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Anterior region of the atrioventricular perinodal area in relation to radiofrequency ablation procedures

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Atrioventricular nodal reentry tachycardia base on reentry circulation in nodal--perinodal area. The radical treatment of choice is radiofrequency ablation. Procedure approached from the anterior-superior (fast) region sufficient a few seconds of energy delivery for success, however this can result in A-V block. The possibility that arrhythmias substrate may lie very superficially (success of ablation) and damage the normal structures (complication) in the perinodal region must be considered. In order to confirm this hypothesis we examined the autopsy material of 100 normal hearts, both sexes from 18 to 105 years of age (control) and 50 hearts with A-V total block 45–95 years of age (block). We paid attention to the morphology of the nodal artery (NA), atrial inputs (AI) and transitional inputs (TI).

It was observed that NA at the level of the central fibrous body was positioned in 94% in the central and in 6% in the inferior part of Koch's triangle. It was removed from the endocardium 3–6 mm in control and 2–5 mm in block group respectively (NS). In the perinodal area we distinguished AI that directly joined the A-V compact node: superficial (right part of the interatrial septum) or deep (left part). The former occurred in 100% of controls and in 80% of block groups (NS), and the latter in 80% of control group and in 34% in block respectively ($p < 0.05$).

The real substrate of arrhythmia in anterior-superior region lies very superficially and far from the conduction tissue; NA in examined hearts was lying deep beneath the endocardium; ablation close to the node could result in A-V block.

key words: atrioventricular perinodal area, atrioventricular node, Koch triangle

INTRODUCTION

Atrioventricular nodal reentry tachycardia (AVRNT) is a heart arrhythmia which is based on dual atrioventricular conduction within the node or perinodal tissue and the circus movement mechanism [9]. Electrophysiologically two pathways can be differentiated. The slow pathway with slow anterograde conduction and short refractory time appears to be situated at the posterior-inferior approaches to the atrioventricular node in the region between the coronary sinus orifice and the tricuspid annulus. The fast pathway, characterised by fast anterograde conduction and long refractory time, appears to be situated in the anterior-superior approaches to the atrioventricular node at the apex of Koch's triangle, close to the His bundle [3]. The radical treatment of choice

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in patients, especially with drug-resistant AVNRT, is radiofrequency current fast or slow pathway ablation [4]. Ablation of the reentrant circuit in the region of His bundle, when approached from the anterior-superior region (fast pathway), can result in complete atrioventricular block (6–10%). This is less likely if the posterior-inferior (slow pathway) approach is used (2–6%). On the other hand, only a few seconds (5–8 seconds) of energy delivery in the fast pathway region is sufficient for successful ablation, but a longer period of time (approximately 30 seconds) is needed in the slow pathway region [2].

The possibility that arrhythmia's substrate in the anterior-superior region may lie very superficially (success of ablation) must be considered. Radiofrequency current may damage the vascular supply to the atrioventricular node or normal structure in the nodal-perinodal area (complication of ablation) leading to A-V block [6]. In relation to this, it was decided to examine the morphology and topography of the atrioventricular node and related structures in order to eventually define the anatomical basis of the circus movement mechanism in atrioventricular nodal reentry tachycardia.

MATERIALS AND METHODS

Research was carried out on autopsy material consisting of 100 normal human hearts of both sexes (38 female, 62 male) from 18 to 105 years of age (avg. 56 ± 12 years) fixed in formalin-ethanol solution in which no macroscopic pathological (e.g. not related to the age) changes were found. This group we indicated as the control group. We took also observation on the autopsy material of 50 paced human hearts of both sexes (27 female, 23 male) from 45 to 95 years of age (avg. 67 ± 18 years). This group of hearts we denoted as the paced group. The last of the mentioned investigated hearts were from patients with VVI or DDD pacemakers, which were implanted as a treatment for II and III degree atrioventricular block.

Specimens were taken containing the interatrial and interventricular septum, which encompassed the entirety of the triangle of Koch (the apex of the triangle — right fibrous trigone; the base — coronary sinus orifice, the upper side — tendon of Todaro, the lower side — attachment of the septal leaflet of the tricuspid valve). These histological sections were sectioned with the profile of the long axis of the cardiac septum facing the knife. Serial sections were cut at 10 micrometre thickness and every 10th section was stained with Masson's in Goldner's modification. Koch's triangle was divided in the sagittal plane into three parts: inferior (between the base and the attachment of the tricuspid valve), central (between the base and the apex of the right fibrous trigone) and superior (between this trigone and the tendon of Todaro). From the clinical point of view we divided Koch's triangle into: the base (near the coronary sinus orifice), the apex (near the right fibrous trigone) and the central part (between both the previously mentioned) [7]. We paid the greatest attention to the morphology of the atrioventricular nodal artery, atrionodal inputs and transitional nodal zone. Multivariate analysis was performed by Cox proportional hazards regression model; Student's t-test of unpaired data and the Yates corrected Chi-square test were used to determine the statistical significance. Differences were considered significant at a p value < 0.05.

RESULTS

The level of the triangle's base encompassed the posterior-inferior region (slow pathway area), the triangle's centre encompassed both regions (slow and fast pathway areas), the apex of the triangle the anterior-superior region (fast pathway area). Taking the topography and morphology of the atrioventricular nodal artery, according to the above-mentioned division of the triangle of Koch, it was observed that the position of the artery varies. At the level of the right fibrous trigone the artery was positioned in the central part in 94% of specimens and in the inferior part only in 6% in both of the investigated group of hearts. Its localisation was not observed within the superior part of Koch's triangle. The atrioventricular nodal artery was removed from the endocardium 3 mm (3%), 4 mm (10%), 5 mm (53%) and 6 mm (34%) in the control group (Fig. 1); 2 mm (4%), 3 mm (8%), 4 mm (38%), and finally 5 mm (54%) in the paced group respectively (Fig. 2). No statistically significant relationship was observed between those groups. The morphology of the artery varied in both groups. We stated that in 30% of hearts from control group small parietal thrombi were to detect and in 90% hearts of paced group respectively ($p < 0.05$).

In the perinodal area we distinguished atrionodal inputs that directly joined the atrioventricular compact node. They composed two layers: superficial and deep. The former ran from the right part of the interatrial septum as shown in Figure 3. The deep layer of the atrionodal inputs was composed of the muscles running from the left part of the interatrial

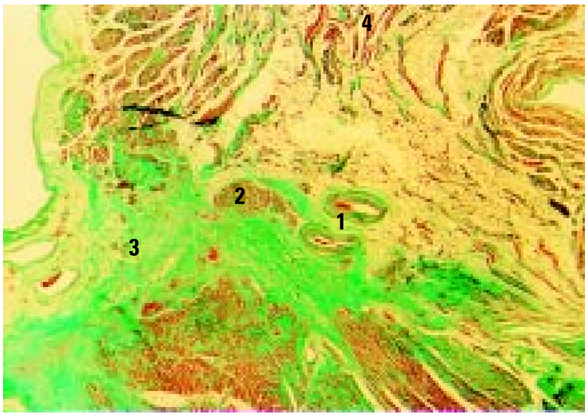

Figure 1. Microphotograph showing the atrioventricular artery in the control group. The artery in the central part of Koch's triangle at the distance of 5 mm; 1 — atrioventricular artery, 2 — atrioventricular node, 3 — right fibrous triangle, 4 — interatrial septum (female, 87-year-old; Masson-Goldner, × 45).

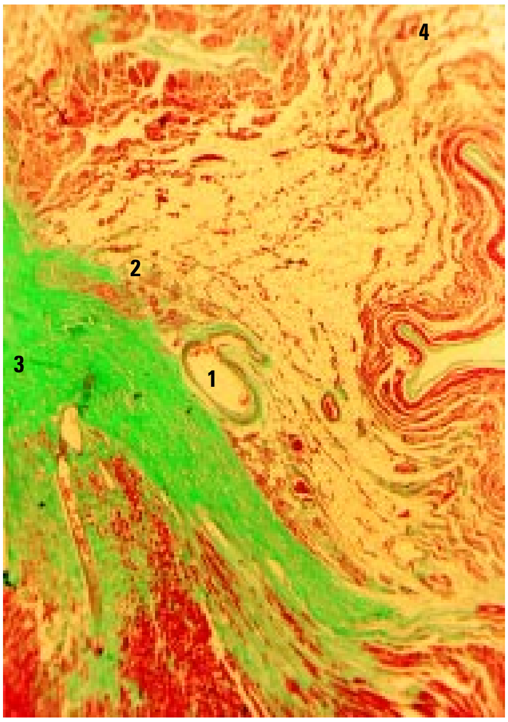

Figure 2. Microphotograph showing the atrioventricular artery in the paced group. The artery in the central part of Koch's triangle at the distance of 3 mm; 1 — atrioventricular artery, 2 — atrioventricular node, 3 — right fibrous triangle, 4 — interatrial septum (male, 92-year-old; A-V block with pacing VVI, Masson-Goldner, × 45).

septum (Fig. 4). The superficial part occurred in all hearts of the control group and in 80% of the paced group. No statistically significant relationship was observed between these groups. The deep layer of the atrionodal inputs occurred in 80% of the control group and in 34% of the paced group ($p < 0.05$).

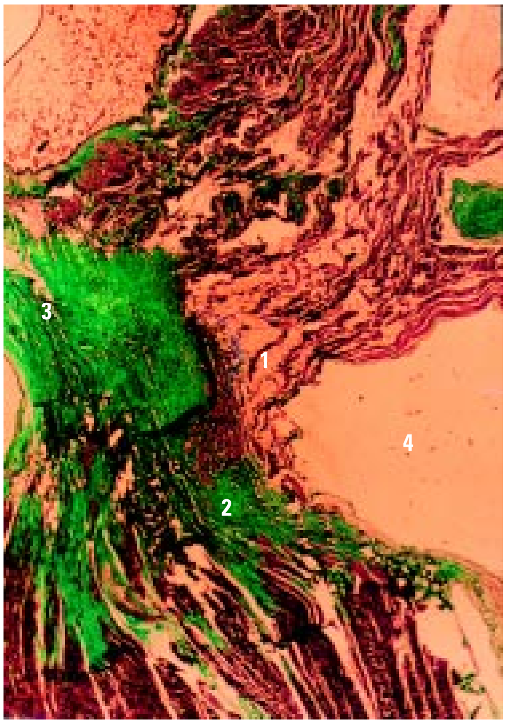

Figure 3. Microphotograph showing the superficial part of the atrionodal inputs (female, 68-year-old); 1 — atrionodal inputs (superficial part), 2 — atrioventricular node, 3 — right fibrous triangle, 4 — right atrium cavity.

Figure 4. Microphotograph showing the deep part of the atrionodal inputs (female, 57-year-old); 1 — atrionodal inputs (deep part), 2 — atrioventricular node, 3 — right fibrous triangle, 4 — right atrium cavity.

DISCUSSION

Radiofrequency current ablation is the only radical method of therapy of atrioventricular reentrant tachycardia. With the use of delivering of energy arrhythmia substrate can be damaged of both circus and focal origin [5]. The area of damaged tissue during the application of radiofrequency energy in optimal application conditions is 3–5 mm in diameter and 2–4 mm in depth, according to various authors [1]. Tanaka et al. [10] confirmed that, during direct nodal ablation in dogs producing atrioventricular blocks, atrioventricular nodal artery showed only slight intimal oedematous fibrosis and slight medial oedema with up to 25% stenosis, but in one dog it showed intimal fibroelastosis with 50% stenosis. As a result of these authors' experiments, distant complete A-V block occurred most often in dogs with a stenotic nodal artery [10]. On the basis of our results, parietal thrombi occurred in 90% of cases in the paced group of hearts and in 30% in the control group. It would seem inevitable to have atrioventricular nodal changes with concurrence of A-V block. On the other hand we were able to confirm that a fair distance between the atrioventricular nodal artery and A-V junction in the area of the fast pathway protects it from eventual damage from applied energy. Therefore, as it seems to date, the only explanation for such a complication is direct damage of the atrioventricular junction.

Anderson and his colleagues [3], however, connect the explanation of various complications after radiofrequency ablation in the area of the fast pathway with the presence of tissue responsible for conducting impulses. He stresses the presence of so-called atrionodal inputs which, running into the node, could act as one of the circus movement tracks. From the histological standpoint these are transitional cells which form an arch around the compact node, being the continuation of the atrial cells approaching from the left side of the septum, from the anterior rim of the oval fossa, and from the sinus septum. It is the damage of exactly these during the ablation of the fast or slow pathway which can lead to complete A-V block [3]. On the basis of our results, we can confirm that in approximately 80% of examined hearts in the area of the right fibrous trigone, and therefore in the same area where radiofrequency energy is applied in fast pathway ablation, hypothetically, coagulation of the atrionodal inputs can occur and lead secondarily to infarct within nodal tissue.

Some investigators confirmed that the complication after fast pathway ablation could be connected with the size of the triangle of Koch. McGuire et al. [8] studied the dimensions of the triangle during surgical procedures and demonstrated that Koch's triangle was relatively uniform, however Ueng et al. [11] reported, based on post mortem hearts, a marked variability in the dimensions. Our data also suggest that diversity in the histologically measured size of Koch's triangle may have clinical importance during ablation procedure.

On the basis of our study we could conclude that the real substrate of atrioventricular nodal reentry tachycardia seems to lie in the anterior-superior region very superficially and far from the conduction tissue. Atrioventricular nodal artery in this area was lying deep beneath the endocardium and the distance probably protects it from eventual damage from applied energy. It seems to date the only explanation of atrioventricular block as a procedure complication is direct damage of the atrioventricular junction.

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