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Original Research Article

Mechanical function of left atrium and pulmonary vein sleeves before and after their antrum isolation

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ABSTRACT

Background and objective: Pulmonary vein (PV) sleeves are established as the main substrate taking part in the mechanisms of atrial fibrillation (AF) initiation. However, we have extremely few data concerning their physiological role in the heart contractility. The aim of the study was to estimate the mechanical function of the left atrium (LA) and PV sleeves before and early after their isolation.

Materials and methods: A total of 17 patients with a mean age of 57.4 ± 8.3 years who underwent PVs isolation due to AF were enrolled in the study. A day before the procedure a computed tomography (CT) of the LA and PVs and dopplerography of transmitral flow were performed. During the procedure the mechanical function of the LA and PV sleeves were estimated by transesophageal echocardiography and manometry in the left heart chambers.

Results: During the invasive study the patterns of the heart chambers and PV sleeves pressure were identified. These patterns confirmed the active role of the PV sleeves in LA filling and active LA relaxation during left ventricular systole. After PV isolation an alteration of transmitral blood flow and increase of LA pressure were registered. However, diastolic dysfunction was ruled out by LV manometry, thereby testifying LA mechanical function disturbance. The change in PV hemodynamics also occurred as a result of the decrease in PV sleeves contractility, revealed by manometry and paired CT scans.

Conclusions: The PVs take an active part in left atrial filling by contraction of their sleeves. Antrum isolation of the PVs leads to the deterioration of their contractility and LA reservoir function.

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1. Introduction

Traditionally, left atrial mechanical function implies three different mechanisms: the left atrium (LA) actively empties immediately before the onset of left ventricle (LV) systole, the LA is a reservoir that stores pulmonary venous return during LV contraction and isovolumic relaxation, the LA passively empties into the LV down the pressure gradient during LV diastasis [1]. Up to this day, LA mechanical function has been evaluated only in the context of its stunning, which is the development of LA appendage mechanical dysfunction usually accompanied by spontaneous echocardiographic contrast [2]. Mechanisms of stunning are well known, but the overwhelming majority of data concerning these mechanisms were obtained in experimental studies on isolated heart specimens [3]. The analysis of LA mechanical function in humans in so far published studies included peak A presence and amplitude in transmitral blood flow [4–6], measured by the LA dimensions and volume [7] or LA appendage outflow velocity [8,9]. The majority of studies suggested only the fact of contractility decrease or the presence of spontaneous echo contrast after the restoration of the sinus rhythm [10]; in a few studies, there were control groups with sinus rhythm at baseline [2]. As to the LA and pulmonary vein (PV) sleeves mechanical function after their antrum isolation in sinus rhythm patients, in none of the studies the evaluation of any pathogenetic component alteration has been undertaken.

PV sleeves are established as the main arrhythmogenic substrate taking part in the mechanisms of atrial fibrillation (AF) initiation and maintenance [11–14]. However, we have extremely few data concerning their physiological role, namely their direct or mediated participation in contractile function of the heart. Recently, the role of the PV sleeves receptor complex in inotropic responses was established [15], and contradictory data concerning their muscle fibers active contraction was obtained [16–18]. Some authors linked physiological means of this contraction with an obturative function of PV sleeves preventing blood regurgitation during atrial systole [11]. These data were also obtained mainly in experimental studies in animals. There are unpublished reports indicating the ability of the PVs to change the diameter of their ostia during the cardiac cycle. The question is whether these diameter changes depend on active muscle contraction or on passive stretching by the blood pressure.

The objective of the study is to estimate the mechanical function of the LA and PV sleeves before and early after their antrum isolation.

2. Materials and methods

A total of 17 consecutive patients (12 men and 5 women) with a mean age of 57.4 ± 8.3 years were enrolled in the noncontrolled study. The duration of symptoms was 25.2 ± 8.1 months. In 12 patients, arrhythmia was considered idiopathic; 5 of them had postmyocardial infarction syndrome 17.2 ± 6.1 months ago and underwent percutaneous coronary revascularization. All of the patients suffered from paroxysmal atrial fibrillation due to which they underwent antrum PV isolation. All patients had sinus rhythm before, during and immediately after ablation. No one had echocardiographic signs of LA "stunning."

The day before the procedure the ECG-gated contrast multislice computed tomography (MSCT) of the LA and PVs in 4-D mode and simultaneous transmitral blood flow dopplerography were performed. For MSCT a 64-sliced Somatom Sensation 64 (Siemens, Germany) computed tomographic scanner was used. For LA opacification, 100-mL bolus of 350-mg/mL contrast agent was injected in the cubital vein with an automated injection device at a pump rate of 5 mL/s. The section thickness of axial scans was 1 mm with a 0.9-mm interval. Multiplanar and 4-D images were analyzed on a Leonardo workstation (Siemens, Germany) using cardiology preset. ECG gating allowed obtaining images in all the phases of the cardiac cycle. For transthoracic dopplerography Aloka SSSD-5500 Prosound (Aloka, Japan) scanner with sector 3 MHz phased-array transducer was used. After simultaneous registration of both data, the cardiac cycle was divided into 10 equal intervals with an increment of 10%. At the beginning of each interval the diameters of each PV at the sleeve level were measured (Fig. 1), then these measurements were compared with transmitral blood flow pattern (Fig. 2).

During the PV isolation procedure the mechanical function of the left atrium and PV sleeves was estimated by simultaneous

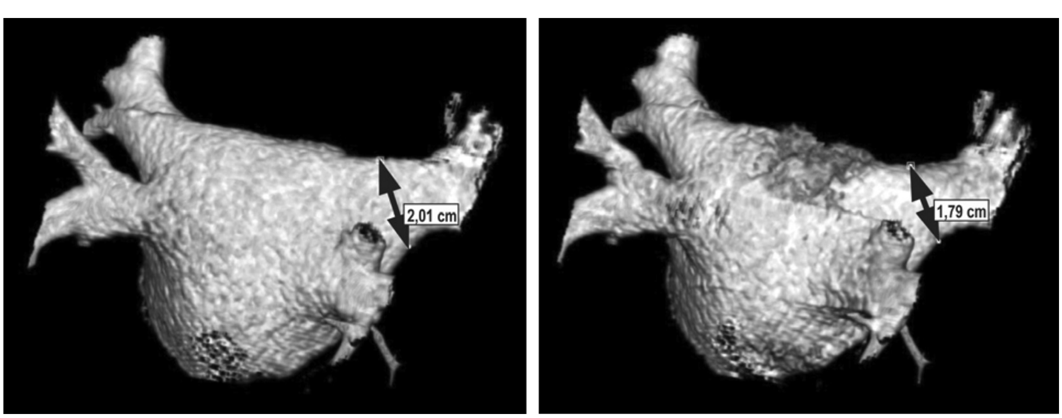

Fig. 1 – Variability of the right superior PV sleeve diameter (1.79–2.01 cm) in the same patient during the cardiac cycle by 4-D multislice computed tomography.