Junctional Tissues of Human Heart

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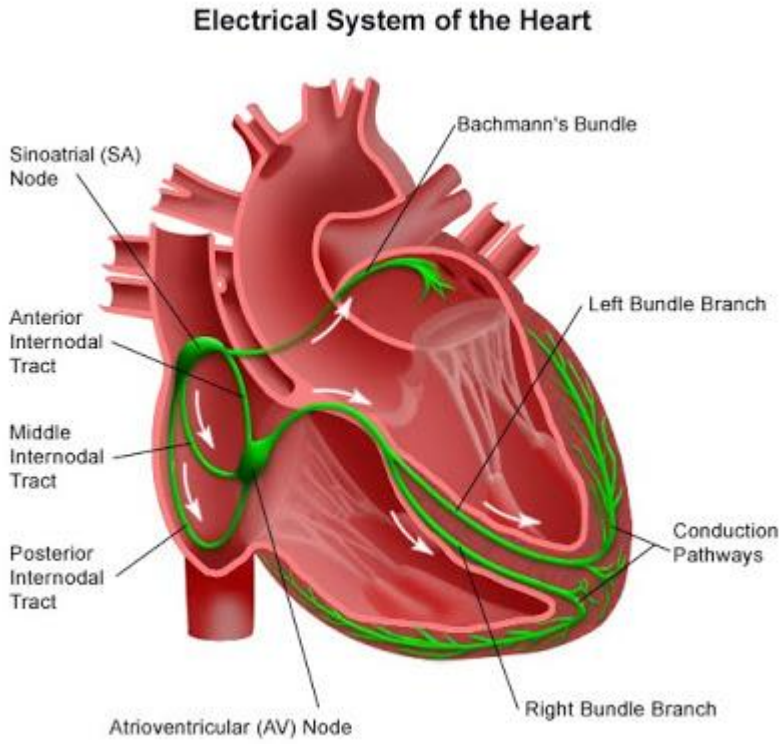
Cardiac muscle consists essentially of certain specialised structures which are responsible for initiation and transmission of cardiac impulses at a higher rate than the rest of the muscle. Those specialised cardiac tissues operate such mechanism are collectively known as the junctional tissues of heart.



<u>They comprise the following structures:</u>

(a) Sino-atrial (S.A.) node,

(b) Atrioventricular (A.V.) node,

(c) Internodal fibers,

(d) Bundle of His (atrioventricular bundle) and its right and left branches

(e) Purkinje fibres.

The sino-atrial and atrioventricular nodes and bundle of His are composed of specialised cardiac tissue and contain high amount of glycogen. These have got more sarcoplasm than the rest of the cardiac muscle fibres. Purkinje fibres also contain high amount of glycogen in their sarcoplasm.

The atrial muscle fibre is connected with the ventricular muscle fibre only through the bundle of His because a fibrous tissue ring keeps the atrial muscle separated from the ventricular muscle. Damage of bundle of His causes dissociation of atrial and ventricular rhythm.

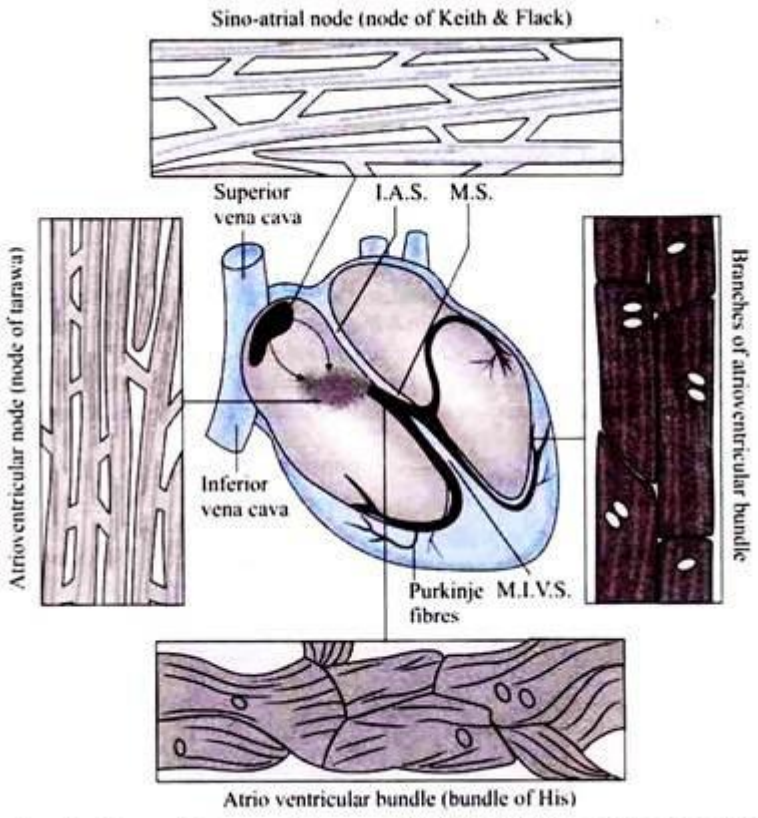


Fig. 7.23 Specialised cardiac tissues. (Diagrammatic representation) I.A.S.=inter-atrial septum, M.S.=membranous septum, M.I.V.S.=muscular interventricular septum.

(a) Sino-Atrial Node:

It is situated in the right atrium at the junction of superior vena cava and the right auricular appendage. It extends downwards along the sulcus terminalis for about 2 cm (three-fourths of an inch). It is broader at the top and tapering below, and measures about 5 × 20 mm.

Histology:

It is made up of modified cardiac muscle fibres. The fibres are thin (one-third the size of cardiac muscle fibres), elongated, tapering at the ends, longitudinally striated and intercrossing with one another in a plexiform manner.

This nodal tissue possesses relatively few myofibrils and also it is claimed to consist of a dense network of small Purkinje fibres. Some investigators believe that the transmission of cardiac impulse from the S.A. node to the A.V. node is mostly facilitated by the presence of Purkinje fibres in the atria. No pathways of special fibres have yet been satisfactorily demonstrated until recently in the walls of the atria.

From electrophysiological studies, **Carvalho and others (1959)** have suggested that the possibility of preferential channels for impulse conduction in both dog and rabbit atria. They have recorded the Purkinje-like action potential from single fibres within a band of tissues—the sinus ring bundle. This sinus ring bundle encircles the vena cava and one branch of the bundle goes to the sinus region very close to the A.V. node. Goldman (1970) has described that there are three internodal atrial pathways originating from the S.A. node go to the A.V. nodal region .

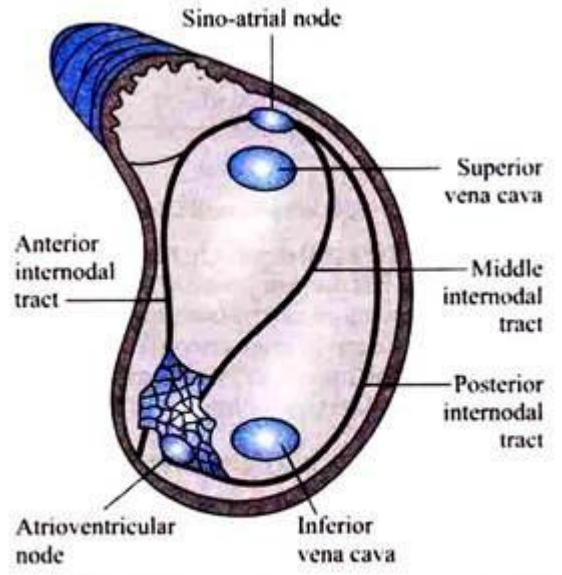


Fig. 7.24 Diagram shows the internodal pathways of impulse-conducting systems from S.A. node to A.V. node

These internodal tracts contain Purkinje type of fibres. The anterior internodal tract after coming out from the S.A. node curves round the superior vena cava and anterior wall of the right atrium. Here it bifurcates into two branches, one of which goes to the left atrium and other goes to the anterior superior region of the A.V. node.

The middle internodal tract and posterior internodal tract after coming out from the S.A. node curve behind the superior vena cava and end in the superior margin and posterior margin of the A.V. node respectively. In between three internodal tracts there are interconnecting fibres which merge just above the A.V. node and also by-pass this node. In between the muscle cells, many nerve cells are found which act as relay stations for the vagus only. Excitor sympathetic fibres are also found here.

Functions:

It generates the normal cardiac impulse at the rate of 70 to 80 per minute in the adult and acts as the pacemaker of heart and the rhythm originated from this region is generally designated as sinus rhythm.

Junctional tissue	Rate of impulse (Impulse/min.)
SA node	70 – 80
Internodal atrial pathway • Anterior (Bachman) • Middle (Wenckebach) • Posterior (Thorel)	60
A-V node	40 – 60
The bundle of His and its branches	30 – 36
Rt and Lt Branches of A-V bundle	30 – 36
Purkinje fiber	15 – 40

(b) Atrioventricular Node:

It is situated in the right atrium at the posterior part of the interatrial septum close to the opening of the coronary sinus. It measures about 2 × 5 mm. The presence of the atrioventricular node was first identified by Kent in 1892 and afterwards **His** in 1893 described a band of modified muscle fibres to course from the atrium to the ventricle. Tawara (1906) described in details the presence of this specialised tissue in many species of animals.

Histology:

The cells of the A.V. node are cardiac muscle fibres but have a few myofibrils. It also consists of Purkinje fibres which form a dense network. The node is extended into the common—the atrioventricular bundle (bunbdle of His).

Functions:

(a) It receives the impulse originating from the S.A. node and transmits it to the ventricles through the bundle of His.

(b) It acts as reserve pacemaker. The rhythm that is originated in the A.V. node is known as nodal rhythm.

(c) It also initiates the cardiac impulse, but at a slower rate (40 to 60 per minute). In abnormal conditions, when the S.A. node fails, the A.V. node generates the impulse (nodal rhythm).

The Sino-atrial node is a right-sided structure, being the remnant of tissues at the entrance of the primitive right great vein, which in the higher animals, becomes transformed into superior vena cava. Hence, it is supplied by the right vagus nerve and is situated in the right atrium, near the superior vena cava. The A.V. node, on the other hand, is a left-sided structure being developed from similar tissues of the primitive left great vein which in the mammalian heart becomes the coronary sinus. Hence, it is supplied by the left vagus nerve.

(c) Bundle of His:

Cause:

The main trunk of this bundle is continuous with the A.V. node and passes upwards until it reaches the posterior margin of the membranous part of the interventricular septum and then forwards below it. It measures about 20 mm long.

(d) Bundle Branch:

Just above the muscular part of the septum, the bundle divides into right and left branches. The right bundle branch is longer than the left one. The left bundle branch bifurcates into superior and inferior divisions. It pierces the membranous septum, enters the left ventricle and passes along the muscular septum towards the apex. The left branch ends in the Purkinje systems of the ventricular subendocardial tissue .

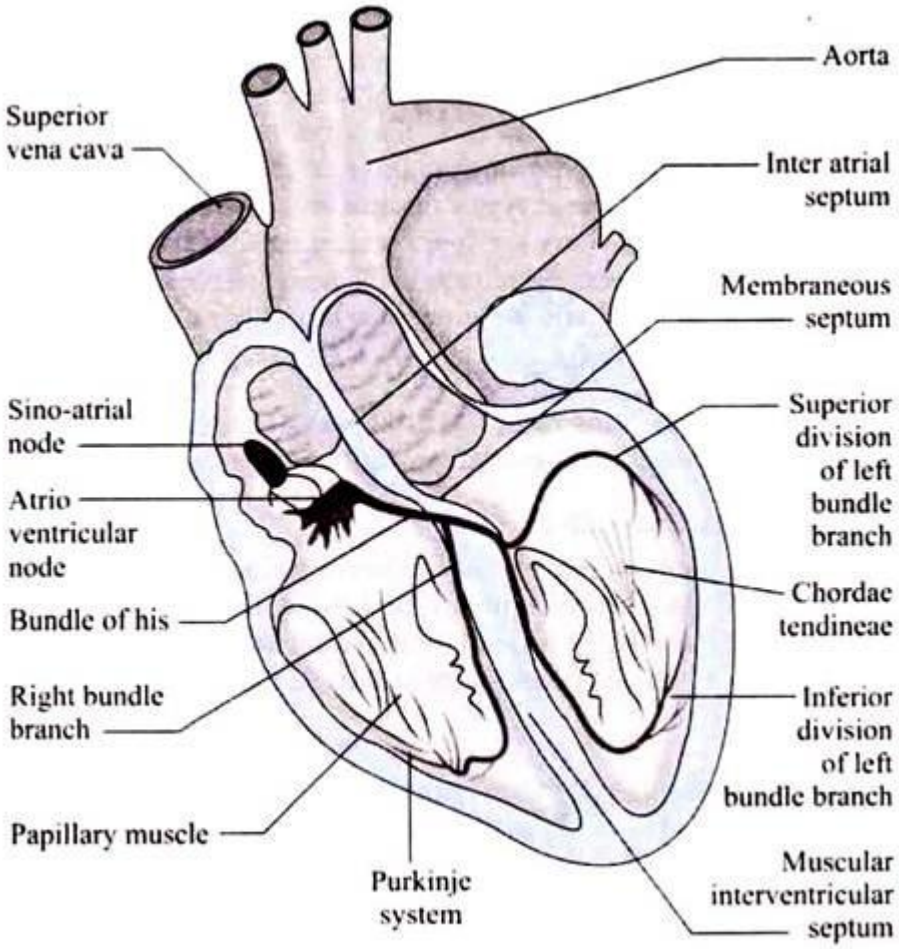


Fig. 7.25 Conducting system of heart muscle (Diagrammatic representation).

The right branch passes down the right side of the septum. These branches remain just under the endocardium. They are finally distributed through the terminal arborisations of a special type of cardiac muscle fibres, known as the Purkinje fibres. The main bundle (bundle of His), its right and left branches and the finer ramifications of the latter remain en-sheathed in a special connective tissue covering and thus separated from the surrounding cardiac muscles.

Histology:

The bundle is about 1-2 mm thick, consisting of fusiform parallel fibres with scanty striations. They are rich in glycogen. The fibres gradually increase in size as one proceeds onwards, and merges with the Purkinje fibres.

Functions:

i. Conduction:

Its normal function is to conduct the atrial impulse into the ventricles,

ii. Rhythmicity:
When the S.A. and A.V. nodes fail, the bundle can originate cardiac impulse. But the rate is very slow, about 36 per minute.

(e) Purkinje Fibres:
The purkinje fibres which arise from the branches of the bundle of His, spread from the interventricular septum directly to the papillary muscle and then to the lateral walls of the ventricle ending ultimately within the subendocardial network. **Purkinje (1845)** first observed the presence of these fibres in the subendocardial tissue of the ungulate heart.

Purkinje fibres have got a larger diameter (50 to 70 μ) than the ordinary cardiac muscle fibre (15 μ). It also contains relatively more sarcoplasm with large amount of glycogen. Myofibrils in the fibre are present mostly in the periphery of cells and the central space is occupied by glycogen.

Functions:
Main function of these fibres is to conduct impulse quickly to every part of the ventricular muscle fibre. These fibres also can initiate impulse (30-35 per min) in case of atrioventricular dissociation.

This specialised conducting tissue—the Purkinje fibres has been demonstrated only in the ventricles of the birds and mammals. In fishes, amphibia and reptiles these are not usually present and conduction is made through the ordinary cardiac muscle fibre. It is claimed that these fibres are relatively poor in carnivores, mammals and primates but highly developed in ungulates. These fibres ramify into the subendocardial network and ultimately loose their special characteristics gradually and become ordinary cardiac muscle fibres.