DIMENSIONS AND MUSCULAR ARCHITECTURE OF THE TRIANGLE OF KOCH

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A b s t r a c t: The variability in the arrangement of the superficial atrial muscle fibers in the areas of the triangle of Koch may be one of the factors influencing the route for impulses entering the AV node.

The purpose of this study was to present the dimensions of the triangle of Koch and to describe the arrangement of the subendocardial atrial muscle fibers that form the approaches to the AV node, in and around the area of the triangle of Koch.

The examination was made on 50 human hearts got obtained after autopsies of patients older than 18 years, died from no cardiac reasons, and fixed in 10% formaldehyde.

The dimensions of the triangle of Koch were measured using the caliper. For the analyzing of the arrangement of the subendocardial muscle fibers, the right atrium was divided into four areas and the atrial endocardium was carefully peeled.

The mean value of the area of the triangle of Koch (P) was 261.65 ± 52.30 mm² (min 160.00; max 375.00), the length of side a, was 24.14 ± 14.25 mm (min 18; max 29), side b, was 20.12 ± 2.42 mm (min 15; max 25) and side c, was 25.80 ± 2.83 mm (min 20; max 31).

The analyzing of the arrangement of the subendocardial superficial muscle fibers showed that 36 of the specimens had approximateley precise patterns of fiber orientation within the areas of the right atrium. Variations in the fiber orientation were observed in 14 specimens.

The knowledge of the anatomic features, dimensions and the architecture of the subendocardial muscle fibers of the triangle of Koch is the essential for both successful...
investigation and interpretation of the electrophysiological basis of heart dysrhythmic diseases.

**Key words:** atrioventricular node, statistics & numerical data, subendocardial arrangement of right atrial muscle fibers at triangle of Koch.

**Introduction**

The development of ablation techniques for treatment of atrioventricular nodal reentry tachycardia (AVNRT) renews the interest for the morphology of the content in the triangle of Koch. This triangular area is situated between the lower atrial septum and the tricuspid valve. It was for the first time described by Koch in 1909, with the heart as seen within the body viewed in the anatomic position. The margins of the triangle are as follows: the tendon of Todaro (the fibrous commissure of the valves guarding the openings of the inferior cava vein and the coronary sinus) and the attachment of the septal leaflet of the tricuspid valve that converge at its apex, and the orifice of the coronary sinus which is triangle’s base [1, 2, 3, 4]. For ease description of the right atrium, during gross dissection, four mean areas can be distinguished: posteroinferior (PI), sinus septal (SS), vestibular (V), and anterosuperior (AS) area [1, 5]. The superficial muscle fibers are arranged in almost regular patterns within those areas. The AV node itself is located deep beneath the intersection of the sinus septal, vestibular, and anterosuperior areas, toward the apex of the triangle of Koch. The variability in the arrangement of the superficial atrial muscle fibers in the areas of the triangle of Koch may be one of the factors influencing the route for impulses entering the AV node [1, 5].

The purpose of this study was to present the dimensions of the triangle of Koch and to describe the arrangement of the superficial atrial muscle fibers that form the approaches to the AV node, in and around the area of the triangle of Koch.

**Materials and Methods**

The examination was made on 50 human hearts obtained from autopsies of patients older than 18 years, died from no cardiac reasons. The hearts were removed intact, together with the proximal parts of the great arteries and veins, and fixed in 10% formaldehyde, for at least 72 hours. The right atrium was opened through an incision between the superior and inferior caval venous orifices, and then by extending an incision perpendicular to the first along the lateral wall of the atrium into the right appendage.
The dimension of the triangle of Koch was measured using the caliper. Margin a was measured as the length of the tendon of Todaro; margin b (the base of the triangle) was the distance from the tendon of Todaro to the septal leaflet of the tricuspid valve (at the right angle to the leaflet) through the coronary sinus ostium; margin c was the distance from the insertion of the side b to the central fibrous body, along the septal leaflet of the valve (Figure 1). The square area of the triangle was calculated as \( P = \frac{b \times c}{2} \). Values were expressed as mean ± standard deviation.


For the analysis of the arrangement of the inner atrial muscle fibers, the right atrium was divided into four areas (schematically presented at figure 2).
and the atrial endocardium was carefully dissected. In describing the findings, the term "muscle fiber" was used in a macroscopical sense to refer to those bundles that can be revealed simply by removing the endocardium. The orientation of the fibers was found as follows: circumferential (parallel to the AV junction), longitudinal (parallel to the interatrial groove at the right angle to the AV junction) and oblique (oblique to the AV junction).

**Figure 2 – Areas of the triangle of Koch**

A – anterosuperior area; P – posteroinferior area; SS – sinus septal area;
V – vestibular area; CS – coronary sinus; OF – oval fossa;
OVC – orifice of the caval vein; TT – tendon of Todaro

**Слика 2 – Зона на триаголникот на Koh**

A – антеросупериорна зона; P – постероинфериорна зона; SS – синус септална зона; V – вестибуларна зона; CS – коронарен синус; OF – овална јама; OVC – остиум на вена сака; TT – тендон на Todaro

Results

The post mortem measuring of the 50 heart specimens from the patients with average age of 57 ± 16.89 (min 20; max 88) years, 18 females and 32 males, obtained the following results:
The mean value of the area of the triangle of Koch (P) was $261.65 \pm 52.30 \text{ mm}^2$ (min 160.00; max 375.00), the length of side a, was $24.14 \pm 14.253 \text{ mm}$ (min 18; max 29), side b, was $20.12 \pm 2.42 \text{ mm}$ (min 15; max 25) and side c, was $25.80 \pm 2.83 \text{ mm}$ (min 20; max 31).

The analyzing of the arrangement of the atrial superficial muscle fibers showed that 36 of the specimens had similar precise patterns of fiber orientation within the areas of the right atrium. In the posteroinferior area the superficial muscle fibers had longitudinal, while in vestibular and sinus septal areas they had circumferential direction. In anterosuperior area both types of fiber orientation were present: circumferential (anterior to the oval fossa) and longitudinal (running from the aortic mound, over AV node, to the attachment of the septal leaflet of the tricuspid valve).

Variations in the fiber orientation were observed in 14 specimens. In 9 specimens muscle fibers run obliquely in anterosuperior (5 cases), posteroinferior (2 cases), vestibular (2 cases) and sinus septal (1 case) areas. In 2 specimens muscular fibers in vestibular area had longitudinal direction. Two specimens had only longitudinal fiber orientation in anterosuperior area.

**Discussion**

The triangle of Koch occupies the right atrial part of the muscular AV septum, a sloping area that attains its AV location because of the major difference in the levels of attachment of the leaflets of the tricuspid and mitral valves on either side of the septum [1]. Dimensions of the triangle got with the post mortal measuring in our study varied among the patients, and where correspondent to the published data [1, 3, 4, 6]. Authors, who perform radio frequent ablation techniques for treatment of AVNRT, considering that the tissue of AV node is located at the apex of the triangle of Koch approximately 1 cm anterior of the coronary sinus valve, are interested in such part of the triangle that is smaller than the anatomic one [7, 8, 9, 10]. According to the studies published by Mc Guire *et al.*, the triangle of Koch is described as area with uniform size, so that measurements in hearts postmortem show that the mean height (distance from the tricuspid annulus to the nearest edge of the coronary sinus) was $13 \pm 3 \text{ mm}$ and the mean length (the distance from the central fibrous body to the nearest edge of the coronary sinus) was $17 \pm 3 \text{ mm}$ [7, 9]. The mean height of the triangle measured in postmortem hearts was slightly greater than the one measured at surgery for cardiac arrhythmia ($15 \pm 4 \text{ mm}$) [7].

The right atrium, in and around the triangle of Koch, can be divided into four areas which consist similar orientation of its muscle fibers [1, 2, 3] (Figure 2). The posteroinferior (P) area located behind and beneath the orifice of the coronary sinus, containing mostly longitudinally oriented fibers that
extended from the pectineate muscles to the isthmus between the orifice of the coronary sinus and the septal leaflet of the tricuspid valve. The sinus septal (SS) area is made up of circumferential fibers that ran between the orifices of coronary sinus an inferior vena cava, encircled the oval fossa. The fibers in the vestibular (V) area provided a continuation of the P fibers toward the AV node, but also turned in a spiral pattern around the orifice of the coronary sinus as well as anterosuperiorely to join the SS fibers. Anterosuperior (A) area mostly consisting two groups of subendocardial fibers: circumferential fibers passing in front of the oval fossa, and longitudinal fibers protruding over the AV node. Most variations in fiber arrangement are observed in this area. Marked changes in fiber orientation in the zone of intersection of fibers from SS, V and A areas (at the apex of the triangle of Koch) could account for discontinuity in the spread of the excitatory wave front [1, 3]. In our study 36 of the examined specimens had the usual architecture of the superficial atrial fibers, and most variations were in A area, that correspondent to the published data.

Previous studies have shown that the conduction of the impulses within the muscular walls of both atria reflects the arrangement of well developed muscular bundles. Experimentally were demonstrated two broad bands of atrial approaches to the AV node, one from the inferior region beneath the orifice of the coronary sinus (V area), and the other from the SS area [5]. These approaches reflected the geometry of the right atrium produced by the orifices of the caval veins, the coronary sinus, and the oval fossa.

The relationship between the above described gross morphologic picture of the atrial approaches and the compact AV node is of great importance. The orientation of the superficial muscle fibers correlated with the known patterns of activation. The propagation of impulses directed parallel to the muscle fibers is faster than propagation in a direction at right angles to the fiber (anisotropic conduction). So, the variability in the orientation of the fibers in the approaches may influence the input of impulses to the AV node. The variation or changes in orientation from one area to another, or within the same area, may potentiate reentrant circuit.

In conclusion, the knowledge of the anatomic features, dimensions and architecture of the subendocardial muscle fibers of the triangle of Koch is of great importance for successful observation and interpretation of the electrophysiology of the atrioventricular node in health and disease.

REFERENCES


Резиме

ДИМЕНЗИИ И МУСКУЛНА АРХИТЕКТУРА НА ТРИАГОЛНИКОТ НА КОХ

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Варијациите во организираноста на површинските предкоморни мускулни влакна во пределот на триаголникот на Кох, можат да влијаат на патот на шириење на импулсите до атриовентрикуларното (АВ) јајло.

Целта на овој труд е да се прикажат димензизите на триаголникот на Кох и да се направи опис на организираноста на површинските предкоморни мускулни влакна кои ги формираат природите на АВ јајлот, во и около триаголникот на Кох.

Испитувањето е направено на 50 хумани срца добиени по аутоопсии на пациенти постари од 18 години, кои не се починали од срцеви заболувања, фиксирани во 10% формалин.

Димензиите на триаголникот на Кох се мерени со калипер. За анализирање на организираноста на површинските предкоморни мускулни влакна, десната предкомора е поделена на четири зони, а ендокардот е внимателно излупен.

По мерењата добиени се следниве средни вредности: површината на триаголникот на Кох изнесува 261,65 ± 52,30 мм² (min 160,00; max 375,00), должината на страната а, беше 24,14 ± 14,2,53 мм (min 18; max 29), на страната b, 20,12 ± 2,42 мм (min 15; max 25) и на страната c, 25,80 ± 2,83 мм (min 20; max 31).

Анализата на организираноста на површинските предкоморни мускулни влакна покажа дека 36 од препаратите имаат поставеност на мускулните влакна карактеристична за соодветните зони. Каж од препаратите утврдени се варијации во нивната ориентација.

Познавањето на анатомските карактеристики, димензии и архитектура на површинските мускулни влакна на триаголникот на Кох претставува основан предуслов за успешно толкување на електрофизиолошките студии.

Ключни зборови: атрио-централен јазол, електрофизиологија, нумерички и статистички податоци, триаголник на Кох.

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