Congenital Heart Disease

Introduction:

Are abnormalities in the **heart** or **blood vessels** that are present at **birth** *which mostly arise from faulty embryogenesis during gestational* ***week's 3 to 8.***

It ranges from **severe** (*fatal in perinatal period*) to **mild lesions** with minimal symptoms *even in adult life*.

Incidence approximately **1% of live births** and is **higher** in **premature infants and stillborns** and it's **the most common** heart disease in children.

Survival rates have **increased** although surgery can correct the hemodynamic abnormalities the heart **may not be completely normal (hypertrophy and cardiac remodeling may be irreversible)**
such changes elicit
a) Late onset arrhythmia.
b) Ischemia.
c) Myocardial dysfunction.

Pathogenesis:

Cause is unknown in almost 90% of cases but 2 factors maybe involved:

a) Environmental factors such as congenital rubella infection.
b) Genetic factors evidenced by familial congenital heart diseases **associated with chromosomal abnormalities** (trisomies 13, 15, 18 and 21 and Turner syndrome).

Cardiac morphogenesis *(involves multiple genes and is tightly regulated)* have these key steps:

1) Specifying cardiac cell fate.
2) Morphogenesis and looping of the heart tube.
3) Segmentation and growth of the chambers.
4) Valve formation.
5) Connection of big vessels with the heart.

Transcription Mutations:

Several congenital heart diseases are associated with **transcription mutations** such as mutations on transcription factors **TBX5** and **NKX2.5**

TBX5 mutation cause **atrial and ventricular septal defects** as seen in **Holt-Oram syndrome**.

NKX2.5 mutation associated with **isolated atrial septal defects [ASDs]**)

Outflow tract defects

Which has a unifying feature of **abnormal development of neural crest derived cells** whose migration into embryonic heart is required for outflow tract formation.

Genes located on **chromosome 22** have a **major role** in forming
a) The conotruncus
b) Branchial arches
c) And **the human face.**

And **deletions** of **chromosome 22q11.2** underlie **15%** to **50%** outflow tract abnormalities and these deletions can **cause anomalies** of **the fourth branchial arch** and **derivatives of the third and fourth pharyngeal pouches** which leads to
a) Thymic and parathyroid **hypoplasia.**
b) Di George syndrome.
c) And **hypocalcemia.**

Divisions:

There are **12** disorders accounting for **85%** of congenital heart disease and they are **subdivided into 3 major groups**:

A) Malformations causing *left to right* shunts.
B) Malformations causing *right to left* shunts. (Cyanotic Congenital Heart disease).
C) Malformations causing *obstruction*.

A **shunt** is an **abnormal communication between chambers or blood vessels** depending on **pressure** a shunt permit flow from one side to the other.

Right to left shunts:
a) Dusky blueness of the skin (cyanosis).
b) Caused by **pulmonary circulation bypass** (poorly oxygenated blood enter systemic circulation).

Left to right shunts:
a) Increase pulmonary blood flow.
b) Not associated with cyanosis.
c) Expose **low pressure low resistance pulmonary circulation to increased pressure and volume.**
d) Right ventricular hypertrophy.
e) Right sided heart failure.

Obstructive congenital heart disease:
a) Narrowing of **1) chambers 2) valves 3) major blood vessels.**
b) Atresia is when a complete obstruction occur.

Tetralogy of Fallot**:**
Is an **obstruction** (pulmonary stenosis) associated with a **shunt** (right to left through a VSD)

A) Left-to-Right Shunts

a) Are **abnormal communications** permitting blood to flow from **the left** to **the right** cardiac chambers.
b) Most common type
c) May be **asymptomatic** at birth or **may cause fulminant congestive heart failure**
d) Cyanosis is **NOT** an early feature but it may occur late
e) A shunt **produces pulmonary hypertension** to cause a **reversal of blood flow** phenomena called **tardive (late) cyanosis.**
f) Include **1) Atrial septal defect**
2) Ventricular septal defect
3) Patent ductus arteriosus

1) Atrial Septal Defect (ASD):

The **atrial septum** develops **between the 4th and 6th weeks** of embryonic life.

Phases of atrial septum development: (physiological)

1) Growth of **primary septum** (septum primum) from **dorsal wall of common atrial chamber** toward **endocardial cushions** which separates the atrial and ventricular cavities.
2) A gap **(ostium primum)** separates the septum from the cushions.
3) Continued **growth and fusion** of septum with cushions **obliterates ostium primum.**
4) A **second opening** appears in the **center** of the primary septum**.**
5) Flow of oxygenated blood from **right to left (**chambers**).**
6) Ostium secundum **enlarges, septum secundum** appear on th**e right** of primary secundum.
7) Septum secundum **proliferates** forming a **crescent shaped** structure **surrounding the foramen ovale.**
8) The foramen ovale is guarded on the **left side** by a flap of tissue derived from **the primary septum** which acts as a **one way valve** allows blood to flow from **right to left** during **intrauterine life.**
9) At birth pulmonary vascular resistance **falls** and systemic arterial pressure **increases.**
10) Pressure in the **left atrium (**higher than the right**) closes** the foramen ovale**.**

Usually the foramen ovale is **permanently sealed** by fusion of the **primary and secondary septa** although **25%** of the general population will have a **certain patency.** (Stays open).

Abnormalities in the events (phases) result in various **ASDs**
Three types of ASD are recognized:

1) Ostuim secundum ASD:

a) Most common 75%

b) When the septum secundum **does not enlarge** sufficiently to cover the ostium secundum.

2) Ostium primum ASD:

a) Less common **15%**

b) When septum primum and endocardial cushions **fail to fuse**

c) Often associated with abnormalities in other structures derived from the **endocardial cushions** such as the **mitral and tricuspid valves.**

3) Sinus venosus ASD:

a) Least common 10%

b) Pathogenesis unclear.

Clinical Features

ASDs are **most common** congenital cardiac malformations in **adults** (after birth) because many **VSDs** (more common at birth) **close spontaneously**.

Note: ASDs causes **lower pressures in the pulmonary circulation** and **right side of the heart.**

1) Ostium secundum defects:

a) Well tolerated especially if <**1 cm** in diameter

b) Larger lesions **don't produce any symptoms in childhood** because the flow of blood is from left to right

c) Pulmonary vascular resistance increases which leads to **pulmonary hypertension** which causes **reversal** of the left-to-right shunt manifested by **cyanosis and congestive heart failure**

2) Ostium primum defects:

a) Initially asymptomatic

b) Associated with **congestive heart failure** because of **high frequency of associated mitral insufficiency.**

2) Ventricular Septal Defect (VSD):

The **ventricular septum** develops **between the 4th and 8th weeks** of gestation.

Development: By **fusion** of **intraventricular muscular ridge** (grows upward from the apex of the heart) with **thinner membranous partition** (grows downward from the endocardial cushions).

Note: Basal (membranous) region **a) Last part to develop b) The site of 70% of the defects.**

VSDs are the **most common** congenital heart defects **at birth**, but its not so in adults (because many small VSDs close spontaneously in childhood).

Occurrence:

a) They may occur in **isolation** (around **30%** of cases).
b) or usually associated with other cardiac malformations.

Clinical Features:

Small VSDs may be **asymptomatic** and those in the **muscular portion** of the septum may **close spontaneously** during infancy or childhood

Larger defects cause a **severe left-to-right shunt** complicated by **pulmonary hypertension** and **congestive heart failure**

Features:
a) Progressive pulmonary hypertension.
b) Reversal of the shunt.
c) Cyanosis.
(All occurs **earlier and more frequently** in VSDs than ASDs)

d) Larger lesions requires **early surgical correction**
e) Small or medium-sized defects produces **jet lesions in the right ventricle (superimposed by infective endocarditis).**

3) Patent Ductus Arteriosus (PDA):

Is an **arterial channel** that courses between the **pulmonary artery** and **aorta**.

a) The ductus arteriosus permits blood to flow freely **from the pulmonary artery** to **the aorta** bypassing the unoxygenated lungs **(During intrauterine life).**

b) The ductus **constricts** in response to: **(Shortly after birth).**
1. **Increased** levels of arterial oxygen.
2. **Decreasing** pulmonary vascular resistance.
3. **Declining** levels of prostaglandin E2.

c) Functional closure is complete **within 1 to 2 days** after birth.

d) Complete, irreversible closure occurs within the **first few months** forming **ligamentum arteriosum.**

e) Its delayed in infants with **hypoxia** caused by **respiratory distress** or **heart disease.**

f) Isolated PDA **(10% of cases of congenital heart disease)**.

g) May also occur in combination with other anomalies particularly **VSDs.**

Clinical Features

PDA **Causes:**
a) A **high-pressure** left-to-right shunt.
b) Machinery murmur: (Audible as a harsh waxing and waning murmur).

A small PDA causes **no symptoms,** In larger defects symptoms develop **in childhood or adulthood.**

Just like left-to-right shunts there is
a) Pulmonary hypertension.
b) Cyanosis.
c) and Congestive heart failure.

The high-pressure shunt also **predisposes to infective endocarditis.**

Early surgical correction of large PDAs may be **lifesaving.**

B) Right-to-Left Shunts (Cyanotic Congenital Heart Disease)

a) Cardiac malformations associated with **right-to-left shunts**.
b) Cyanosis at or near birth.
c) Because **poorly oxygenated blood** (from the right side of the heart) is introduced directly into the arterial circulation.
d) Types:
   1) Tetralogy of Fallot.
   2) Transposition of the great vessels.

1) Tetralogy of Fallot:

6% of all congenital cardiac malformations.

Tetralogy of Fallot is the **most common** cause of cyanotic congenital heart disease

It has **four** components
1) VSD.
2) A "dextraposed" aortic root that overrides the VSD.
3) Right ventricular outflow obstruction.
4) Right ventricular hypertrophy.

Abnormal division of the **truncus arteriosus** into a **pulmonary trunk** and **aortic root** suggested as the **primary event** although complete pathogenesis is **unclear.**

Clinical Features

Hemodynamic consequences are:
1) Right-to-left shunt.
2) Decreased blood flow to the lungs.
3) Increased blood flow through the aorta.

The extent of shunting is determined by the **degree of right ventricular outflow obstruction.**

If the pulmonic obstruction is **mild** the condition **resembles an isolated VSD** because the **higher pressure on the left side causes a left-to-right shunt with no cyanosis.**

Stenosis causes cyanosis **early** in life.
Most patients are cyanotic from birth or soon after.

As patients grow the **pulmonic orifice** does **not** enlarge despite increase in the size of the heart.

Stenosis becomes **worse** in time and associated with **increasing cyanosis.**

The lungs are **protected** from excessive **hemodynamic load** by the **pulmonic stenosis**, pulmonary hypertension **does not develop.**

Patients with tetralogy of Fallot:

Have increased risk for:	**Develop complications of chronic cyanosis:**
a) Infective endocarditis	**a) Erythrocytosis with attendant hyperviscosity**
b) Systemic emboli	**b) Digital clubbing**
c) Brain abscesses	

Surgical correction is available.

2) Transposition of the Great Arteries:

The **second** leading cause of cyanotic congenital heart disease

Abnormal truncal septation cause:
a) Aorta to rise from right ventricle.
b) Pulmonary artery to rise from left ventricle.

In its complete form:
1) The pulmonary and systemic circulations are **entirely separate.**
2) And there is **no shunting** of blood.

Condition is **incompatible** with extrauterine life

Survivers have **some type of shunt (ASD, VSD, or PDA)** that allows oxygenated blood to reach the **aorta.**

Clinical Features

Cyanosis is the predominant manifestation.

Prognosis depends on the degree of:
1) Intracardiac or extracardiac shunting.
2) Degree of arterial oxygen saturation.

Infusions of **prostaglandin E2** to restore patency of the **ductus arteriosus.**

Atrial balloon septostomy are used to **create shunts** to enhance **arterial oxygen saturation** and allow the patient to survive until **surgical correction.**

C) Congenital Obstructive Lesions

Malformations that cause **obstruction** of **blood flow.**

They are either:
a) Isolated lesions (eg. Congenital valvular aortic stenosis)
b) One component of a more **complex** malformation (eg. Pulmonic stenosis associated with Tetralogy of Fallot).

Coarctation of the Aorta

Abnormal **narrowing** of **the aortic lumen.**

Other features
a) Isolated lesion in **50%** of cases
b) Remaining cases **associated** with other malformations (PDA, VSD, and ASD).
c) More common in males (particularly when isolated lesion).
d) Associated with **saccular aneurysms** of the central nervous system.
e) Increased frequency with Turner syndrome.

Two major categories:
1) Preductal coarctation.
2) Postductal coarctation (more common).

Clinical Features

1) Preductal coarctation:
[Usually in infancy (It was called Infantile coarctation)]

a) Congestive heart failure.
b) Selective cyanosis of the **lower extremities** (Caused by perfusion of the lower part of the body by poorly oxygenated blood delivered **via the ductus arteriosus**).
c) Femoral pulses **weaker** than in upper extremities.
d) Narrowing of **more proximal segments** of the **aortic root,** cause diminished pulses in the **upper extremities** as well.

These patients do **not** survive the neonatal period **without** surgical correction.

2) Postductal coarctation

[Present as **symptoms** in older children and adults because the blood reaching the **distal aorta** comes from **collateral branches** connected to the **proximal aorta]**

a) Oxygen content is normal. **b) No** cyanosis.
c) Hypertension of the **upper extremities** due to:
  1) Decreased perfusion of the **kidneys.**
  2) Activation of the **renin-angiotensin system.**
d) Blood pressure is **low** and pulses are **weak** in the **lower extremities.**
e) Arterial insufficiency in the legs **(Intermittent claudication).**

Morphology

We will be speaking about:
1) ASDs 2) VSDs 3) PDAs 4) Tetralogy of Fallot
5) Transposition of the Great Arteries 6) Coarctation of the Aorta

1) ASDs:

1) The Ostium secundum ASD:

a) Smooth-walled defect in the vicinity of the **foramen ovale.**
b) Isolated lesion **or** associated with other cardiac abnormalities.
c) Right atrial and ventricular dilation.
d) Right ventricular hypertrophy.
e) Dilation of the pulmonary artery.
f) (in some cases) **pulmonary hypertension.**

2) Ostium primum ASDs:

a) Lowermost of the atrial septum.
b) Extend to **the mitral and tricuspid valves.**
c) Abnormality of the **atrioventricular valves** in the form of:
1) A cleft in the anterior leaflet of the mitral valve.
2) Septal leaflet of the tricuspid valve.
d) Severe ostium primum defect is accompanied by **VSD** and **severe mitral and tricuspid valve deformities.**
e) Atrioventricular canal.
f) Sinus venosus ASDs located **high in the atrial septum.**
g) Anomalous drainage of **pulmonary veins into right atrium or superior vena cava.**

2) VSDs:

a) Size and location variable (From **minute** in the **muscular or membranous portions** of the septum **to large defects involving the entire septum**).

b) In defects associated with a significant **left-to-right shunt:**
1) Right ventricle hypertrophy and dilation.
2) Diameter of pulmonary artery increases due to increased volume ejected by the right ventricle.
c) Vascular changes of pulmonary hypertension **common.**

3) PDAs:

a) PDA rises from **left pulmonary artery** and **joins the aorta** distal to the origin of **left subclavian artery.**

b) Lumen is **uniform** and **lined by smooth endothelium.**
c) Oxygenated blood flows **out from left ventricle** (Some is **shunted back** to the lungs through the **patent ductus** eventually returning to **left atrium**).

d) Volume overload causes left atrium and ventricle dilation and hypertrophy.
c) Proximal pulmonary arteries dilated.
d) Pulmonary hypertension.
e) Atherosclerosis of main **pulmonary arteries.**
f) Proliferative changes in more **distal pulmonary vessels.**
g) Right ventricular hypertrophy and dilation.
h) Right atrial dilation.

4) Tetralogy of Fallot:

a) Heart is **enlarged** externally and **boot** shaped.
b) Right ventricular hypertrophy.
c) Proximal aorta **larger** than normal.
d) Pulmonary trunk **reduced** in diameter.
e) Left cardiac chambers are of normal size.
f) Thickness of the **right** ventricular wall may **equal or even exceed** that of the **left**.

(I know its long but what can we do)

g) The VSD lies in the vicinity of the **membranous portion** of **the interventricular septum** and may efface all or part of the septum.
h) The aortic valve lies **over** the VSD.
i) The pulmonary outflow tract is **narrowed**.
j) The pulmonic valve may be **stenotic**.
k) Additional abnormalities include **PDA** or **ASD** (Protective because they allow some blood **flow to the lungs**).

5) Transposition of the Great Arteries:

Abnormal origin of the pulmonary trunk and aortic root cause the lesions.

Right ventricular hypertrophy because of **increased (systemic) pressure** load placed on that chamber.

Varying combinations of **ASD, VSD, and PDA** are seen in survivors.

6) Coarctation of the Aorta:

1) Preductal coarctation:

a) Narrowing of aortic isthmus (the segment of aorta that lies between the left subclavian artery and the point of entry of the ductus arteriosus).
b) In some cases narrowing takes the form of a **ridge** in other cases the **entire aortic arch is hypoplastic.**
c) Ductus arteriosus is usually **patent** and is the **main source** of blood delivered to the **distal aorta.**
d) The right cardiac chambers are **hypertrophic and dilated**
e) The pulmonary trunk is **dilated** to accommodate **the increased blood flow.**

2) Postductal coarctation:

a) The aorta is **constricted** by a sharply defined ridge of tissue **at, or just distal to,** the **obliterated ductus arteriosus (the ligamentum arteriosum).**
b) The constricted segment is made up of **smooth muscle** and **elastic fibers** that are: **1) Continuous with the aortic media.**
2) Lined by a thickened layer of intima..
c) The ductus arteriosus is closed.
d) Proximal to the coarctation, the **aortic arch** and its **branch vessels** are **dilated** and in older patients, often **atherosclerotic.**
e) The left ventricle is **hypertrophic.**

f) Collateral flow that supply **distal aorta:**
1) Intercostal, 2) Phrenic and 3) Epigastric arteries. (Almost always dilated).

(Finally the end of this part of the chapter, god help us)