

II. CONDUCTION SYSTEM ANATOMY

The functions of the electrical system of the heart (Fig. II-1) are not only initiation and rate of the heartbeat, but its coordinated transmission to the entire heart resulting in maximum mechanical efficiency.

Anatomy of the conduction system

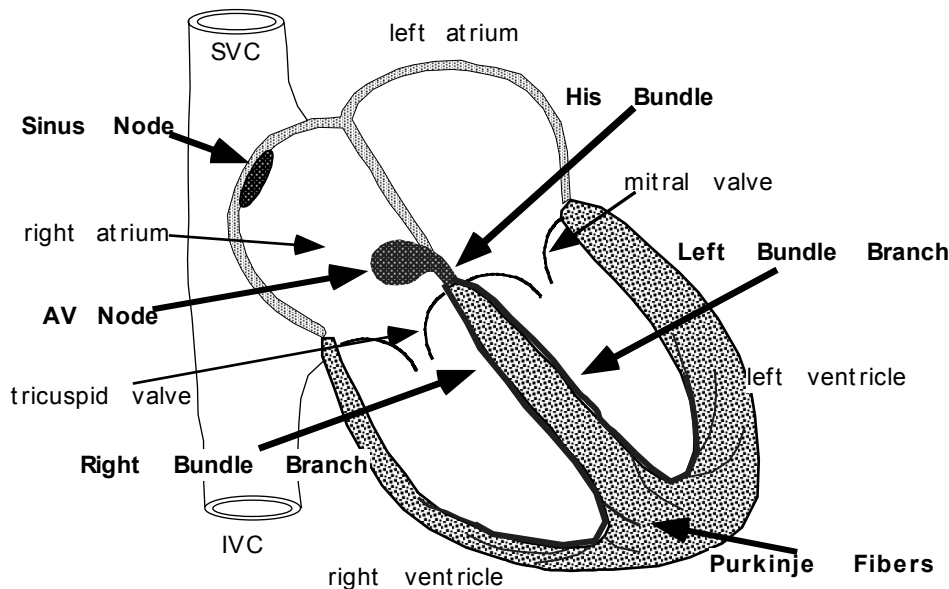


Fig. II-1. Conduction system anatomy; specialized conduction tissues labeled in **bold type**.

A. Sinus node and atrium

The heartbeat is normally begun in cells of the *sinoatrial* (SA), or sinus, node which is located in the high lateral right atrium where it adjoins the superior vena cava (embryonic sinus venosus region) (Fig. II-2). Blood supply is from the right coronary artery in 55% of cases, the circumflex branch of the left coronary artery in 45%. Impulses spread from the sinus node over the atria, from right to left/top to bottom, completing atrial depolarization in about 80-100 ms.. Although there are bundles of atrial tissue to which some have ascribed enhanced conduction properties, there are probably really no specialized interatrial tracts (i.e., like the Purkinje fibers). Function of the sinus node is influenced profoundly by autonomic nervous system tone – increases in parasympathetic tone decrease automaticity of the sinus node, slowing the heart rate, while increases in sympathetic tone increase automaticity, resulting in increased heart rate.

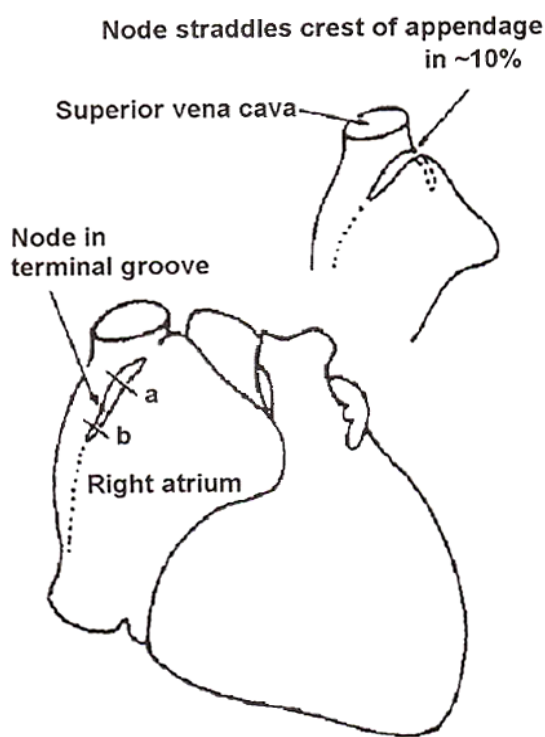
A

Fig. II-2. Anatomy of the human sinoatrial (SA) node. In most hearts the node is located in the terminal groove lateral to the superior cavoatrial junction, but in 10% of hearts it is a horseshoe-shaped structure straddling the crest of the atrial appendage. A and b denote the body and tail of the node, respectively.

B. Atrioventricular (AV) node

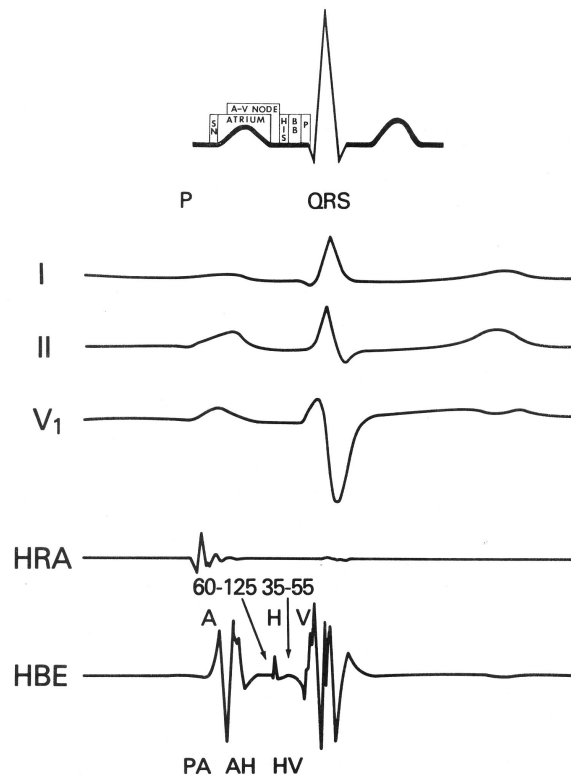
The AV node is situated in the inferomedial right atrium and forms the top of the only normal electrical connection between atria and ventricles. Special cells transmit impulses very slowly, requiring 60-125 ms to traverse the ~1 cm long node. The AV node's slowing of the impulse protects the ventricles from racing in response to rapid atrial arrhythmias (e.g., atrial fibrillation, flutter) by not allowing all impulses through; it can also fail to let *any* impulses through, and is the most common location of *heart block*. The AV node is profoundly influenced by autonomic tone; blood supply is from the right coronary artery in 90% of cases, the left circumflex in the remainder.

C. His-Purkinje System and Ventricles

The rapid spread of impulses through the ventricles is mediated by cells of the His-Purkinje system (HPS). The His bundle is located at the crest of the interventricular septum. The AV node terminates in the top of the *His* bundle which then branches into a *left* and *right bundle* branch. The right bundle branch is a cable-like structure, insulated from surrounding myocardium for most of its length. When it reaches the right ventricular apex it makes its initial electrical contact with myocardial cells of the anterior papillary muscle. In contrast, the left bundle branch is usually a fan-like structure, dividing soon after its origin into anterior and posterior fascicles. These fascicles then further ramify into the rest of the Purkinje network. Conduction is especially rapid through these cells, activating the left side of the interventricular septum, then the apex, finally the base, from endocardium to epicardium. The entire mass of ventricular myocardium is depolarized in about 80-100 ms, the same as in the atria. HPS blood supply is almost entirely from the left anterior descending artery; the proximal His bundle may have dual supply, from both right and left coronary arteries.

An electrode catheter placed in the region of the AV node and His bundle can record the His deflection, or potential; the amount of time taken to traverse the AV node is approximated by the AH interval (local atrial deflection to His spike, normally 60-125 ms), and the time spent in the HPS is reflected by the HV interval (from His spike to onset of ventricular activation, normally 35-55 ms. (Fig. II-3).

Fig. II-3



D. Abnormal connections - Wolff-Parkinson-White syndrome

Additional atrioventricular connections (aside from the normal AV node-HPS) exist in some people. Usually these are fibers of myocardium indistinguishable from normal atrial or ventricular cells, from 5-20 cells thick, which traverse the AV groove extrinsic to the valve ring tissue. These fibers typically have properties similar to normal myocardial tissue (i.e., rapid conduction) and connect directly between atrium and ventricle--bypassing the HPS. They can conduct anterogradely (atrium to ventricle) leading to unusual ECG appearances, since ventricular depolarization occurs 1) without the usual AV nodal delay and 2) without the rapid spread of impulses mediated by the HPS. These "bypass tracts" can also conduct retrogradely (ventricle to atrium) and participate in *tachycardias* (rapid heart rates; see below).