B.Sc. (Hons.) Part-II

paper - IV

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7.1. Introduction

The heart of vertebrates is the central organ for propulsion of the blood. It lies in the pericardial sac, the walls of which constitute the pericardium. Vertebrate heart is in fact a specialized part of the primary longitudinal vessel which has receiving and propulsive chambers and valves so arranged as to permit the blood to flow in one direction only.

7.2. General Structure

The heart is a single structure situated ventrally in the anterior region of the trunk. Although much modified, histologically it is comparable to that of other blood vessels. It has a thin ventral lining, the **endocardium**; an outer covering of a thin mesodermal epithelium called **epicardium**; and the main bulk of the heart consisting of connective tissue and muscles called **myocardium**. In the more primitive vertebrates, the heart consists of four successive chambers. Termed from back to front, they are—

(i) Sinus Venosus—A thin-walled sac with little muscular tissue. It receives venous blood through the hepatic veins and the cardinal veins (or ductus cuvieri).

(ii) Atrium or Auricle—The next anterior thin-walled and distensible chamber.

(iii) Ventricle—Thick-walled chamber which constitutes the main contractile portion of the heart.

(iv) Conus Arteriosus—The anteriormost thick-walled and tube-like chamber which is provided with several sets of valves.

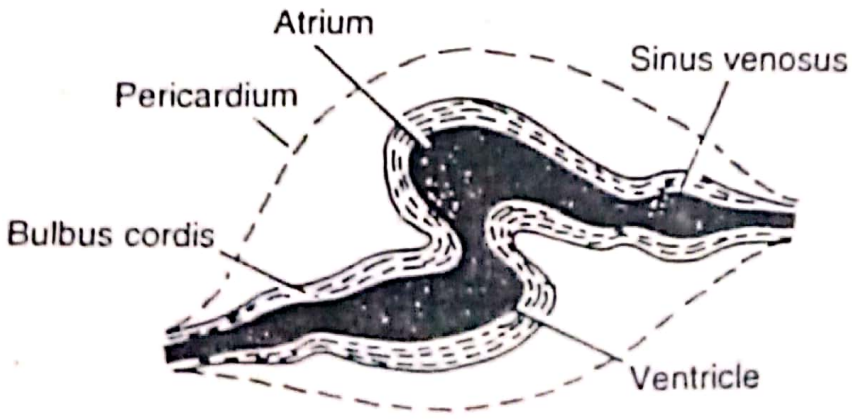

Fig. 7.1 Twisting of the straight tube

In advanced groups of vertebrates, the first chamber and the last chamber disappear and the atrium and ventricle tend to subdivide.

The heart always arises as a simple, straight and cylindrical cardiac tube of splanchnic mesoderm. But during development the anterior part of the cardiac tube becomes twisted in a characteristic S-shaped curve (Figure 7.1).

As a result of this twisting the more posterior heart chambers tend to be situated dorsal to the anterior ones, and the atrium may be anterior as well as dorsal in position with regard to the ventricles. This twisting of cardiac tube is more pronounced in higher vertebrates.

7.3. Heart in Different Groups of Vertebrates (Evolution of Heart)

Primitively the heart consists of four chambers (Figure 7.2): **sinus venosus, atrium, ventricle** and **conus arteriosus** (e.g., in typical fishes). The heart of higher vertebrates like birds and mammals also consists of four chambers. But here the four chambers do not correspond to the basic four as the sinus venosus and conus arteriosus loose their identity. The atrium and ventricle, in fact, become divided into two chambers each and thus four chambers are formed. The heart of vertebrates has undergone a great number of changes correlated with the change in breathing habit—from gill breathing to lung breathing—and changes associated in the course of blood circulation.

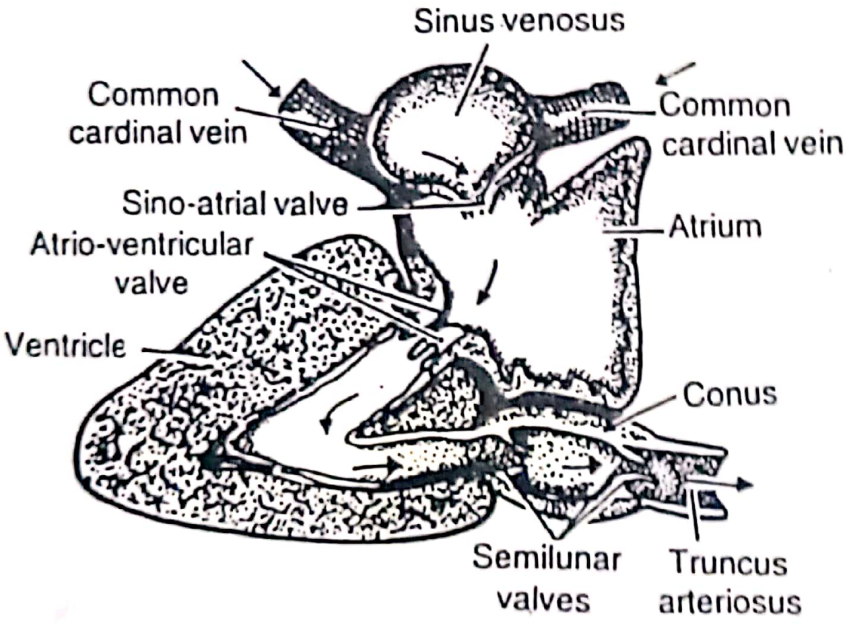

Fig. 7.2 A diagram of the primitive (fish) heart, as seen in a median longitudinal section. Anterior is to the right. The course of blood in the heart is indicated by arrows.

I. Heart in Anamniotes

7.4. In Cyclostomes

The heart of the cyclostomes (Figure 7.3) is essentially an S-shaped structure with four chambers namely a **sinus venosus, atrium, ventricle** and **truncus**

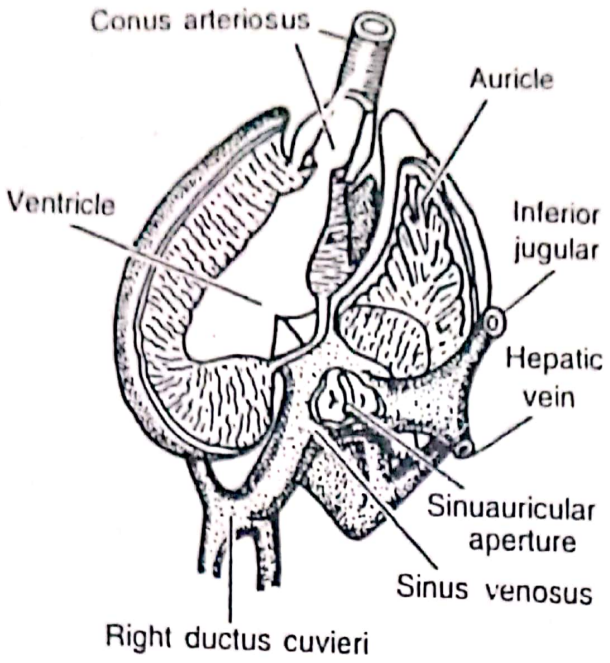

Fig. 7.3 Diagrammatic longitudinal section of the heart of *Petromyzon* (Lamprey)

arteriosus. There is no well-developed conus arteriosus and this is represented by a short region at the root of the truncus arteriosus. The passage from the ventricle to the conus is provided with a pair of valves. In lamprey (Figure 7.3) the blood enters the sinus dorsally through the right ductus Cuvieri (the left is lost during development) and ventrally from the hepatic and inferior jugular veins. The truncus arteriosus is elastic and has a single pair of valve at its root—the conus arteriosus.

The heart of myxine is similar to that of the lamprey. However, in this case the left ductus Cuvieri is retained instead of the right. The right ductus is modified into a portal heart pumping blood to the liver.

Owing to the strange fact that only one ductus Cuvieri is retained in adult cyclostomes, their heart in some respect is considered highly specialized (Goodrich, 1958). In the heart of cyclostomes the atrioventricular valves prevent a reverse flow of blood. The pericardial sac of cyclostome is thick-walled and in the case of lamprey it is supported by a cartilaginous skeleton.

7.5. In Fishes

(A) In Elasmobranchs

The heart of cartilaginous fishes in many features resembles that of cyclostomes (Figure 7.4). The heart is bilaterally symmetrical and is enclosed in a spacious pericardial cavity. There is a large sinus venosus and a still larger atrium dorsally; and a ventricle and conus arteriosus ventrally. The sinus venosus receives the hepatic veins and ductus Cuvieri. The sinus opens into the atrium through a sinu-atrial aperture which is guarded by a pair of sagittal valves. The atrium opens into the ventricle through the atrioventricular aperture. This aperture is also guarded by a pair of obliquely set valves. The conus arteriosus is well developed and contractile. It is usually provided with three main longitudinal rows (one dorsal and two ventrolateral) of valves.

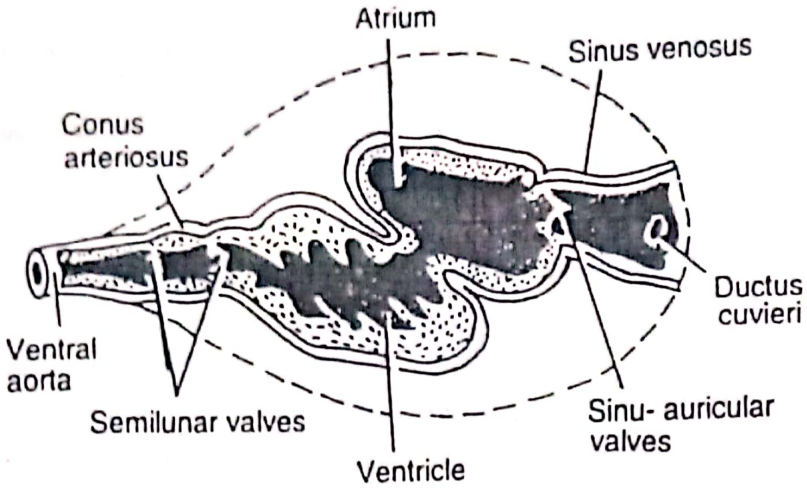

Fig. 7.4 Heart of an elasmobranch (dog-fish)

However, in sharks there are only two rows of well-developed valves. The conus usually leads into the ventral aorta which is not differentiated into truncus arteriosus.

(B) In Teleosts

The structure of the heart of the Teleostomi resembles closely to that of elasmobranchs except in the region of conus arteriosus (Figure 7.5). In teleostean heart, the conus tends to become reduced and is replaced in front by a non-contractile region called the **bulbus arteriosus** which has a fibrous wall. In a typical teleost, the conus has been practically abolished and is represented only by a most narrow muscular zone with a pair of valves.

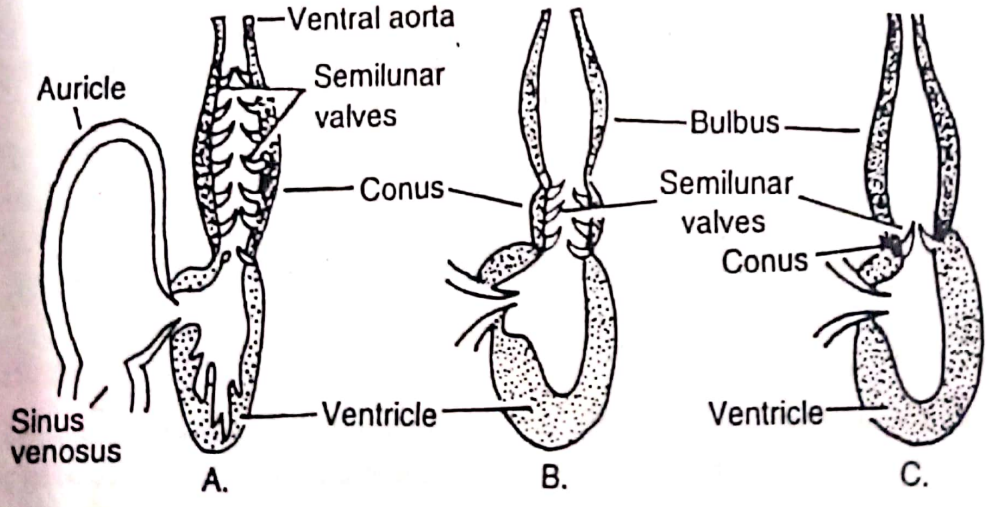

Fig. 7.5 Diagrammatic section of the heart of an elasmobranch (A) *Amia* (B) and a teleost (C)

However, in lower Teleostomi such as Chondrostei, Polypterini and Lepidosteoidei the conus arteriosus persists. In *Acipencera* well-developed conus with three rows of valves is present. Further, in certain forms like

Polypterus and *Lepidosteus* the conus has become elongated and contains many rows of valves. *Amia* possesses a large conus besides a large bulbus arteriosus (Figure 7.5B). Certain lower teleosts such as *Albula* (Boas, 1880), *Tarpon* and *Megalops* (Senior, 1907) represent an intermediate condition between elasmobranchs and teleosts. These have a distinct remnant of valvular conus arteriosus. Whether the teleostean bulbus arteriosus is a newly-developed structure or simply the converted part of conus is doubtful. According to Hoyer and Smith the conus gets telescoped into the ventricle.

(C) In Dipnoi

In lungfishes (Dipnoi), due to the emergence of 'lungs', we find some advances towards the mammalian circulation (Figure 7.6). In the heart of lungfishes the atrium becomes partly divided by incomplete longitudinal septa. This is why the deoxygenated blood from the sinus flows to the right of the inter-auricular septum while the aerated blood from the 'lungs' flows to the left. The sinu-atrial aperture is valvular while the opening of pulmonary vein is protected by a small fold. The atrio-ventricular opening is large and in this opening is a large cushion mass, the **atrioventricular cushion**. This cushion is a plug-like structure which may be fibrous or partly cartilaginous. Atrioventricular cushion arises from the posterior margin of the atrioventricular opening and continues into the ventricle as a partial **interventricular septum**. This is why the ventricle is also partly divided into the left and the right.

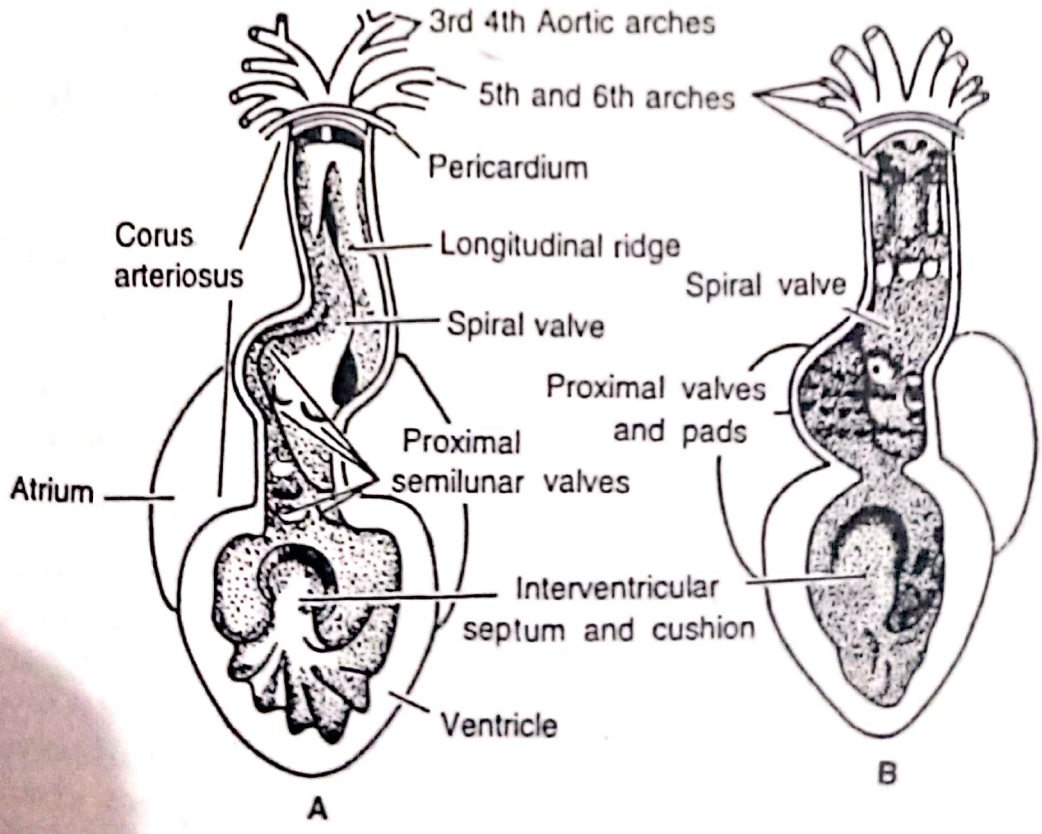

Fig. 7.6 Hearts of *Protopterus* and *Neoceratodus* as seen from below and with the truncus opened to show the valves