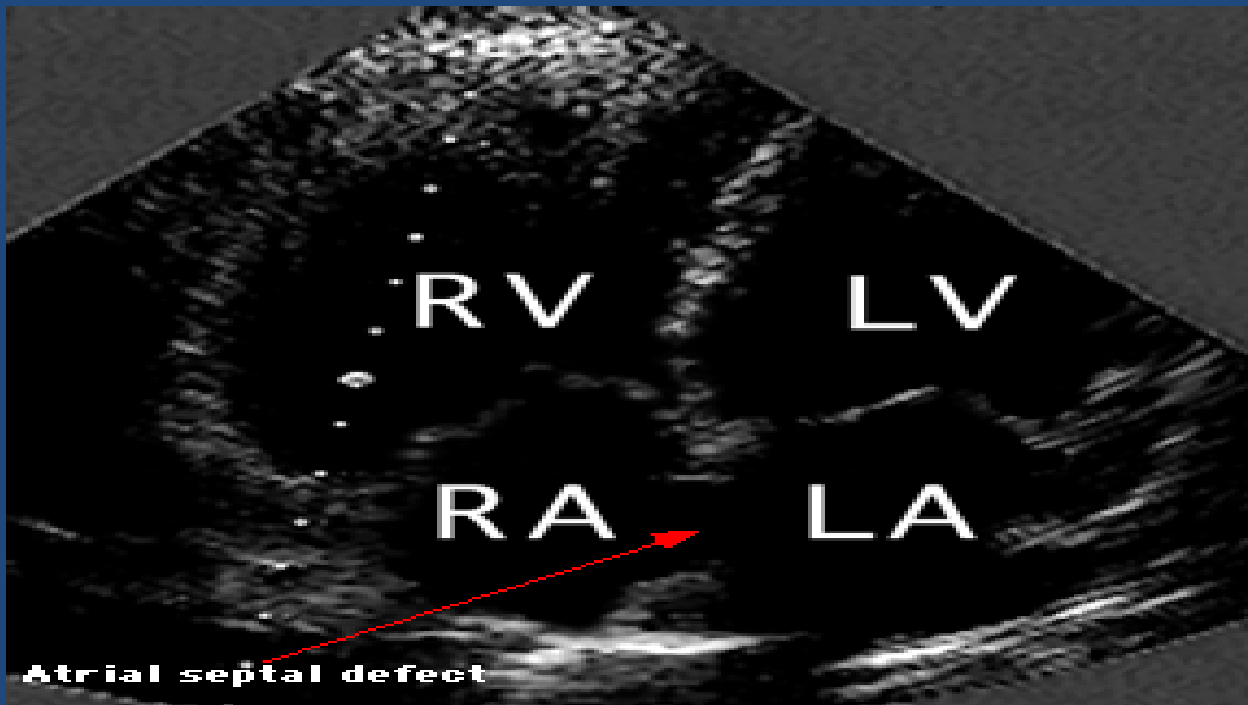


Anatomic Abnormalities of Transitional Circulation

- Atrial Septal Defect
 - Patent Foramen Ovale
 - Secundum Atrial Septal Defect
- Patent Ductus Arteriosus



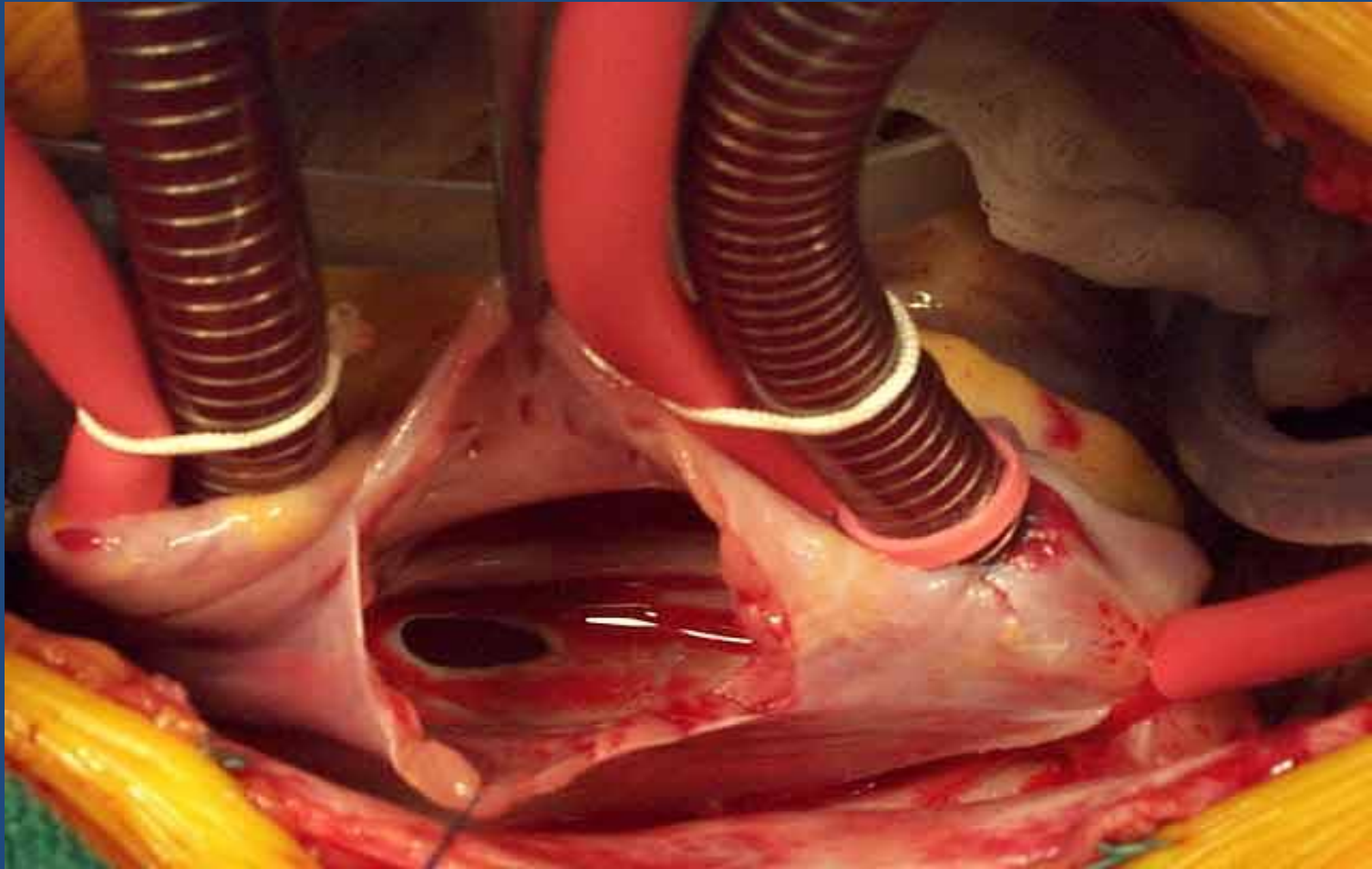
Atrial Septal Defect



Atrial septal defect Apical four chamber view from a 2-D echocardiogram shows a large secundum type atrial septal defect. RA = right atrium, RV = right ventricle, LA = left atrium, LV = left ventricle.



Atrial Septal Defect

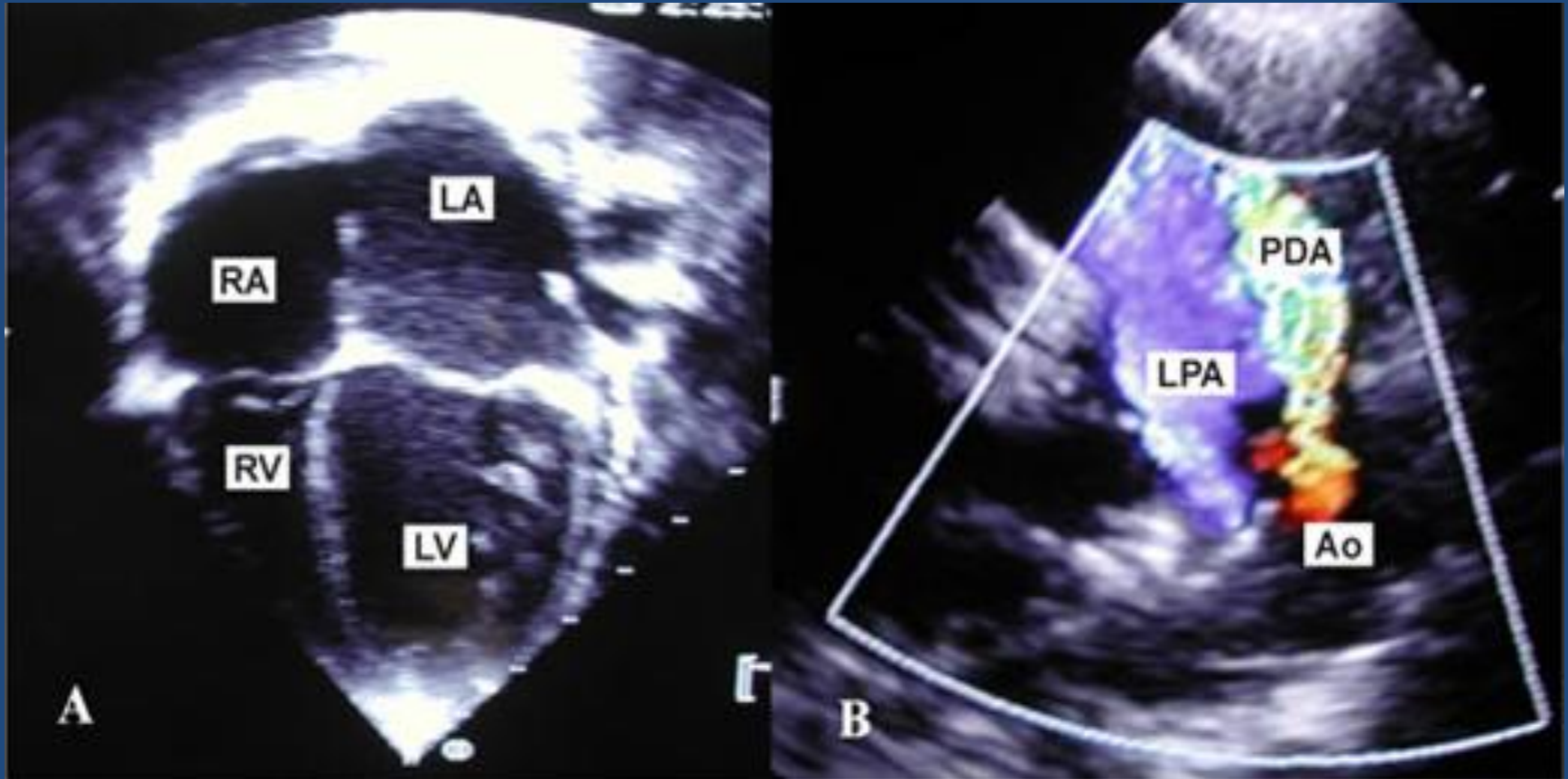


Patent Ductus Arteriosus

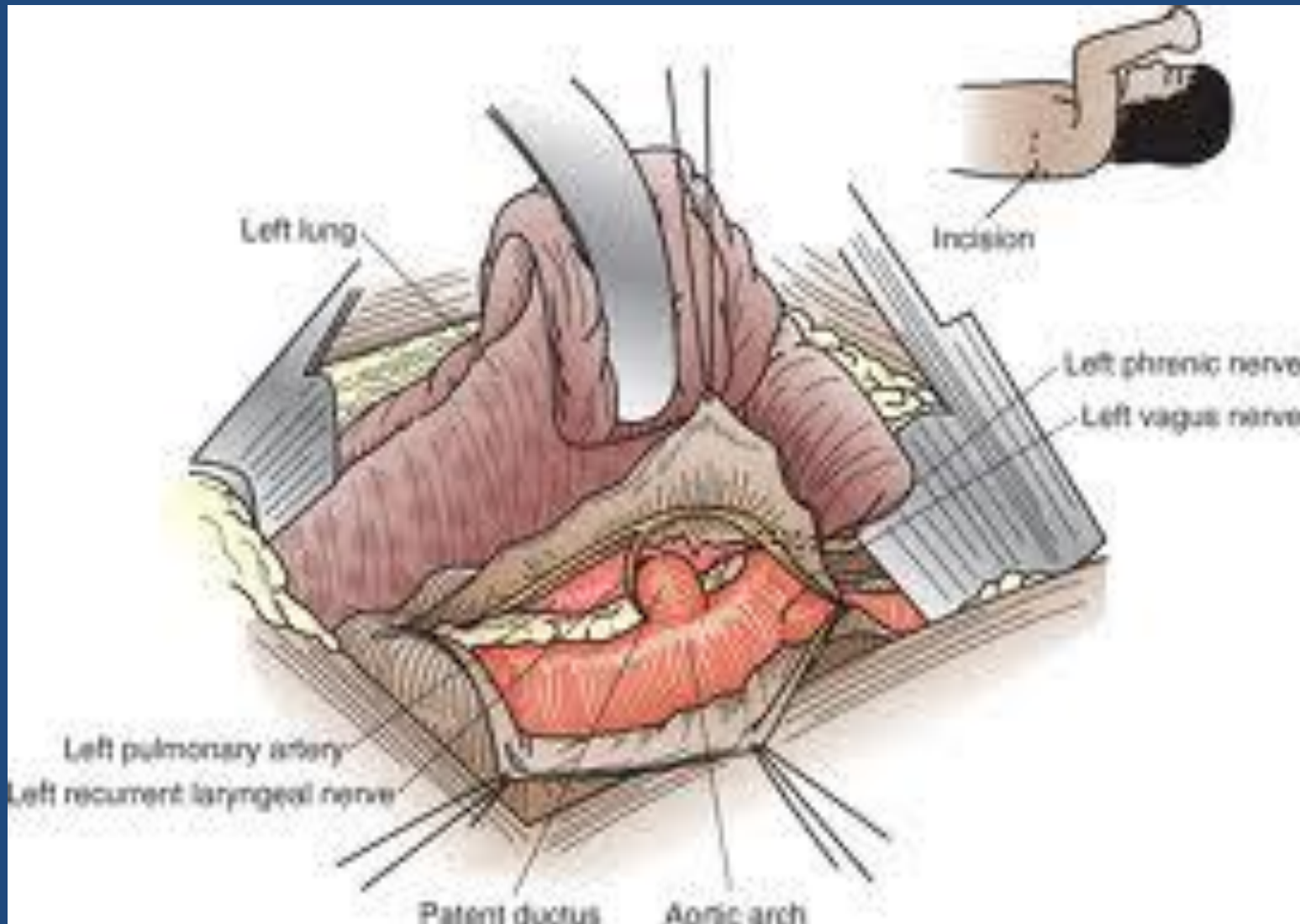
- More common in premature infants
- Left to right shunt
- Neonatal Population
 - Congestive heart failure
 - Pulmonary over circulation
 - Systemic hypo perfusion
- Adult Population
 - Eisenmenger's Syndrome



Patent Ductus Arteriosus



Patent Ductus Arteriosus



Neonatal Myocardial Physiology

- Cardiac Output
 - Increases up to 3X at birth
 - Decreased capacity to increase cardiac output
- Preload
- Afterload
- Heart Rate
 - Increased dependency upon heart rate to increase cardiac output



Neonatal Myocardial Physiology

- Autonomic Nervous System
 - Sympathetic Nervous System
 - Incomplete at birth
 - Parasympathetic Nervous System
 - Complete at birth
 - Response to inotropes is decreased
 - Heart rate – stress response is bradycardia



Neonatal Myocardial Physiology

- Impact of developmental changes on the immature heart and overall cardiac output:
 - Decreased force of contraction
 - Decreased velocity of fibrous shortening
 - Decreased response to exogenous catecholamines
 - Increased dependency upon increases in heart rate to enhance cardiac output



Importance of Pulmonary Vascular Resistance (PVR)

- Pulmonary circulation undergoes important physiologic and anatomic changes at birth:
 - In utero – pulmonary arteries are thick walled
 - PVR is high
 - At birth changes occur:
 - Mechanical expansion of lungs
 - Increased oxygen tension / shear stress
 - Increased synthesis of prostacyclin and nitric oxide
 - Release of bradykinin and adenosine
 - Acute decrease in PVR



Importance of Pulmonary Vascular Resistance (PVR)

- Impact of intra cardiac defects
 - L -> R shunting
 - Increase in pulmonary blood flow
 - Production of pulmonary vascular disease
- PVR has a role in determining systemic oxygen delivery
 - Delivery is the product of CO and systemic arterial oxygen content
 - Systemic arterial content impacted by pulmonary venous return
 - Congenital cardiac malformations affect PVR which in turn regulates pulmonary blood flow and as such pulmonary venous return



Summary

- Fetal Circulation
- Transitional Circulation
- Neonatal Myocardial Physiology
- Importance of Pulmonary Vascular Resistance

