THE MORPHOLOGICAL CHARACTERISTICS OF THE SINO-AURICULAR AND AURICULO-VENTRICULAR NODES IN MOOSE, CATTLE, PIG, AND HUMAN HEARTS[1]

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ABSTRACT: Comparative-anatomic studies on morphometric characteristics of the heart, cardiac circulatory system (CCS), and qualitative estimation of specific volumes of CCS structural components were conducted. It was found that the histologic structure of CCS in the investigated species (moose, calf, pig, and man) differs in size, blood supply, innervation, and in the correlation of specific volumes of conducting and contracting cardiocytes of connective tissue. The original data collected on the structure of moose will help to explain functional characteristics in the moose electrocardiogram.

ALCES SUPPLEMENT 2: 7-10 (2002)

Key words: calf, comparative anatomy, circulatory system, heart, man, moose, pig

There are data in the literature concerning the anatomy of the cardiac circulatory system (CCS) in cows (Abe 1987), pigs (Lopes 1976), and man (Sinev and Krymsky 1987). However, the structure of the moose circulatory system has not been studied, although ECG recordings were made long ago (Roshchevsky et al. 1976). Because of this lack of study, a problem with the comparative anatomy of the cardiac circulatory system in ungulates living in different ecological conditions still appears in biology, physiology, and zoo-veterinary science.

The purpose of this study was to investigate the morphometric characteristics of the moose heart, structural and comparative anatomy of its circulatory system, and to quantitatively estimate specific volumes of structural components of the cardiac circulatory system (conducting cardiocytes, hemocirculatory path, conductive tissue, and stromatic elements) in moose, calf, pig, and man.

MATERIALS AND METHODS

The objects of the investigation were moose heart (n = 10), calf heart (n = 12), and pig (n = 20). The measurements were made on the heart mass, wall thickness in different parts of the myocardium, length of inflow and outflow parts of the right heart, and the area of the great vessels. Paraffin serial histotopograms (approximately 7 microns) were stained according to the method of Van Gizon, Vergoff, and Mallory in Masson's modification. To estimate peculiarities of the circulatory system, blood supply, and structure of the heart, bone coronaroangiography and rentgenography were performed on 12 preparations. Specific volumes of structural components of the cardiac circulatory system were studied on histopreparations with the application of

[1]Editor's note: this manuscript was submitted without references and due to difficulties contacting the author the manuscript was published without them.

planimetric methods.

RESULTS AND DISCUSSION

The sinoauricular node (NSA) of moose was found in the myocardium of the right auricle in the initial part of the bordering groove, which is located between the right external wall of the superior vena cava at the level of its orifice and the base of the left ridge of the right auricle. The head and the body of moose NSA are located deep under the endocardium and isolated by a thick layer of connective tissue in the bordering groove. It is 25 – 30 mm x 3.5 mm – 5 mm in size.

The part that runs up along the right wall of the superior vena cava is separated from adventitia by a great amount of fatty tissue and from the internal side of this vena by transverse bundles of ascending layers of the right auricle from 0.6 to 1.2 mm in diameter. Cardiomyocytes of NSA are sinuous and concentrate around arterial branches. They are irregularly thickened and are equal to 15 – 18 microns; there are not many of them here and in the nodal connective tissue (Fig. 1). From the muscles of the adjacent crest, the NSA and its artery gradually shift to the epicardium. Here they are located on the surface, their tail-part is on the posterioapical surface of the right auricle. Morphometrical investigation of NSA structural components of moose showed that the largest part of its specific volume is represented by fatty and connective tissue (Fig. 2a).

The atrioventricular node (NAV) of moose has a rastriform configuration 10 – 12 mm long, 2.5 mm wide, and 6 – 7 mm thick (Fig. 3). NAV is separated from the endocardium by contractile myocytes and a layer of connective tissue. Stretching into the interventricular septum, the NAV is lengthened and becomes thinner, thus forming a zone of NAV and atrioventricular bundle connection. The zone includes about 10 cardiomyocytes separated by connective tissue. Bundles of cardiomyocytes are slightly curved and oriented along the longitudinal cardiac axis. In the 2–3 mm after

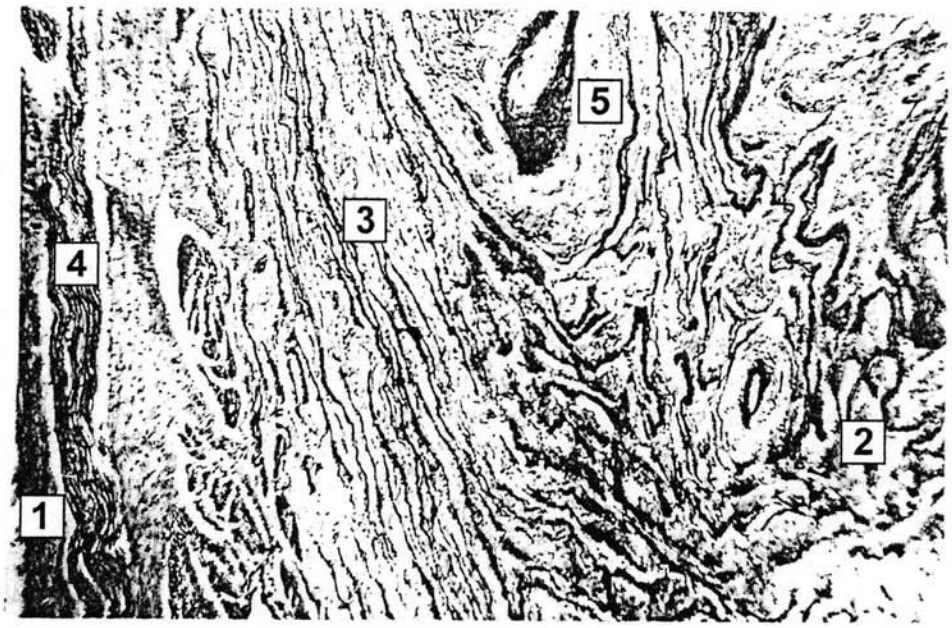

Fig. 1. Sinoauricular node of moose. 1 – Epicardium. 2 – Nodal cells. 3 – Connective tissue. 4 – Working myocardium of the right auricle. 5- Nodal artery. Staining by hemotoxiline.

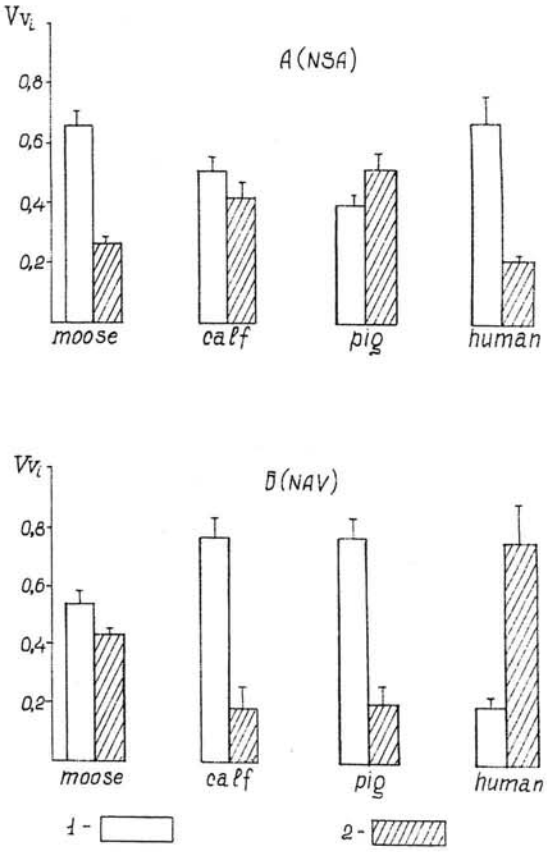

Fig. 2. Structural components of sinoauricular (A) and atrioventricular (B) nodes of hearts in moose, calf, pig, and man. 1 – Cardiomyocytes. 2 – Connective and fatty tissue.

NAV, the number of cardiomyocytes in the bundle increases. The atrioventricular bundle is separated from the endocardium of the right atrium by massive myocytes and connective tissues, and develops into the right branch of the His' bundle. Cardiomyocytes of the right His' bundle-branch gradually increase in size; the percentage of polymorphic cells increase and enter the right side of the interventricular septum. Some bundles of cardiomyocytes leave the lower-left fragment of the atrioventricular bundle. They penetrate into the central fibrous body of the crest of the interventricular septum below the heart bone. The following 2–3 mm of this part of the bundle turn to the left and down to form the His' left bundle branch (Fig. 3). Blood supply of the atrioventricular part of the moose cardiac circulatory system is exercised through the nodal branch of the right coronary artery and front septal branches from the anterior interventricular artery.

The sinoauricular node of the calf is located under the epicardium and its structure is similar to NSA of moose but is 10–15 mm shorter (Fig. 2). There are many tissue-connecting bridges among NSA cardiomyocytes of the calf, but the connecting tissue is half as much as in the NSA of the moose heart. The NAV of the calf is observed between the coronary sinus and the basis of septal leaf of the tricuspid valve. It should be noted that the cardiomyocytes of the calf's NAV are the largest in all the kinds of mammals that we investigated.

The structure of NSA of pig's heart differs from that of man by the position of the node, which is completely located in the auricle of the right atrium. From above, the node borders on the adjacent groove and from the exterior, it is approachable by a bundle conducting cardiomyocytes, located subepicardially. Blood supply of NSA of the pig's heart is realized through the artery of NSA that runs from the right coronary artery. Morphologically, circulatory cardiomyocytes of the pig are similar to those in the right auricle of man.

Compared to all of the species investigated by the authors, the atrioventricular node of a pig shows greatest innervation. We noted the increase of specific volume of the connecting-tissue component and fatty tissue of the NAV in the pig and calf. As far as man is concerned, these correlations show an opposite dependence (0.15 and 0.78, respectively), although conducting myocyte's volume and those in the heart of a pig are insignificant (0.2 vs. 0.43 and 0.78

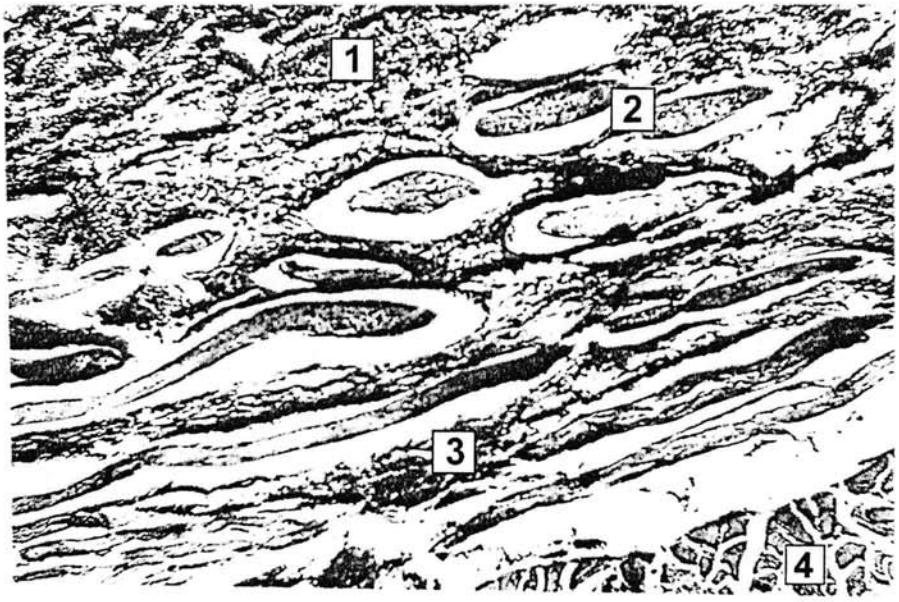

Fig. 3. Zone of artrioventricular node transition into atrioventricular bundle of moose heart. 1 – Endocardium. 2 – NAV cells. 3 - Connective tissue. 4 - Contractive cardiocytes. Magnification 20 X 4. Staining Van Gizon.

for moose and man, respectively).

Thus, the general analysis of the cardiac circulatory system of the moose heart is similar to those in the animal species investigated and in man. Morphometric analysis of the heart in general and some of its sections have led to the conclusion that the increase of the absolute mass of the heart is in line with man, pig, calf, and moose and is followed by an increase in its volume.