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Preliminary study of external interatrial muscle fascicles

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The atria are highly complex multidimensional structures composed of a heterogeneous branching network of subendocardial muscular bundles. The relief of the inner part of the right atrium includes the crista terminalis as well as multiple pectinate muscles that bridge the thinner atrial free walls and appendages. However, a handful of studies have focused attention on the role of the naturally occurring complexities of the atrial subendocardial muscle structures in the mechanisms of cardiac arrhythmias. In accordance with the facts mentioned above, it was decided to examine the morphology and topography of the external interatrial junctions and related structures in order to define the possible anatomical basis of impulse propagation in focal atrial fibrillation.
Research was conducted on material consisting of 15 human hearts of both sexes (female — 6, male — 9) from 18 to 82 years of age. In addition we were concerned, on the basis of the history and electrocardiograph tracings, that none of the patients had shown focal and non-focal type of atrial fibrillation. The classic macroscopic methods of anatomical evaluation were used. The walls of the atria were prepared via a stereoscopic microscope, the pericardium and fatty tissue were eliminated from the surface of the atria, visualising muscle fibres linking both of the atria, and the beginnings and the endpoints of fascicles in the right and left atrium were estimated. The structure, large muscle bundle, was present in all examined hearts. The muscle fascicle was descending from the anterior wall of the right atrium just below the orifice of the superior vena cava. The fascicle, running towards the left atrium, divided into two branches, one of which joined with the superior fascicle from the posterior wall and created one running above the interatrial septum and infiltrating into the wall of the left atrium on its superior surface between the superior pulmonary veins. The other branch of the anterior fascicle was running across the anterior wall of the atria and it penetrated into the left atrium muscle in the region of the inferior pole of the left auricle outlet. On the posterior wall of the atria three types of interatrial fascicles were distinguished: unifascicular, bifascicular and trifascicular. The bifascicular type was the most frequent configuration (9 cases — 60.0%), in 5 cases it was trifascicular (33.3%) and finally the unifascicular configuration was observed in just 1 heart (6.7%). On the basis of our study we can conclude that the external interatrial fascicles are the constant structure of the heart,

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although they may have a variable morphology. Those structures could be responsible for physiological conduction between the atria and may play an important role in patients with atrial fibrillation.

key words: interatrial muscle bundle, exterior of the atria, atrial fibrillation, gross anatomy

INTRODUCTION

The atria are highly complex multidimensional structures composed of a heterogeneous branching network of subendocardial muscular bundles [5, 7]. The relief of the interior of the right atrium includes the crista terminalis and Bachmann bundle, as well as multiple pectinate muscles that bridge the thinner atrial free walls and appendages. On the other hand, muscular continuity is interrupted by a number of natural orifices [11, 12]. The major orifices of the atria have been suspected of being involved in the initiation and maintenance of the so-called focal type of atrial fibrillation. However, a small number of studies have focused attention on the role of the naturally occurring complexities of the atrial subendocardial muscle structures in the mechanisms of cardiac arrhythmias [6, 10]. It has been shown that impulse propagation in such structures is anisotropic and may be discordant with respect to epicardial activation, particularly in those areas in which the atrial wall is thickest [14]. This phenomenon could be responsible for the initiation of atrial fibrillation. Gross anatomy distinguished the presence of three intraatrial pathways. The anterior internodal pathway begins at the anterior margin of the sinus node and curves anteriorly around the superior vena cava to enter the anterior interatrial band. This band continues to the left atrium, with the anterior internodal pathway entering the superior margin of the atrioventricular node. The large muscle bundle appears to conduct the cardiac impulse preferentially from the right to the left atrium [1]. Mapping studies in humans have revealed that more rapid conduction velocity in some parts of the atrium than in other parts does exist and may be due to fibre orientation, size and geometry. More recently, experiments conducted by de Ponti et al. [13] have proved that, in normal patients, propagation of the sinus rhythm goes via the roof of the left atrium. In contrast, patients with atrial fibrillation have a transseptal way of propagation. In relation to this, it was decided to examine the morphology and topography of the external interatrial junctions and related structures in order to define the possible anatomical basis of impulse propagation in focal atrial fibrillation.

MATERIAL AND METHODS

Research was conducted on material consisting of 15 human hearts of both sexes (female — 6, male — 9) from 18 to 82 years of age. Hearts were fixed in a 10% formalin/98% ethanol solution. Only hearts showing no pathological changes or congenital disorders were considered. In addition we were concerned, on the basis of the history and electrocardiograph tracings, that none of the patients had shown focal and non-focal type of atrial fibrillation. The classic macroscopic methods of anatomical evaluation were used. The walls of the atria were prepared via a stereoscopic microscope. Due to exact observation, the pericardium and fatty tissue were eliminated from the surface of the atria, visualising the muscle fibres linking both of the atria. Thereafter the beginnings and the endpoints of fascicles in the right and left atrium were estimated.

RESULTS

The large muscle bundle was present in all examined hearts. The muscle fascicle was descending from the anterior wall of the right atrium just below the orifice of the superior vena cava. The fascicle, running towards the left atrium, divided into two branches, one of which joined with the superior fascicle from the posterior wall and created one running above the interatrial septum and infiltrating into the wall of the left atrium on its superior surface between the superior pulmonary veins. The other branch of the anterior fascicle was running across the anterior wall of the atria and penetrated into the left atrium muscle in the region of the inferior pole of the left auricle outlet (Fig. 1). On the posterior wall of the atria three types of interatrial fascicles were distinguished: unifascicular, bifascicular and trifascicular. All of the fascicles took their beginning inferiorly to the outlet of the superior vena cava and, running obliquely and upwards above the interatrial septum, penetrated into the left atrial muscle on its postero-superior surface. The superior

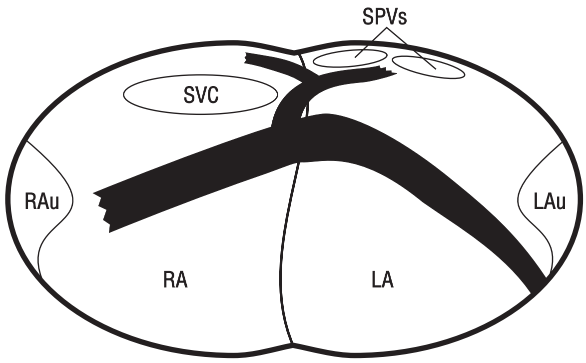

Figure 1. Antero-superior view of fascicles between right and left atrium; SVC — superior vena cava, SPVs — superior pulmonary veins, RA — right atrium, LA — left atrium, RAu — right appendage, LAu — left appendage.

fascicle, as mentioned above, always linked with the anterior wall fascicle, independently of the bundle type. The most frequent configuration — 9 cases — was the bifascicular scheme (Fig. 2A); in 5 cases it was trifascicular (Fig. 2B). The unifascicular configuration was observed in just 1 heart (6.7%) and was the most infrequent one (Fig. 2C). The bifascicular, trifascicular, unifascicular configurations of interatrial fascicles on the posterior wall of the atria are clearly shown in Figures 3A, 3B and 3C respectively.

DISCUSSION

Atrial fibrillation is the most common cause of arrhythmias, occurring in 0.4% of the general population and increasing rapidly with age to 5.9% over the age of 65 years [3]. The mechanism of this cardiac rhythm disturbance has been the subject of study since the beginning of last century [6]. Initially focal mechanisms were favoured, later giving way to reentrant mechanisms. The first author to focus on morphological changes in atrial fibrillation was Bailey. He stressed that atrial fibrillation leads to diffuse atrophy of the muscle. However, he did not mention any pathological changes within the external interatrial muscles [3]. In contrast, van Dam and Durrer [4] observed fractionated electrograms in the left atrium and concluded that functional dissociation between various elements in these muscle strips may give rise to atrial fibrillation. On the basis of our morphological study, we can confirm that non-homogeneous morphology of the interatrial bundles could be the reason for electrophysiologically heterogeneous propagation and thus initiation and maintenance of atrial fibrillation. De Ponti et al. [13], using the newest three-dimensional system CARTO,

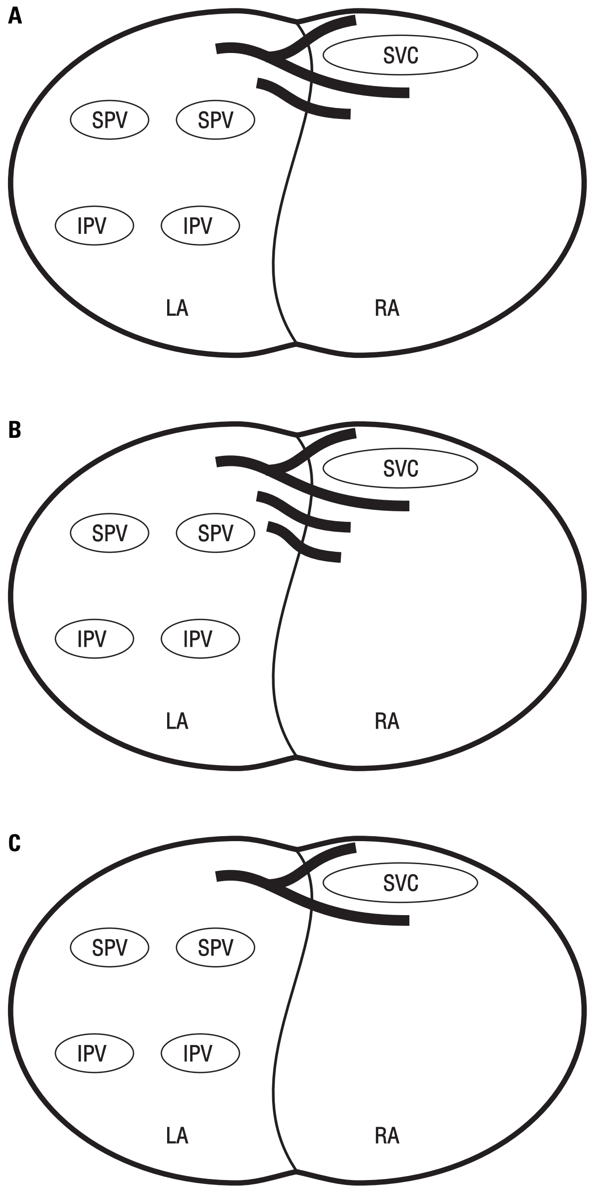

Figure 2 A. Scheme of bifascicular configuration of interatrial fascicle on the posterior wall of atria; **B.** Scheme of trifascicular configuration of interatrial fascicle on the posterior wall of atria; **C.** Scheme of unifascicular configuration of interatrial fascicle on the posterior wall of atria; SVC — superior vena cava, RA — right atrium, SPV — superior pulmonary vein, LA — left atrium, IPV — inferior pulmonary vein.

mapped both atria during sinus rhythm in patients suffering from atrial fibrillation. They confirmed that in patients without atrial arrhythmia propagation of the sinus rhythm involves the upper parts of both atria (from the roof of the right to the roof of the left atrium). In addition, the site of earliest activation was the superior-middle part of the left atrium, where the special muscle bundle ends. In contrast, in patients with atrial fibrillation, they reported the

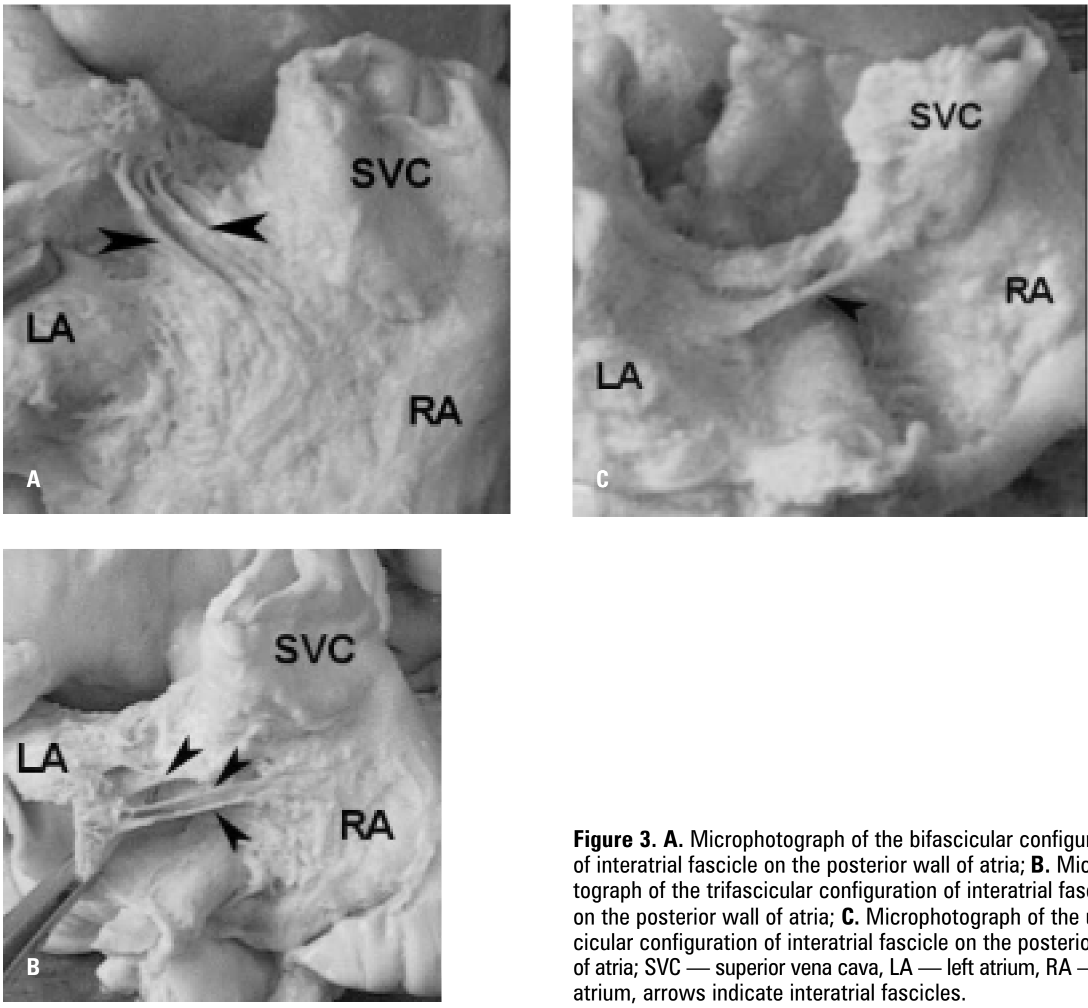

Figure 3. A. Microphotograph of the bifascicular configuration of interatrial fascicle on the posterior wall of atria; **B.** Microphotograph of the trifascicular configuration of interatrial fascicle on the posterior wall of atria; **C.** Microphotograph of the unifascicular configuration of interatrial fascicle on the posterior wall of atria; SVC — superior vena cava, LA — left atrium, RA — right atrium, arrows indicate interatrial fascicles.

transseptal way of propagation [13]. Our morphological study confirms, in all examined hearts, that a special muscle bundle between both atria exists, and always terminates in the middle-superior part of the left atrium. The electrophysiological study of de Ponti et al. [13] is very highly concordant with our anatomical study. The limitations of both studies are the small number of patients (de Ponti's study — 25, our study — 15). Another important piece of advice is surgery for atrial fibrillation. Sueda et al. [16] performed intraoperative mapping of both atria in patients with atrial arrhythmia. They were able to show that the mean atrial fibrillation cycle length in the left atrium was shorter than in the right atrium. Furthermore Sueda and Nagata [15] reported a shortened refractory period in the left atrium, especially in the area of the posterior wall. In our specimens we reported that in the posterior view of the left atrium three types of the morphology of the muscle could be distinguished. The most rare is the unifascicular type and the bifascicular one occurred in the majority of examined hearts. Thus the so-called linear ablation, which modifies the atrial substrate, is not successful in all patients. We suggest that heterogeneous morphology gives a high percentage of procedure failure. A complete linear block enforces an obligatory activation detour, whereas slow conduction in the line allows for an additional activation wavefront across it. Clinical studies indicate that the creation of a linear block is a predictor of a successful clinical outcome [9]. The lines in the right atrium should be septal, however in the left atrium they could create a rectangle involving the posterior wall (which exhibits the most disorganised activity). This supports our findings, showing the most complicated structure of the interatrial muscle bundle on the posterior left atrial wall. Many investigators additionally postulate that within this block

Table 1. Frequency of the interatrial fascicles on the posterior wall of the atria

Type of fascicles	Sex	Number of hearts	Percentage of hearts
Unifascicular	Male	1	6.7%
Bifascicular	Male-Female	5–4 (9)	60.0%
Trifascicular	Male-Female	3–2 (5)	33.3%
Total		**15**	**(100%)**

the roof muscle bundle could be involved. However, the procedure is prolonged and multistage because with current technology it is difficult to achieve a stable linear conduction block [8]. Therefore a history of thromboembolism or tachycardia-related heart failure is the indication for the ablation procedure. On the other hand the morphological basis is still unclear and needs further investigations on a greater number of hearts, especially using microscopic methods.

On the basis of our study we can conclude that the external interatrial fascicles are the constant structure of the heart, although they may have a variable morphology. Those structures could be responsible for physiological conduction between the atria and may play an important role in patients with atrial fibrillation.

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