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# Microscopic study of right fibrous annulus

M. Dudziak[1], M. Skwarek[2], J. Hreczecha[3], J. Jerzemowski[4], M. Grzybiak[3]

[1]*Noninvasive Cardiovascular Diagnostic Unit, II Chair of Cardiology, Medical University of Gdańsk, Poland*
[2]*Department of Sports Medicine, the J. Śniadecki Academy of Physical Education and Sport, Gdańsk, Poland*
[3]*Department of Clinical Anatomy, Medical University of Gdańsk, Poland*
[4]*Department of Anatomy and Anthropology, the J. Śniadecki Academy of Physical Education and Sport, Gdańsk, Poland*

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*The term annulus fibrous is still used in anatomical and clinical terminology but does not exist in anatomical nomenclature. This structure is proposed as an anatomical substrate for circus movement of excitation. Multiple cardiac damage after blunt chest trauma is rare, but usually affects the septal part of the right fibrous annulus. Histological observation confirms the results of our previous macroscopic study and shows that the most stable part of fibrous annulus is the septal part and the region of anterior angle of the right ventricle, and the most labile parts are the lateral and posterior angles of the right ventricle and the posterior part of the fibrous annulus. Our histological study shows that the right fibrous annulus is a heterogeneous structure and may play a role in changes of shape of the right atrio-ventricular ostium during human life.* (Folia Morphol 2009; 68, 1: 32–35)

**Key words: tricuspid valve, right atrio-ventricular ostium, human heart, morphology, morphometry**

## INTRODUCTION

The right and left fibrous annuli and right and left fibrous trigoni build the skeleton of heart, which is described in classic textbooks of anatomy. The term annulus fibrous is still used in anatomical and clinical terminology but does not exist in anatomical nomenclature. This structure is proposed as an anatomical substrate for circus movement of excitation [1, 2, 4, 5, 12]. Multiple cardiac damage after blunt chest trauma, as first described by Hewett in 1847 as traumatic ventricular septum defect, is very rare, but usually affects the septal part of the right fibrous annulus [8]. Real time 3D echocardiography studies show a non-planar structure of the tricuspid annulus [3]. The tricuspid valve orifice changes shape during life [13]. Histological data of right fibrous annulus are incoherent and fragmentary. Microscopic study of the right fibrous annulus may be helpful in answering the question: is it only pressure in the right atrium and right ventricle that exerts an influence in the shaping of the ostium, or does the ultrastructure of the right fibrous annulus, as a part of the fibrous skeleton of heart, have an influence too? According to Puff [10], the ultrastructure of the fibrous annulus may play a role in the regurgitation of valves. Studies by Racker et al. [11] showed that continuous circumferential lamina provided the anatomic substrate for circus movement of excitation.

## MATERIAL AND METHODS

Examinations were carried out on 45 formaline-fixed hearts of human adults of both sexes (32 men, 13 women) ranging from 18 to 90 years old (mean 41.66 ± 15.87 years) (Table 1), without heart malformations and pathological changes, who died

Address for correspondence: J. Hreczecha, Department of Clinical Anatomy, Medical University of Gdańsk, Poland, Dębinki 1, 80–211 Gdańsk, Poland, tel./fax: +48 58 349 14 20, e-mail: chanastra@interia.pl

**Table 1.** Division of studied group with regard to sex and age

| Age group | Sex | Number | Mean age | SD |
|---|---|---|---|---|
| 18–40 years | Female | 9 | 28.55 | 7.78 |
| | Male | 39 | 27.82 | 6.65 |
| 41–65 years | Female | 16 | 58.78 | 5.35 |
| | Male | 25 | 59.28 | 6.31 |
| Over 65 years | Female | 4 | 79.5 | 7.93 |
| | Male | 5 | 71.2 | 4.65 |

from non-vascular diseases. The hearts were non-macerated and preserved by immersion in 4% neutral formalin solution, and then dissected. Dissection of the fixed hearts was performed according to standard autopsy techniques, along the path of blood flow, from the superior vena cava orifice to the right atrioventricular orifice. Right atrioventricular orifices including right fibrous annulus were dissected. After standard processing procedures, the specimens were stained using the van Gieson and Manson methods.

Fibrous annulus was defined as collagen fibres between the muscles of the right atrium and ventricle passing without direct border into the skeleton of the tricuspid valve [14, 15].

## RESULTS

Connective tissue between the muscle of the atrium and the muscle of the ventricle was found in all cases. The epicardial aspect of the fibrous annulus abuts the ventricular septum and aortic root in the medial part and was covered by the fat of the coronary sinus in the posterior region. The endocardial aspect was delimited by the tricuspid leaflets.

Right fibrous annulus is histologically a heterogeneous structure. The central part of the annulus is a "histological centre" and consists of interlinked fibres and fibrocytes, and the peripheral part consists of fibres. The external and middle layers of the musculature of the right ventricle were twisting near the fibrous annulus (Fig. 1). Most compounds were septal parts of the annulus and the region of the anterior angle of the right ventricle. We have observed that the number of fibrocytes and elastic fibres decreases during life and number of collagen fibres increases (Fig. 2), and one muscular fibre of the ventricle passage into many collagen fibres (Fig. 3).

The continuous circumferential lamina of connective tissue is most prominent in all parts of tricuspid attachment.


**Figure 1.** Heart of a 21-year-old men. Longitudinal section in plane oblique to posterior wall of ostium; RAW — wall of right atrium, ATCS — adipose tissue of coronary sulcus, EPRV — external part of right ventricle, CP — posterior cusp (Masson staining).

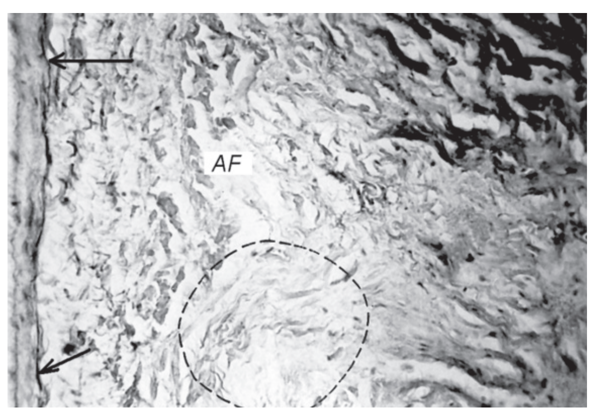


**Figure 2.** Heart of a 21-year-old man, region of lateral angle of right atrioventricular ostium. Arrows show elastic fibres lying in atrial side of fibrous annulus (AF). Histological centre of fibrous annulus has been marked with intermittent line (Van Gieson staining).

We observed that the thickness of the region of the lateral angle of the right ventricle and the posterior part of the fibrous annulus decreased during

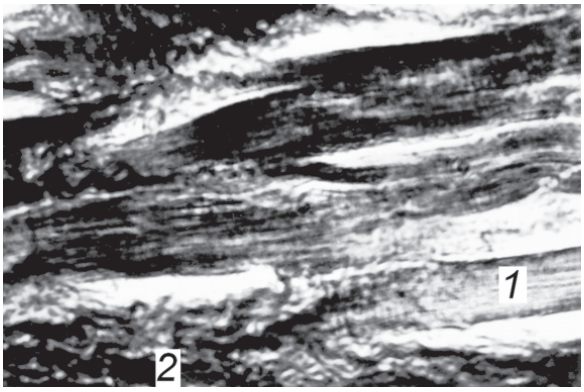


**Figure 3.** Heart of a 47-year-old man. Myocardial fibre (1) passage into many collagen fibres (2) (Van Gieson staining).

life (Fig. 4). The thickness of the right fibrous annulus, compared with the thickness of the right ventricle in the septal part, increases during aging. We observed macro- and microscopically a slim fibromuscular layer under the tricuspid valve in the group of oldest hearts (Fig. 5).

## DISCUSSION

The fibrous nature of the annulus defines its basic function: to provide a hard origin of the leaflets and ensure the leaflets during the systole. The dynamic function as a sphincter, an active contraction provided by the atrial muscle, was observed in electrophysiological study [9, 10].

Histological observation confirms the results of our previous macroscopic study [13], and shows that the most stable part of the fibrous annulus is the septal part and the region of the anterior angle of the right ventricle, and the most labile parts are the lateral and posterior angles of the right ventricle and the posterior part of the fibrous annulus.

Racker et al. [11], in studies performed in the canine model, observed myofibres inserted into fibrous tissue superior to the septal leaflet. These authors found that discontinuous subendocardial perpendicular lamina contains myofibres that

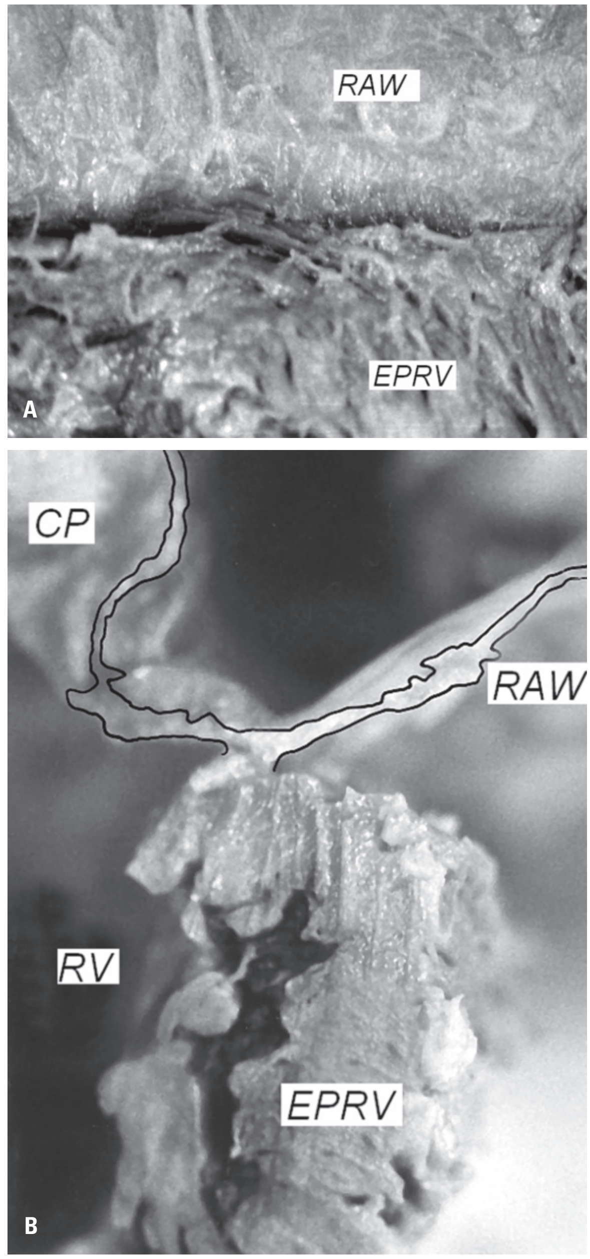


**Figure 5.** Heart of an 86-year-old woman, region of lateral angle of right ventricle; **A.** Lateral angle seen from side of coronary sulcus after removing of epicardium; **B.** Longitudinal section in perpendicular plane to circuit of ostium. The wall of atrium and posterior leaflet has been contoured; RAW — wall of right atrium, EPRV — external part of right ventricle (RV), CP — posterior cusp.

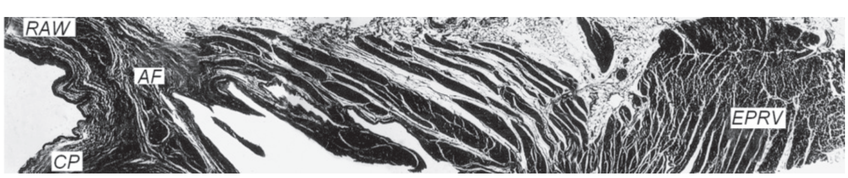


**Figure 4.** Heart of an 87-year-old man. Thickness of fibrous annulus (AF) in heart of older person is thinner than in younger hearts; RAW — wall of right atrium, EPRV — external part of right ventricle, CP — posterior cusp (Van Gieson staining).

descend from the atrium, which insert into the fibrous annulus. They concluded that the continuous circumferential lamina provided the anatomic substrate for circus movement of excitation in this model. We did not find myofibres in the fibrous annulus, but our other results are coherent with this study. Mathematical models of heart valves as resistance components and the blood-leaflet interaction effect showed that the highest pressure forces of blood are located in the septal part and the anterior angle of the right fibrous annulus [7]. A similar conclusion was formed based on studies performed in magnetic resonance imaging [6]. These observations are coherent with our results. Our histological study shows that the right fibrous annulus is a heterogeneous structure and may play a role in changes of shape of the right atrio-ventricular ostium during human life.

Our histological observation showed that the most stable parts of the fibrous annulus are the septal part and the region of the anterior angle of the right ventricle, and the most labile parts are the lateral and posterior angles of the right ventricle and the posterior part of the fibrous annulus. This study confirmed that the right fibrous annulus is a heterogeneous structure. This heterogeneity may play an important role in changes of its shape during life and, with other risk factors, in the occurrence of acquired right regurgitation as a consequence of it.

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