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Considerations on the sinus node microangioarchitecture

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Abstract

The importance of the sinus node as the cardiac pacemaker is well known. The aim of the present study was to investigate the microangioarchitecture at the level of the sinus node. Ten human adult hearts were injected with India ink in the initial segments of the coronary arteries. Pieces were drawn and diaphanized. The results of the study can be summarized: (1) the sinus node is rather an irregularly shaped structure, with peripheral strands intermingling with strands of the atrial myocardium; at this level two vascular patterns can be recognized: (a) the myocardial capillary networks that parallels the muscular bundles, and (b) the peripheral nodal networks built upon dichotomizing arterioles; (2) it seems that while the thick and large sinus node artery does not branch in the nodal tissue, the blood supply of this tissue is ensured by the peripheral nodal networks; (3) characteristically, in the periphery of the nodal tissue are largely present glomeruli made by capillaries with pericellular dispositions. The results strongly suggest that the nodal tissue is mainly supplied from its periphery and the sinus node artery is rather a scaffold than a supplier of that tissue.

***Keywords*:** human heart, coronary arteries, nodal tissue, glomeruli, capillaries.

Introduction

The sinus node represents the cardiac pacemaker that initiates (in some of its cells) each cardiac cycle. It is located at the junction between parts of the right atrium derived from the embryonic venous sinus and the atrium proper. Nodal tissue does not occupy the full thickness of the right atrial wall from epicardium to endocardium in humans, but rather sits as a wedge of specialized tissue subepicardially within the terminal groove [1].

The origin of the artery of the sinus node was largely studied; for example, DiDio LJ *et al.*, in 1995, demonstrate that the sinoatrial node of the normal human heart is supplied by the right coronary artery more frequently than by the left one [2].

The distribution of the coronary arteries allows understanding the possible ischemic etiology of the sinusal node syndrome and permits to the surgeon a safe approach to cardiac disease [3].

Material and method

For the present study ten human adult hearts without any history of cardiovascular diseases were used. The specimens were washed in warm water and injected with India ink (20 ml in each coronary artery, left and right).

After fixation the sinus node arteries were dissected and the sinoatrial nodes were drawn in block with their arterial pedicles. Longitudinal cuts were made and diaphanized.

Results

On the longitudinal cuts of the sinus node (SN) and perisinusal right atrial myocardium the sinus node artery (SNA) could be easy recognized due to its large caliber and thick arterial wall. Generally, the SNA was eccentrically disposed to the SN and on the preparates we could not distinguish branches provided by this artery for the nodal tissue (Figure 1A).

The peripheral nodal tissue was not clearly delineated but instead strands of it intermingled with myocardial strands that were provided with rich longitudinal capillary networks (Figure 1B).

The vascular pattern of the peripheral nodal tissue was different to that of the perinodal atrial myocardium and consisted of dichotomizing arterioles that after a variable number of branches ended with characteristic glomerular capillary networks (Figure 1, B and D).

Except the prevalent dichotomizing arteriolar pattern of the nodal tissue, a scalariform branching pattern of the nodal arterioles was recognized (Figure 1C).

Some of the perinodal arterioles were both supplying the myocardial bundles and the nodal tissue between which were disposed (Figure 1D).

The glomerular networks of the nodal tissue seemed to consist of individual pericellular capillary rings (Figure 1D).

Discussions

The results of this study can be summarized as it follows:

▪ the sinus node is rather an irregularly shaped structure, with peripheral strands intermingling with strands of the atrial myocardium; at this level two vascular patterns can be recognized: (1) the myocardial capillary networks that parallels the muscular bundles and (2) the peripheral nodal networks built upon dichotomizing arterioles;

▪ it seems that while the thick and large sinus node artery does not branch in the nodal tissue, the blood supply of this tissue is ensured by the peripheral nodal networks;

▪ characteristically, in the periphery of the nodal tissue are largely present glomeruli made by capillaries with pericellular disposition, ring-like.

Our study demonstrates the undoubtful existence of the "*arterial network of the perinodal sinusal area*", described by DiDio LJ *et al.* (1995) after an imagistic study [2].

Also, arteriographies were performed by Lopes AC *et al.* (1998) to get similar results (the "*arterial perisinusal network*") [4].

A clarification must be made: that network would rather be termed "*arterial network of the peripheral nodal sinusal area*" and must be distinguished from the myocardial adjacent capillary networks.

A recent study of Sanchez-Quintana D *et al.* (2005) mentions that a sheath of fibrous tissue does not insulate the sinus node; its margins are irregular, with multiple radiations interdigitating with ordinary atrial myocardium [5].

We also evidenced the lack of an insulating sheath and the presence of the nodal radiations, intermingled with strands of atrial myocardium, disposition that facilitates the blood supply of the peripheral nodal tissue from the vessels that supply the atrial myocardium at that level.

Studies in cattle noticed that in the region of the sinoatrial node no special capillary arrangement was observed [6]. In contrast, in humans there are characteristically present nodal glomeruli made by pericelullar rings of capillaries.

We agree with Lopes AC *et al.* (1998) who states that: "*it is the network and not the artery of the pacemaker the major responsible for the nutrition of the sinoatrial node*" [4].

Once confirmed the assumption, the term "*artery of the sinoatrial node*" becomes a misnomer, since though closely related to the node it does not provide directly blood supply to the pacemaker. This statement correlates with studies performed in dogs that evidence other arterial suppliers for the sinus node, except the artery of the sinus node [7].

So, when considering the sinus node vascularisation it may be useful to consider all the arterial sources for that area, including the adjacent atrial myocardium, and not only the sinus node artery. The peripheral networks of the sinus node appear to be the main source of the nodal tissue.

Conclusions

The correct knowledge and acceptance of the peripheral arterial suppliers of the sinus node allows a correct interpretation of the ischemic conditions at that level. The peripheral nodal networks may ensure a degree of protection to ischemia, but this protection correlates with the site of arterial occlusion; as larger is the occluded arterial trunk, as larger may be the nodal area supplied by it and the compensatory supply will not be provided.

Once established the different supply of the peripheral and the central areas of the sinus node a further direction to investigate will be how the differences in vascularisation are reflected on the electrophysiological properties of the nodal tissue.

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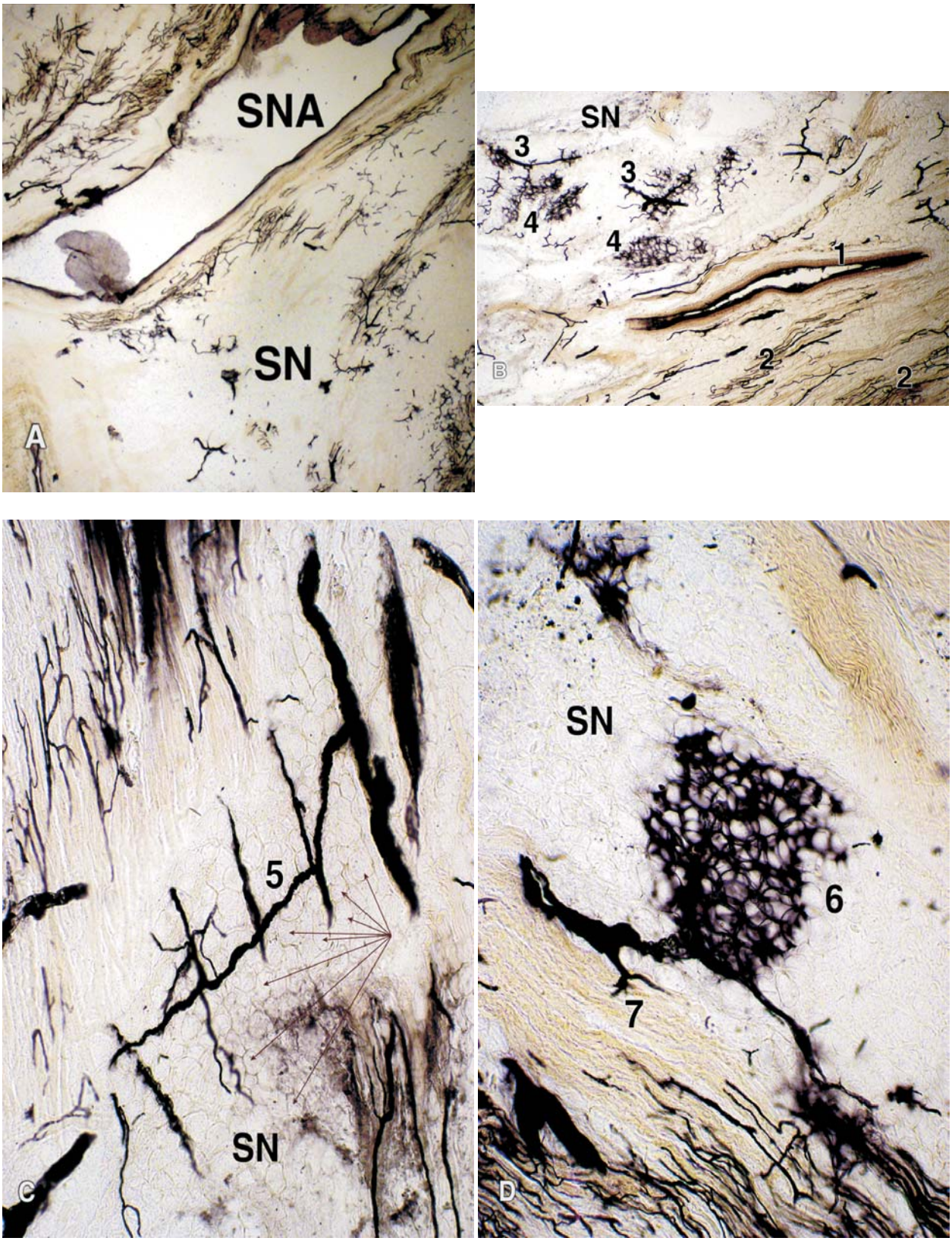

Figure 1 – ***Human adult heart injected with India ink in the coronary arteries. Longitudinal cuts of the sinus node. Diaphanisation.*** **A*) The sinus node artery (SNA) is eccentrically to the sinus node (SN), which, in turn, shows peripheral vascular networks unsupplied by the SNA (×20);*** **B*) In the periphery of the SN strands of atrial myocardium intermingle with strands of nodal tissue. At this level a longitudinal large caliber artery is present (1). The myocardial strands are provided with rich longitudinal capillary networks (2) while the periphery of the SN presents several dichotomizing arterioles (3) that end with characteristic nodal glomerular capillary networks (4) (×100);*** **C*) Scalariform branched arteriole (5) in the periphery of the nodal tissue (×400);*** **D*) Characteristic peripheral nodal glomerular capillary network (6) consisting of individual pericellular capillary rings supplied by a longitudinal arteriole that also supplies the adjacent muscular strand (×400)***