Clinical Anatomy of Kidney, U.B, uterine tubes, vas deference

2004 - microscopic Anatomy of Nephrons

2013 - Gross + Relation of Kidney

Arterial Supply

Vascular Segments

Development
Embryo = Placenta + Placental barriers

Development of heart, gut, kidney, uterus, ovary, testis & their appendages.

1994 - Main events in heart development & congenital anomalies

1996 - Right atrium of heart

1998 - Descend of Testes

1999 - Placenta

1999 - Development of Rt + left atria + congenital anomalies of heart

2000 - Development of uterus + congenital anomalies

2002 - Face development + anomalies

2003 - Development of kidney + anomalies
Notes of Dr. Ravindra Goswami (IAS-2015, AIR-153)

Development of Heart:

- From Splanchnopleureic mesoderm of Cephalogenic area.
- Endothelial Heart tubes → Development of atria.

Key:
- Right Common Cava (Rt. Cava) → Sinus venosus
- Left Hone of Sinus venosus
- Pulmonary Sinus venosus → Primitive Atrium
- Primitive aortic arch

Schema, 23:

- Left Atrium
- primitive Atrium
- Right Atrium

Both ventricles:

- Bulbus cordis → Primitive ventricle
- Intervent
Development of Cet. Ateium

- Bulbus cordis
- Verteicle
- Atrium
- sinus venosus

1. Sinus atrialis
   - Septum atrium
   - Septum spuriae

2. AV node
   - Fused AV cushion
   - Septum secundum
   - Right valve
   - Ostium terminalis

- Right vitelline vein
- Left horn of sv
- RCCM
- LCCM
- SVC
- Coron sinus
- Left renous valve
- Cavity sep
Chapter 15
Cardiovascular System

HIGHLIGHTS

- The heart develops from splanchnopleuric mesoderm related to that part of the intra-embryonic coelom that forms the pericardial cavity. This mesoderm is the cardiogenic area.
- Two endothelial heart tubes (right and left) appear and fuse to form one tube. This tube has a venous end, and an arterial end (Fig. 15.1, 15.2).
- A series of dilatations appear on this tube (Fig. 15.3). These are (1) bulbus cordis, (2) ventricle, (3) atrium, and (4) sinus venosus.
- Further subdivisions are named as follows (Fig. 15.3). The bulbus cordis consists of a proximal one-third (which is dilated), a middle one-third called the conus, and a distal one-third called the truncus arteriosus. The narrow part connecting atrium and ventricle is the atrioventricular canal. The sinus venosus has right and left horns.
- The right and left atria of the heart are formed by partition of the primitive atrium. This partition is formed by the septum primum and the septum secundum (Fig. 15.6). A valvular passage, the foramen ovale, is present between these two septa. It allows flow of blood from right atrium to left atrium.
- The dilated proximal one-third of the bulbus cordis, the conus, and the primitive ventricle unite to form one chamber. This is partitioned to form right and left ventricles. This partition is made up of the following. (1) Interventricular septum that grows upwards from the floor of the primitive ventricle. (2) a bulbar septum that divides the conus into two parts. (3) The gap left between these two is filled by proliferation of atrioventricular cushions that are formed in the atrioventricular canal (Fig. 15.11).
- The truncus arteriosus is continuous with the aortic sac (Fig. 15.27). This sac has right and left horns. Each horn is continuous with six pharyngeal (or aortic) arch arteries. These arteries join the dorsal aorta (right or left). The first, second and fifth arch arteries disappear. The caudal parts of the right and left dorsal aortae fuse to form one median vessel (Fig. 15.28).
- The ascending aorta and pulmonary trunk are formed from the truncus arteriosus (Fig. 15.28B).
- The arch of the aorta is formed by the aortic sac, its left horn, and the left fourth arch artery (Fig. 15.29A).
- The descending aorta is formed partly from the left dorsal aorta, and partly from the fused median vessel (Fig. 15.29B).
- The brachiocephalic artery is formed from the right horn of the aortic sac (Fig. 15.29C)
- The common carotid artery is derived from part of the third arch artery (Fig. 15.30B).
- The pulmonary artery is derived from the sixth arch artery (Fig. 15.31B).
- The arteries to the gut are formed from ventral splanchnic branches of the dorsal aorta (Fig. 15.36).
The **renal, suprarenal** and **gonadal arteries** are formed from lateral splanchnic branches of the dorsal aorta.

Arteries to the body wall and limbs are derived from dorsolateral (somatic intersegmental) branches of the aorta.

The **left subclavian artery** is derived from part of the seventh cervical intersegmental artery. On the right side this artery is formed partly from the seventh cervical intersegmental artery, and partly from the right fourth arch artery.

The **portal vein** is formed from right and left vitelline veins and anastomoses between them (Fig. 15.42).

The **superior vena cava** is derived from part of the right anterior cardinal vein, and from the right common cardinal vein.

The **inferior vena cava** receives contributions from several veins (and anastomoses between them). These are the right posterior cardinal vein, the right subcardinal vein, the right supracardinal vein, and the right hepato-cardiac channel.
PART 1: THE HEART

DEVELOPMENT OF THE HEART: MAIN FACTS

The development of the heart is complex. To avoid confusion that may be caused by numerous details, the main facts are presented first. Details are presented later.

Introduction

The heart (like all blood vessels) is mesodermal in origin. It is formed from splanchnopleuric mesoderm lying immediately cranial to the prochordal plate. This mesoderm constitutes the cardiogenic area. It is closely related to the pericardial cavity (which is derived from part of the intraembryonic coelom). For a good understanding of the relationship between developing heart tube and the pericardial cavity students are advised to study Figs. 5.11 to 5.14.

The heart is at first seen in the form of right and left endothelial heart tubes (Fig. 15.1A) that soon fuse with each other. The single tube thus formed shows a series of dilatations. These are:

- Bulbus cordis.
- Ventricle. (We will refer to it as the primitive ventricle).
- Atrium. (We will refer to it as the primitive atrium or atrial chamber).
- Sinus venosus.

![Diagram of heart development](image)

Fig. 15.1: (A) Right and left heart tubes. (B) to (D) progressive fusion of tubes from cranial to caudal end. Fusion of sinus venosus is partial.

The ventricle and atrium are connected by a narrow atrioventricular canal. The sinus venosus has prolongations that are referred to as its right and left horns.

The bulbus cordis lies at the arterial end of the heart. It is divisible into three parts i.e., proximal, middle and distal. The proximal one-third is dilated and does not have any special name; the middle one-third is called the conus, and the distal one-third is called the truncus arteriosus (Fig. 15.2A and 15.3). The truncus arteriosus is continuous distally with the aortic sac. The aortic sac is continuous with right and left pharyngeal arch arteries. These arteries arch backwards to become continuous with the right and left dorsal aortae.
The sinus venosus lies at the venous end of the heart. It has right and left horns. One vitelline vein (from the yolk sac), one umbilical vein (from the placenta) and one common cardinal vein (from the body wall) join each horn of the sinus venosus.

The fate of the various parts of the heart tube is summarised in Fig. 15.3.
Chapter 15 – Cardiovascular System

- After disappearance of the dorsal mesocardium, the visceral and parietal layers of pericardium are in continuity only at the arterial and venous ends of the heart tube (Figs. 15.19A, B, D, E).

- With the folding of the heart tube, the arterial and venous ends come closer to each other. The space between them becomes the **transverse sinus of pericardium** (Figs. 15.19C, F).

- A number of blood vessels are formed at the two ends of the heart tube. At the arterial end, these are the aorta and the pulmonary trunk. At the venous end, they are the superior vena cava, inferior vena cava, and four pulmonary veins (Fig. 15.20A).

- The definitive reflections of the pericardium are formed merely by rearrangement of these vessels as shown in Fig. 15.20B. Rearrangement of the veins at the venous end results in the formation of an isolated pouch of pericardium, in relation to the four pulmonary veins. This is the **oblique sinus of pericardium**.

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**Fig. 15.19:** Schemes showing the relationship of the heart tube to the pericardial sac. (A), (B) and (C) are lateral views while (D), (E) and (F) show the dorsal aspect of the interior of the pericardial sac at corresponding stages. Disappearance of the mesocardium leads to formation of the transverse sinus of pericardium. Note that with the folding of the heart tube, the arterial and venous ends of the heart tube are brought closer together, and the transverse sinus comes to lie between them.
Fig. 15.20: Scheme to show that the oblique sinus of pericardium is established by rearrangement of veins entering the heart. The sinus is indicated by the lower arrow in (B). The upper arrow indicates the transverse sinus.

Clinical Correlation

Congenital Anomalies of the Heart

Anomalies of Position

- **Dextrocardia**: The chambers and blood vessels of the heart are reversed from side to side, i.e., all structures that normally lie on the right side are on the left, and vice versa (Fig. 15.21). This may be a part of the condition called **situs inversus**, in which all organs are transposed. When dextrocardia is not a part of situs inversus, it is usually accompanied by anomalies of the chambers of the heart and of the great vessels.

- **Ectopia cordis**: The heart lies exposed, on the front of the chest, and can be seen from the outside, due to defective development of the chest wall.

Fig. 15.21: Dextrocardia. The chambers and large blood vessels show right-left reversal.

Fig. 15.22: Patent truncus arteriosus. The ascending aorta and pulmonary trunk are represented by a single channel that opens into both ventricles.
Fig. 15.11: Two stages in the formation of the ventricular septum. (B) and (D) correspond to (A) and (C) respectively. (A) Bulbar septum grows down from above, and interventricular septum grows upwards from below. (C) and (D) The gap between the bulbar septum and the interventricular septum is filled in by proliferation from A.V. cushions. For explanation of orientation of these figures see legend to Fig. 15.10.
FURTHER DETAILS ABOUT THE DEVELOPMENT OF THE HEART

Introduction

The internal surfaces of the heart and of all blood vessels are lined by a layer of flattened cells called **endothelium**. The endothelium is supported, on the outside, by varying amount of muscle, and connective tissue. All components of the heart and blood vessels, i.e. endothelium, muscle and connective tissue are of mesodermal origin. Very early in the life of the embryo, mesenchyme differentiates, over the yolk sac, in the connecting stalk, and in the body of the embryo itself, to form small masses of **angioblastic tissue**. This angioblastic tissue gives rise to endothelium and also to **blood cells**. The first blood vessels are derived from this endothelium. The vessels rapidly proliferate in number and become interconnected to form a vascular system. Soon thereafter, a primitive heart begins to pump blood through this network of vessels with the result that nutrition from the placenta and yolk sac can be made available to the growing embryo. The heart is, therefore, the first organ of the body to start functioning.

We have seen that the pericardial cavity is formed from the cranial, midline, part of the intra-embryonic coelom (Figs. 5.6, 5.11). With the formation of the coelom, the intra-embryonic mesoderm of the region splits into a somatopleuric layer adjoining the ectoderm (in roof of pericardial cavity), and a splanchnopleuric layer adjoining the endoderm (Fig. 5.6) and forming the floor of the pericardial cavity. The heart develops from angioblastic tissue that arises from this splanchnopleuric mesoderm, which is, therefore, called the **cardiogenic area**. With the establishment of the head fold, the splanchnopleuric mesoderm and the developing heart come to lie dorsal to the pericardial cavity, and ventral to the foregut (Fig. 5.13).

We have seen that the endothelial heart tube is derived from the splanchnopleuric mesoderm related to the pericardial cavity (Fig. 15.12A). After formation of the head fold, this tube lies dorsal to the pericardial cavity and ventral to the foregut (Fig. 15.12B). The tube now invaginates the pericardial sac from the dorsal side. As it does so, the splanchnopleuric mesoderm lining the dorsal side of the pericardial cavity proliferates to form a thick layer called the **myoepicardial mantle** (or **epimyocardial mantle**) (Figs. 15.12C, D). When the invagination is complete, the myoepicardial mantle completely surrounds the heart tube. It
Clinical Correlation... contd...

**Atresia or Stenosis**

Any of the orifices of the heart may have too narrow an opening (stenosis), or none at all (atresia). The aortic and pulmonary passages may also show supravalvular, or subvalvular, stenosis (Fig. 15.23). Alternatively, the openings may be too large as a result of which the valves become incompetent.

In pulmonary stenosis, the foramen ovale and the ductus arteriosus remain patent. In aortic stenosis also, the ductus arteriosus is patent and blood flows into the aorta through it.

**Abnormal Growth**

There may be accessory cusps in the valves. Congenital tumours may be formed. The left atrium may be partially subdivided by a transverse septum. The myocardium may be poorly developed (hypoplasia).

**Defective Formation of Septa**

This results in the formation of abnormal passages.

- **Interventricular septal defects** may be of three types:
  - The septum primum may fail to reach the atrio-ventricular endocardial cushions, as a result of which the foramen primum persists (Fig. 15.24A). This *ostium primum defect* can also be caused by defective formation of atrio-ventricular endocardial cushions.
  - The septum secundum may fail to develop as a result of which the foramen secundum remains wide open *(ostium secundum defect; Fig. 15.24B).*
  - The septum primum and secundum may develop normally but the oblique valvular passage between them may remain patent *(patent foramen ovale; Fig. 15.24C).* The patency is significant only if there is shunt of blood through it. In many cases a probe can be passed through the oblique slit *(probe patenty)* but there is no shunt.

  Occasionally, there is premature closure of the foramen ovale (i.e. before birth). As a result, the right atrium and ventricle undergo great hypertrophy, while the left side of the heart is underdeveloped.

- **Interventricular septal defects** may be seen either in the membranous or in the muscular part of the septum (Fig. 15.24D). They are the most common congenital anomalies of the heart.

- **Defects of the spiral septum:** The spiral septum may not be formed at all. This condition is called *patent truncus arteriosus* (Fig. 15.22). Partial absence of the septum leads to communications (shunts) between the aorta and the pulmonary trunk.

- **Atrio-ventricular canal defect** or **persistent atrio-ventricular canal:** Defective formation of the atrio-ventricular cushions may lead to a condition in which all four chambers of the heart may intercommunicate. The interatrial and interventricular septa are incomplete (as the normal contributions to these septa from the endocardial cushions are lacking).

  If fusion of endocardial cushions is too far to the right, it causes *tricuspid atresia.* As such cushions are not in alignment with the interventricular septum, the upper part of the latter is defective. With tricuspid atresia there is increased pressure in the right atrium, as a result of which the foramen ovale fails to close.

  Defective formation of septa, if marked, can lead to a two-chambered heart *(Cor bilocular)* in which there is one common ventricle and one common atrium. Alternatively, a three-chambered heart *(Cor triloculare)* may be seen; it may consist of a single ventricle with two atria or of a single atrium with two ventricles *(Cor triloculare biventriculare).*
Clinical Correlation contd...

**Combined Defects**
Two or more of the defects may coexist. One classically recognised condition of this type is known as *Fallot's tetralogy*. It consists of (Fig. 15.25).

- Interventricular septal defect;
- Aorta overriding the free upper edge of the ventricular septum;
- Pulmonary stenosis;
- Hypertrophy of the right ventricle.

**Other Defects**
- The pericardium may be partially or completely absent.
- May be congenital defects in the conducting system of the heart.

**Anomalies of Relationship of Chambers to Great Vessels**

1. **Transposition of great vessels:** The aorta arises from the right ventricle and the pulmonary trunk from the left ventricle.
2. **Taussig-Bing syndrome:** The aorta arises from the right ventricle; and the pulmonary trunk overrides both the right and left ventricles, there being an interventricular septal defect.
- The superior or inferior vena cava may end in the left atrium.
- The pulmonary veins may end in the right atrium or in one of its tributaries.
"PART 2: THE ARTERIES"

Pharyngeal Arch Arteries and Their Fate

The first arteries to appear in the embryo are the right and left primitive aortae. They are continuous with the two endocardial heart tubes. Each primitive aorta consists of a portion lying ventral to the foregut (ventral aorta), an arched portion lying in the first pharyngeal arch, and a dorsal portion lying dorsal to the gut (dorsal aorta) (Fig. 15.26A).

After the fusion of the two endocardial tubes, the two ventral aortae partially fuse to form the aortic sac, the unfused parts remaining as the right and left horns of the sac (Fig. 15.26B). Successive arterial arches now appear in the second to sixth pharyngeal arches, each being connected ventrally to the right or left horn of the aortic sac and dorsally to the dorsal aorta (Fig. 15.27). The major arteries of the head and neck, and of the thorax, are derived from these arches as follows:

- The greater part of the first and second arch arteries disappear (Fig. 15.28A).

In adult life, the first arch artery is represented by the maxillary artery. The second arch artery persists for some part of fetal life as the stapedial artery: it may contribute to the formation of the external carotid artery.

- The fifth arch artery also disappears (Fig. 15.28A).

- The aortic sac is, therefore, now connected only with the arteries of the third, fourth and sixth arches. The third and fourth arch arteries open into the ventral part, and the sixth arch artery into the dorsal part, of the aortic sac. The spiral septum, that is formed in the truncus arteriosus, extends into the aortic sac; and fuses with its posterior wall in such a way that blood from the pulmonary trunk passes only into the sixth arch artery, while that from the ascending aorta passes into the third and fourth arch arteries (Fig. 15.28B).
Several changes now take place in the arterial arches to produce the adult pattern as follows:

- The two dorsal aortae grow cranially, beyond the point of attachment of the first arch artery (Fig. 15.28B).
- The portion of the dorsal aorta, between the attachment of the third and fourth arch arteries (*ductus caroticus*), disappears on both sides (Fig. 15.28B).

**Fig. 15.27**: Aortic arches. Each arch connects the aortic sac to the dorsal aorta. Note that actually all arches are never present at the same time. The first and second arches have retrogressed by the time the sixth appears.
Development of Testis:
- Develops from coelomic epithelium that covers medial side of mesonephros.

- Migration of the germinal cells from neighborhood of yolk sac to developing gonad.

- Formation of genital ridge.

- Solid sex cords.

- Canalisation to form seminiferous tubules.

- Incorporation of germinal cells.

- Formation of tunica albuginea by mesenchymal cells.
Testes

1. Mesonephric duct and tubule
2. Thickened Coelomic epithelium forming genital ridge
3. Mesonephric duct becomes duct of epididymis
4. Mesonephric tubules become Vasa efferentia
5. Rete testis
6. Seminiferous tubules
7. Compartment of cords
8. Tunica albuginea
The cranial part of the mesonephric duct becomes highly coiled on itself to form the **epididymis** while its distal part becomes the **ductus deferens**. The **semenal vesicle** arises, on either side, as a diverticulum from the lower end of the mesonephric duct. The part of the mesonephric duct between its opening into the prostatic urethra, and the origin of this diverticulum, forms the **ejaculatory duct**.

**Descent of Testes**

The testes develop in relation to the **lumbar region of the posterior abdominal wall**. During fetal life, they gradually descend to the **scrotum**. They reach the iliac fossa during the third month, and lie at the site of the deep inguinal ring up to the seventh month of intrauterine life. They pass through the inguinal canal during the seventh month, and are normally in the **scrotum** by the end of the eighth month (Fig. 16.31).

The descent of the testes is caused or assisted by several factors. These are:

1. **Differential growth of the body wall.**
2. **Formation of inguinal bursa:** About the sixth month of intrauterine life, the various layers of the abdominal wall, of each side, show an outpouching towards the scrotum (Fig. 16.32). This pouch progressively increases in size, and depth, and...