Development of the atrioventricular junctional area in the human heart

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[Received 20 December 2000; Accepted 12 January 2001]

INTRODUCTION

The heart has been the subject of much research, and observations regarding its structure reach back to the beginnings of medical research. The first information regarding the existence of special neuromuscular fibres was described by Purkinje [11]. He differentiated strands of cells within the ventricles, which now carry his name, he described them as nerve cell cardiac fibres — he was not however, aware of their connection to the conductive system of the heart. Most publications which determined the structure of the atrioventricular part of the conduction system were written by Tawara [13]. He described the a-v node in great detail and showed its connection to the bundle of His and Purkinje fibres. Also Bharati et al. [5] and Truex et al. [14] described the microscopic anatomy of the a-v node and bundle with connection to the cause of death. The system-
Table 1. Break down of the researched material

<table>
<thead>
<tr>
<th>Material (hearts)</th>
<th>Age</th>
<th>Number of hearts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foetal</td>
<td>16–42 Hbd</td>
<td>31</td>
</tr>
<tr>
<td>Newborn</td>
<td>5 minutes–1 month</td>
<td>11</td>
</tr>
<tr>
<td>Infant</td>
<td>2–11 months</td>
<td>9</td>
</tr>
<tr>
<td>Children</td>
<td>2.5–16 years</td>
<td>16</td>
</tr>
<tr>
<td>Younger adult</td>
<td>19–46 years</td>
<td>21</td>
</tr>
<tr>
<td>Older adult</td>
<td>50–105 years</td>
<td>12</td>
</tr>
<tr>
<td>Total</td>
<td>16 Hbd–105 years</td>
<td>100</td>
</tr>
</tbody>
</table>
up till 6 (older hearts) compartments of nodal tissue and their cells pass over the right fibrous trigone form in 70% islets (‘tongue’ like — 80%, “loop” like — 20%), especially in the very young (foetal) and old (older adults) hearts (Fig. 2).

The penetrating bundle is built of typical, well-known small cells, forming the muscle tissue of the conductive system of the heart. This is a homogeneous structure and completely bounded by a sheath of connective tissue. With regards to topography, it is located in the membranous septum, and more precisely in the a-v part of the septum. Within the penetrating zone, fibrous tissue made 2–5 (only older hearts) compartments of tissue and their distal cells could form in 5% of examined hearts islet (“tongue” like only — 100%), especially in the very young (foetal) and old (older adults) hearts. The non-branching bundle does not differ practically from the penetrating with regards to morphology but the difference was in its topography. However, it is not a stable structure, as it occurred in only 10% of examined hearts, and only in hearts above 50 years of age (Fig. 3). The branching bundle did not differ with regards to histological structure from the previously mentioned parts, but the main difference was that within it the right and left branches were starting to form. As the origin of the branching bundle we accepted the exit of the left branch, as it first emerged from the bundle. In 87% of hearts it is placed very superficially and completely subendocardially, but only at the level of the smooth muscle part of the interventricular septum (Fig. 4). However, most often, in 98%, the right
branch was the direct prolongation of the a-v bundle axis and its initial part was a homogeneous structure, and afterwards directed itself downwards and penetrated the middle part of the septum.

**DISCUSSION**

The atrioventricular junctional area, due to its clinical significance, was the subject of interest for many researchers. Some were only interested in its anatomy, others took their observations from a clinical standpoint (invasive electrophysiology). Anderson et al. [2,3] differentiated four parts of the a-v junctional area, based however on the examination of adult human hearts only. Based on the relative position of various types of cells, we could differentiate an additional two zones: prenodal zone (occurred in all hearts) and non-branching bundle zone (occurring in 10% of examined hearts). This difference comes from the various group of examined hearts (35 vs 100 hearts). Inoue and Becker [8] determined that the initial portion of the a-v node in the form of posterior extensions does not occur in all hearts. They examined 21 hearts only and did not give details regarding the age of the histologically proved hearts. In our study, in contrast to the above—mentioned authors, we observed the presence of the initial a-v node’s part in all groups of hearts, which is consistent with our previous results [9]. This part was composed of cells which can form three groups around the a-v nodal artery. The prenodal zone, running into the consistency of the so-called internodal zone, directly joining both nodes, the sinoatrial and the atrio-ventricular, has been and still is a place of much controversy. Hypothetically, within the right atrium three internodal tracts are differentiated: the anterior (Bachmann’s bundle), the middle (Wenckebach’s bundle) and the posterior (Thorel’s bundle). Their placement in the prenodal zone was similar to the course of the atrial muscle tissue forming the terminal bundles [6]. Hecht et al. [7], based on electrophysiological properties within in the a-v part of the conduction system, differentiated two main zones: junctional tissues and subjunctional tissues. We stated that within the prenodal zone two bundles were visible: superior and inferior only. Both of them consisted of typical muscle working atrial cells. However this does not exclude any incremental conduction from the clinical point of view, as observed by McGuire et al. [10]. Within the cells of the compact zone we stated fibrous tissue made 2 up to 6 compartments of nodal tissue and their cells pass over the right fibrous trigone form in 70% islets (“tongue” like — 80%, “loop” like — 20%), especially in the very young (foetal) and old (older adults) hearts. Additionally within the penetrating zone fibrous tissue made 2–5 compartments of tissue and their distal cells could form in 5% of examined hearts islet (“tongue” like only — 100%). In the literature we found information regarding this from the clinical point of view only. Rossi et al. [12] and Batsford et al. [4] stated that in the presence of cardiac sudden death such islets may play a role in the creation of the impulses and its circulation, leading to death. We did not think in such a way, because islets (loops or tongues) could be stated in approximately 70% of hearts, which belongs to normal anatomical structure.

This research proves that the atrioventricular junction is a stable structure occurring in all hearts, undergoing involutional changes with age, in which two main parts can be differentiated: the node and the bundle. The morphology of the node is very complex, because it is composed of three zones: the prenodal, the perinodal and the main, differing in cell structure and position. The topography of the node is generally stable, as it lies in the interatrial septum and always above the septal leaflet of the tricuspid valve. The structure of the bundle in contrast to the node is more stable and consists of the following
parts: the penetrating, the non-branching and the branching. Its topography is also stable, as it lies in the membranous septum, mainly below the septal cusp of the tricuspid valve.

REFERENCES