Macroscopic and Microscopic Studies of Sino-Atrial Node in the Heart of Ostrich (Stuthio camelus)

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Abstract: The anatomy and histology of sino-atrial node was studied in 5 ostrich hearts (Stuthio camelus) with serial histological sectioning and transmission electron microscopic method. The result manifested that in the ostrich the SA node was located in the endocardial layer of the atrial surface of terminal part of the left sino-atrial valve and the entire right sino-atrial valve of sinus venosus in the right atrium. Histologically the parenchyma of the SA node contains 3 types: the “P” cell was small and pale, with a relatively large nucleus and sparse myofibrils, the transitional cell was slender and contains more myofibrils and the intermediate cell resembles the P cell, but was darker. The SA node was not covered by connective tissue sheath and there is no central artery in the node, but, some nerve fibers are related to the node.

Key words: Sinoatrial node, Male ostrich, Macroscopy, Microscopy, Ultrastructure

INTRODUCTION

According to Keith and Flack [1], the sino-atrial node was considered as a pacemaker of the heart. Although this node has been demonstrated in some birds, there is still doubt in its location, shape, size, constituent cells and even its presence in different species of birds. De Mayer [2], Truex [3] and Truex and Smythe [4] denied the existence of sino-atrial node in the avian heart. But some investigators described the sino-atrial node in the pigeon [5], kiwi and Yellow Crested penguin [6], fowl [7-13], Indian fowl [14], house sparrow [15], Jungle bush quail [16], Rose ringed parakeet [17], Leghorn chicken and Island chicken [18], short-tailed shearwater, Black crowned night heron, duck, Japanese quail, pigeon, macaw, budgerigars and jungle crow [19] and turkey [20]. The present study therefore, was carried out to deal with the anatomy and microscopic structure of the sino-atrial node in the ostrich heart.

MATERIALS AND METHODS

A total number of 5 hearts from male ostriches (1.5-2 years old) was collected from the slaughterhouse immediately after slaughter. After removal of the pericardium, hearts were flushed with normal saline.

For light microscopic study, the hearts were immersed in 10% buffer neutral formalin for 72 hours (Ventricular apexes were cut off to permit the penetration of formalin into the lumen). The right atria of the hearts were separated and divided into several segments. Then each segment trimmed and embedded in paraffin. Serial sections at 6-8 µm thickness were cut, mounted and preserved. The sections were stained with Hematoxylin and Eosin, Green Masson’s Trichorome, AZAN and Orcein-Van Gisson’s stain.

For electron microscopy, the Karnovsky’s solution was used for fixation. The cubes of tissue (about 1 mm) post fixed in 1% osmium tetroxide with 0.1 M phosphate buffer solution. Specimens were serially dehydrated in graded ethanol and embedded in epoxy resin. Semi-thin sections were stained with toluidine blue to identify the location of conductive system. Ultra-thin sections (about 600 Å) were mounted on copper grids and stained with uranyl acetate and lead citrate, examined with Philips CM-10 electron microscope and electromicrographs were prepared and studied.

RESULTS

The sino-atrial node in the heart of the ostrich is located in the endocardial layer of atrial surface of terminal part of the left sino-atrial valve and the entire right sino-atrial valve of sinus venosus in the right atrium (Figs. 1, 2).
Histologically, the sino-atrial node of the ostrich heart is composed of modified cardiac muscle fibers that organized in a framework of collagenous fibers and fibroblasts. There is no connective tissue sheath around the node. Peripherally, the margin of the node merges with the musculature of the valve. The node can be distinguished from ordinary atrial and sinus venosus myocardium by its special features (Fig. 3).

The paranchyme of sino-atrial node in the ostrich heart contains 3 types of specialized muscle fibers within its loose collage nous frame, “P”, transitional and intermediate cells. They can be differentiated from ordinary atrial and sinus venous myocardium by the smaller size and different organization of myofibrils in the cells (Fig. 4).
“P” cells are composed of clear, structureless sarcoplasm with one or two large nucleus. They may be isolated or clustered. The pale appearance of these cells is due to small number of randomly oriented myofibrils and cytoplasmic organelles (Fig. 5).

The TEM study revealed that the sarcoplastic membrane shows indentation. They contain scattered mitochondria, Golgi complex and delicate filaments. Remnants of sparse sarcoplastic reticulum are also present. T-tubules are absent in these cells. Leptomeres and myofibrillar insertion plaque are distinctive structure in “P” cells. These cells connect with each other or with transitional, intermediate and even ordinary myocardial cell by desmosomes and nexuses (Figs. 6-9).

The transitional cells are slender, elongated and smaller than ordinary myocardial cells. Transitional cells contain a greater number of organized myofibrils than “P” cells, thus they stain darker (Fig. 5). The myofibrils are arranged in parallel pattern and the mitochondria with distinct crista are placed between them (Fig. 10). They connect with each other by desmosomes, nexuses and intercalated discs. There is no distinct separation of transitional cells from sino-atrial valve musculature. They connect to “P”, intermediate and ordinary myocardial cells with desmosomes (Figs. 11, 12).

The intermediate cells have the morphological characteristics between “P” and transitional cells (Fig. 5). They are often bi-nucleated and connected to “P”, transitional and ordinary myocardium. In these cells the filamentous cytoplasm is very distinct (Fig. 13).
Fig. 8: Electromicrograph of “P” cell (P) in the SA node of the male ostrich, showing the insertion of myofilaments onto the cytoplasmic membrane (Uranyl acetate and Lead citrate staining, ×32550). MIP- myofibrillar insertion plaque, *- collagen fibrils, M- myofibrils.

Fig. 9: Electromicrograph of “P” cell in the ostrich SA node, showing leptomeric organelles (L). (Uranyl acetate and Lead citrate staining, ×44100).

The sinus node of the ostrich is not organized around a central artery. But in the parenchyma of the node, there are numerous fibroblasts, nerve fibers, small arteries and capillaries.

Fig. 10: Electromicrograph of transitional cell in the ostrich SA node, note the parallel pattern of myofibrils (M) and mitochondria (Mt). (Uranyl acetate and Lead citrate staining, ×24150)

Fig. 11: Electromicrograph of intercellular junction between transitional cells (T). (Uranyl acetate and Lead citrate staining, ×44100). ID- intercalated disc, M- myofibrils, arrow- desmosome, *-nexus.

Fig. 12: Electromicrograph of intermediate cell in the SA node of male ostrich, note the myofibrils (M) and intermediate filaments (F). (Uranyl acetate and Lead citrate staining, ×59850)
DISCUSSION

Although Mackenzie and Robertson [21], Adams [6], Truex [3] and Truex and Smythe [4] reported the absence of sino-atrial node in the heart of birds, De Mayer [2] stated the sino-atrial node disappears in the wall of right atrium in the heart of fowl. In contrast to these observations, most investigators have found the avian sino-atrial node, but their description is different.

In the ostrich heart, the sino-atrial node is located in the subendocardial layer of atrial surface of terminal portion of the left sino-atrial valve and the entire right sino-atrial valve of sinus venosus. The location of this node in the heart of domestic fowl is in the wall of right atrium [8,10,11]. Kim and Yasuda [12] described this node between right cranial vena cava and caudal vena cava opening. But Khana [7] found this node in the opening of left cranial vena cava in domestic fowl. In the Leghorn cocks and Rhode-Island hens, this node is located near the base of left sino-atrial valve [18], but Lu et al. [13] found the sino-atrial node of the White Leghorn chicken near the base of right sino-atrial valve, thus corresponding to the crista terminalis in mammalian heart and similar to the representation of Davis [5], Adams [6] and Murakami et al. [19]. The Sino-atrial node is located at the cephalic part of the interatrial septum in the heart of jungle bush quail [16], towards the right side of the cephalic end of interatrial septum in rose ringed parakeet [17], in the atrial septum of the house sparrow [15] or in the sinus venosus of common Indian fowl [14] and in the region between the orifices of the right cranial vena cava and of the caudal vena cava beneath the atrial epicardium in the heart of turkey [20].

Histological and cytological features of the constituent cells of sinus node in the ostrich heart showed that the node is composed of some pale cells as “P” cells and slender transitional cells and intermediate cells which have intercellular junction with the myocardium of sino-atrial valves, but most of the authors mentioned above, didn’t describe the cell component of sino-atrial node in detail. Mathur [9] reported that the sino-atrial node of the fowl was composed of purkinje fibers, but Kim and Yasuda [12] described that the nodal fibers are not being purkinje cells, but smaller and thinner than other cardiac fibers. Lu et al. [13] stated that the “P”细胞 and transitional cells made the sino-atrial node of Leghorn chicken. This report is similar to that of Gossrau [22] and Murakami et al. [19]. Davis [5] only said that most of the cells of sino-atrial node of the black swan and pegion were larger than ordinary atrial myocardial cells and smaller than purkinje fibers. In the heart of parakeet, the sino-atrial node composed of elongated and multinucleated specialized fibers [17] and in the heart of quail, specialized muscle fibers is seen in the node [16].

The sinus node of the ostrich is not enclosed by any connective tissue sheath to separate it from the sino-atrial valve musculature. It is similar to the report of Leghorn chickens [13]. The nodal cells connect to myocardial cells by cell junctions. Such connections were also reported by Davis [5], Adams [6], Murakami et al. [19] and Lu et al. [13].

The sinus node of the ostrich is not organized about the central artery, but contains only small arterial branches and it is similar in parakeet [17], while in quail, the delicate nerve fibers were abundant within the sinus node [16].

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REFERENCES


