Histology of the atrio-ventricular bundle in the heart of guinea pig (*Cavia percellus*)

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Summary

The histological structure of the atrio-ventricular bundle (AVB) was studied in 6 adult male guinea pig. The AVB was a direct continuation of the atrio-ventricular node (AVN) where it passes obliquely through the right atrio-ventricular fibrous ring toward the apex of the interventricular septum. After ramifying the right bundle branch (RBB) from the AVB, the bundle continued as the left bundle branch (LBB) at the apex of interventricular septum. The LBB was broader than the RBB. Histologically, the cells of the AVB appeared to be organized into fascicles separated by fine fibrous septa. The majority of the cells of the AVB and bundle branches were ovoid in shape with light cytoplasm and a central nucleus. There was intercalated disc at their intercellular junctions. In general, compared to the conduction system of human being and other animal's heart, the innervation of the AVB and its branches in the heart of guinea pig was poor and there were no ganglia within or around them.

Key words: Histology, Atrio-ventricular bundle, Artio-ventricular bundle branches, Heart, Guinea pig

Introduction

His first described anatomy and histology of the atrio-ventricular bundle (AVB) in 1893 (Walls, 1947), which was later known by his name and is today termed the trunk of the AVB. Since then the anatomy and histology of the AVB of human being (Mahaim, 1947; Widran and Lev, 1951; Lev and Lerner, 1955; Titus, *et al*., 1963; James, 1970; Titus, 1973;), monkey and dog (Nonidez, 1943), hoofed animals (Meyling and Terborg, 1957; Prasad and Sinha, 1980), rabbit (James, 1967), birds (Yousuf, 1965; Szabo *et al*., 1986), lizard (Prakash, 1990), camel (Ghazi and Tadjalli, 1993), domestic cat (Ghazi *et al*., 1998) and recently in goat (Nabipour *et al*., 2002) have been studied in detail. However, there are no detailed data on the histology of the AVB of guinea pig. Therefore, the present study was undertaken to study with the histology of the AVB in the heart of guinea pig.

Materials and Methods

Immediately following euthanization, the heart with its pericardium was dissected free and flushed with warm (40°C) normal saline. The heart was perfused with 10% neutral buffered formalin. The lower part of the interatrial septum (from the upper part of coronary sinus) in continuation with the upper part of the interventricular septum was collected, trimmed and kept submerged in the same fixative for 72 hours. Serial sections at 7 µm thickness were cut sagitally from the right endocardium towards the left endocardium. The sections were selected by the interval of 3 and stained with method of green Masson trichrome (Luna, 1968). The stained sections were examined under light microscope for histological study. The length and width of the AVB were measured by micrometry and its thickness was measured by multiplying the number of sections to 7 µm. The data are represented as mean±SD.

Results

Morphologically, the AVB continued from the anterior and inferior margin of the atrio-ventricular node (AVN). In the nodal

bundle junctional area, the irregularly dispersed fibers of the AVN assume a more orderly parallel arrangement and become the AVB. Generally, there is not a detectable border between the node and AVB. Because the ostium of the coronary sinus was so large in the heart of the guinea pig, the bundle (same as AVN) was displaced anteriorly and near the root of the aorta. The AVB was passed obliquely through the atrio-ventricular fibrous ring to the apex of the interventricular septum, where it was divided into a right and left bundle branches. Therefore, the AVB has a short length.

The AVB was mainly composed of purkinje like cells that were aligned relatively parallel. The cells of the AVB were ovoid in shape with a light cytoplasm and one central nucleus. These cells were shorter, broader and paler than the working myocardial cells. Myofibrils were located at the periphery of the cells and a large perinuclear clear zone was present. In guinea pig, multiple strands of purkinje like cells in AVB were separated from one another by collagen fibers. Also, there was intercalated disc at intercellular junctions (Fig. 1).

The AVB is difficult to define precisely. It may be considered to extend from the region of the nodal-bundle junctional area to the point at which the components of the right and left bundle branches are separated. With this definition, the AVB in guinea pig had a mean dimension of 600±76 µm in length, 382±69 µm in width and 174 µm in thickness. The thickness could only be measured in one sample.

The ganglions were not present within or around the AVB and its branches, but there were blood vessels and nerve fibers around them that appeared to be continuation of the blood vessels and nerve fibers of the AVN (Fig. 2). The AVB and its branches were weakly innervated in guinea pig.

The right bundle branch (RBB) as a compact structure (Fig. 3) separated from the right lateral surface of the AVB. After passing about 750±23 µm through muscular interventricular septum the cells of the more distal ramifications of this branch were difficult to follow and study histologically. The mean width and thickness of the RBB was 250±20 and 251±77 µm, respectively. The RBB was composed of a mix of purkinje cells and some other cells similar to ordinary myocardial cells. In the RBB, the percentage of purkinje cells was relatively less than the AVB.

After ramifying the RBB from the AVB, the bundle continued as the left bundle branch (LBB) at the apex of interventricular septum (Fig. 4). The mean width, length and thickness of the LBB were 382±121, 1476±303 and 295±5 µm, respectively. The width of the LBB was 105±64 µm in the cranial end. Similar to AVB, the LBB was mainly composed of purkinje cells. There were a little collagen fibers between the strands of purkinje cells. The numbers of the purkinje cells in the LBB were much higher and they were more profound (Fig. 5).

Discussion

In the heart of guinea pig the AVB and AVN are relatively small. Since the guinea pig normally has a left cranial vena cava, the ostium of the coronary sinus is unusually large. The large size of coronary sinus has caused the bundle displaced anteriorely near the root of the aorta. This location is similar to that of rabbit. The rabbit has a left cranial vena cava, too (James, 1967). The AVB is relatively small in the guinea pig and rabbit (James, 1967). This may be in part due to the foreshortening of the entire area produced by the presence of the large ostium of the coronary sinus, which drains not only the cardiac veins but normally present left cranial vena cava. In the heart of the ungulate, the AVB has a relatively short length (Meyling and Terborg, 1957). In the heart of goat (Nabipour *et al*., 2002), cattle and horse (Meyling and Terborg, 1957) due to the absence of the membranous part of the interventricular septum, the AVB extends to a shorter distance. However, in those animals that the membranous part is present like cat (Ghazi *et al*.,1998) ,the AVB extends longer .

Fig. 1: Microphotograph of the AVB of guinea pig's heart, note the clear zone around the nucleus of purkinje cells (P); collagen fibers (CF) and intercalated disc (arrows) (green Masson trichrome staining ×640)

Fig. 2: Microphotograph showing nerve fibers (NF); blood vessels (V) around the atrio-ventricular bundle (AVB); interatrial septum (IAS); interventricular septum (IVS); aorta (AO) and (green Masson trichrome staining ×64)

Fig. 3: Microphotograph of the right bundle branch (RBB) in the heart of guinea pig; interventricular septum (IVS); atrio-ventricular fibrous ring (FR) and (green Masson trichrome staining ×160)

Fig. 4: Microphotograph of the left bundle branch (LBB) in the heart of guinea pig; interventricular septum (IVS); aorta (AO) and (green Masson trichrome staining ×64)

Fig. 5: Histological structure of the LBB in the heart of guinea pig; purkinje cell (P); collagen fibers (CF) and (green Masson trichrome staining ×640)

The junction between AVN and AVB in the sheep heart is characterized by finger-like projections in which the two types of tissue overlap (Frink and Merrick, 1974). Histologically, the principal type of cell in the guinea pig's AVB is purkinje like cells. The AVB is partitioning by collagen fibers. In this respect, it is similar to those of human being and dog (James and Sherf, 1971), cat (Ghazi *et al*., 1998) and goat (Nabipour *et al*., 2002) and there is no obvious difference except that the guinea pig's purkinje cells do not represent typical characteristics (Copenhaver and Truex, 1952) of these cells as seen in those of ungulates (James and Sherf, 1971). The typical purkinje cells have a distinct perinuclear clear zone and much greater diameter than the cardiac cells. Ungulate's purkinje cells (James and Sherf, 1971) are almost spherical or polyhedral and make contact with other cells at their entire periphery virtually, whereas the cells in the AVB of canine and human being (James and Sherf, 1971) are elongated and oblong in shape and make contact to some extent along their lateral margins but more often at their terminal ends. There are intercalated discs at intercellular connections of the AVB of guinea pig. In this respect, it is similar to those of camel (Ghazi and Tadjalli, 1993), goat (Nabipour *et al*., 2002), human being and dog (James and Sherf, 1971). Unlike most of other animals, the AVB and its branches are weakly innervated in guinea pig.

In the heart of guinea pig the AVB just after passing through the atrio-ventricular fibrous ring is divided into right and left bundle branches. After ramifying the RBB from the AVB, the bundle continue as the LBB at the apex of interventricular septum. This pattern of branching is similar to those of dog (James, 1964), cat (Ghazi *et al*., 1998) and goat (Nabipour *et al*., 2002). Whereas, in the heart of human being (Titus *et al*., 1963), horse (Bishop and Cole, 1967) and camel (Ghazi and Tadjalli, 1993) the first branch is LBB. The RBB in guinea pig is more compact and narrower than the LBB. In this respect, it is similar to those of human being (Titus *et al*., 1963), rabbit (James, 1967) and cat (Ghazi *et al*., 1998), dog (James, 1964) and goat (Nabipour *et al*., 2002). The RBB in guinea pig composed of mix of purkinje like cells and some other cells similar to ordinary myocardial cells. This finding is different from that of camel (Ghazi and Tadjalli,1993) and human being (James, 1970) in which the RBB is composed of only purkinje cells. The LBB of the AVB of the guinea pig has

relatively compact and broad structure. It's mainly composed of purkinje like cells. The number of the purkinje like cells in the LBB are much higher and they are more profound in shape. The width of the LBB becomes less as it gets closer to the cranial border of the interventricular septum. In the heart of cat (Ghazi *et al*., 1998), the proximal part of the LBB is a compact structure consisting of a mixture of "P" and transitional "T" cells but gradually the rate of "T" cells is increased. This branch after a short course terminate to a brush like structure consisting of "T" cells. In dog (James, 1964) and rabbit (James, 1967) the LBB is sheet-like. In the heart of human being, the LBB is composed of several distinct branches and as a singlewide sheet (Titus *et al*., 1963). In sheep (Frink and Merrick, 1974) the LBB is more discrete and compact structure than that of human being and passes 1-2 mm laterally to the left ventricular subendocardium before splitting into anterior and posterior divisions.

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