Changes of electrophysiological parameters in patients with atrial flutter

Diana Žaliaduonytė-Pekšienė[1], Tomas Kazakevičius[1, 2], Vytautas Zabiela[1, 2], Vytautas Šileikis[1, 2], Remigijus Vaičiulis[1], Martynas Virketis[1], Aras Puodžiukynas[1]

[1]Department of Cardiology, [2]Institute of Cardiology, Kaunas University of Medicine, Lithuania

Key words: *atrial flutter; electrophysiological parameters; refractory period; impulse propagation speed.*

Summary. *Objectives. The aim of the study was to study some anatomic and electrophysiological features of the right atrium, related to the presence of atrial flutter.*

Materials and methods. A total 23 patients with type I atrial flutter and 22 patients without atrial flutter were studied. Right atrium size was assessed using echocardiography before intracardiac examination and radiofrequency ablation.

Results. Effective refractory periods of coronary sinus, high right atrium, low right atrium were different comparing with the control group ($P<0.05$). A stimulus–response time between high right atrium and low right atrium positions in anterograde and retrograde ways, an impulse propagation speed along the lateral wall of the right atrium were statistically different comparing both groups ($P<0.05$). There was a significant correlation among effective refractory periods measured in different sites of the right atrium ($r^2=0.64, 0.44, 0.44$, respectively). All measured effective refractory periods also correlated with stimulus–response time in anterograde way ($P<0.05$) and impulse propagation speed ($P<0.05$). Right atrium dimensions were significantly larger in atrial flutter group. There was no correlation between the right atrium dimensions and measured electrophysiological parameters in both groups.

Conclusions. The presence of atrial flutter associates with diffuse alterations of the right atrium, but not the focal or single changes of refractoriness.

Introduction

In the last decades, the management of cardiac arrhythmias has known remarkable advances. A large amount of knowledge about tachyarrhythmia mechanisms had previously accumulated and opened the way to the curative approaches. Nowadays, catheter ablation is routinely performed in electrophysiology laboratories. Moreover, the availability of potentially effective tools also contributed to stimulate research and promote a better understanding of rhythm disorders.

Atrial flutter (AFL) is a common atrial tachyarrhythmia. After atrial fibrillation, AFL is the most frequent type of the atrial tachyarrhythmias (1). It affects approximately 88 out of 100 000 new patients each year. In the United States, this represents approximately 200 000 patients presenting with AFL annually. Men are affected more often than women, with a 2:1 male-to-female ratio (2).

The mechanism of typical AFL has been well studied (3, 4). Atrial flutter is caused by a reentrant rhythm in either the right or left atrium. The isthmus between the tricuspid annulus and Eustachian ridge has been recognized as a critical portion of the typical AFL circuit and the target site for ablative therapy (5, 6). It is now well established that human type I atrial flutter is a reentrant arrhythmia, mostly localized in the right atrium (7). However, the therapeutic and interventional progress in the management of AFL was accompanied by further elucidation of the underlying mechanisms. There are some data suggesting that AFL might be initiated due to the differences in refractory periods of atrial tissue (8). Shaowen Liu data show that AFL could be induced more often in those patients who had short atrial refractoriness (9).

The aim of our study was to clear some anatomic and electrophysiological aspects of the right atrium, which may be related to the presence of AFL.

Methods

The study included 45 patients admitted to Department of Cardiology of Kaunas University of Medi-

Correspondence to D. Žaliaduonytė-Pekšienė, Kaunas University of Medicine, Department of Cardiology, Eivenių 2, 50009 Kaunas, Lithuania. E-mail: dianazal@yahoo.com

cine Hospital, in 2006. All of them underwent radiofrequency ablation procedure. A total 23 patients with type I AFL documented clinically and electrocardiographically before the study were assigned to AFL group. Twenty-two patients without AFL in the history and admitted to the hospital for intracardiac electrophysiological examination and ablation because of the other reason than AFL were assigned to control group (patients with atrioventricular nodal reentry tachycardia and accessory pathways). All the patients did not receive any antiarrhythmic medication.

2-D echocardiography was performed before intracardiac examination and ablation procedure. The right atrial long axis (defined as the distance from the hinge point of the septal tricuspid valve leaflet to the roof of the right atrium, measured along a line parallel to the interatrial septum) and the right atrial short axis (defined as the distance between the interatrial septum and the right atrial free wall) were assessed.

Patients were admitted to the electrophysiology laboratory. All patients gave written informed consent for electrophysiological examination. The procedure was performed in the fasting state. Electrode catheters were positioned under fluoroscopic guidance. Two quadripolar catheters were inserted percutaneously into the right femoral vein. A 7F catheter (interelectrode spacing 2-5-2 mm; Biosense Webster) was placed in coronary sinus (CS), and a 7F catheter (interelectrode spacing 2-5-2 mm; Biosense Webster) was used to record potentials in high right atrium (HRA), low right atrium (LRA), and CS positions. Pulse oximetry and vital signs were monitored throughout the study. The 12-lead surface ECGs and intracardiac signals were recorded with a computerized multichannel data acquisition system (CardioLab). Intracardiac signals were filtered with low and high cutoff frequencies of 30 and 500 Hz, respectively, with a sampling frequency of 1000 Hz. Programmed stimulation was delivered through a programmable stimulator (EP-4, EPMeSystems).

Effective refractory period (ERP) was registered in CS, HRA, and LRA positions. Stimulus-response time in anterograde ($Stim_{HRA}$ –LRA) and retrograde ($Stim_{LRA}$ – HRA) ways along the right atrium wall from HRA to LRA positions was measured on ECG. The distance between HRA and LRA was measured in millimeters using an X-ray antero-posterior view. Impulse propagation speed from HRA to LRA and backwards was calculated (assessed as v_a and v_r).

Data analysis

Comparisons between the means were made by paired *t* test. Data were expressed as mean ± standard deviation (SD). Relations between variables were assessed by the Pearson correlation coefficient. A value of $P<0.05$ was considered statistically significant.

Results

Demographic data of the patients included in the study are presented in Table 1. There was no significant difference in age and gender between AFL and control groups.

The electrophysiological characteristics of the right atrium and right atrium dimensions of AFL group patients and controls are demonstrated in Table 2. Electrophysiological measurements such as ERP CS, ERP HRA, ERP LRA, $Stim_{HRA}$ –LRA time, $Stim_{LRA}$ – HRA time, impulse propagation speed along the lateral wall of right atrium were significantly different comparing both groups (Fig.). Measured ERPs, $Stim_{HRA}$ – LRA, $Stim_{LRA}$ – HRA in the AFL group were significantly longer. Impulse propagation speed was lower in AFL group. Right atrium dimensions were significantly larger in AFL group.

Correlation analysis of electrophysiological parameters in AFL group revealed significant correlation between ERP CS and ERP HRA, ERP CS and ERP LRA, ERP LRA and ERP HRA parameters (Table 3). ERP CS, ERP HRA, ERP LRA correlated significantly with $Stim_{HRA}$ –LRA (anterograde). We also observed a significant correlation between ERP HRA, ERP LRA and impulse propagation speed in antero-

Table 1. **Demographic data (n=45)**

Data	Atrial flutter group N (%) n=23	Control group N (%) n=22	P
Gender:			
Male	11 (47.8)	9 (40.9)	>0.05
Female	12 (52.2)	13 (59.1)	>0.05
Age (years)	63±10.3	62±17.4	>0.05

Table 2. **Comparison of electrophysiological parameters in atrial flutter and control groups**

Parameter	Atrial flutter group n=23	Control group n=22	P
Long axis of RA (mm)	57.8±4.3	45.42±3.9	<0.01
Short axis of RA (mm)	40.2±3.5	36.31±3.9	<0.01
ERP CS (ms)	253.18±39.8	232.27±19.9	<0.05
ERP HRA (ms)	270.45±50.3	233.63±26.5	<0.01
ERP LRA (ms)	263.18±42.5	224.54±28.7	<0.01
$Stim_{HRA}$–LRA (ms)	75.36±23.3	42.86±14.20	<0.01
$Stim_{LRA}$–HRA (ms)	86.12±30.0	46.37±15.2	<0.05
v_a (m/sec)	0.66±0.32	1.038±0.4	<0.01
v_r (m/sec)	0.60±0.28	0.968±0.4	<0.05

RA – right atrium, ERP – effective refractory period, CS – coronary sinus, HRA – high right atrium, LRA – low right atrium, Stim $_{HRA}$–LRA (ms) – impulse propagation time from HRA to LRA, Stim $_{LRA}$–HRA (ms) – impulse propagation time from LRA to HRA, v_a – impulse propagation speed in anterograde way, v_r – impulse propagation speed in retrograde way.

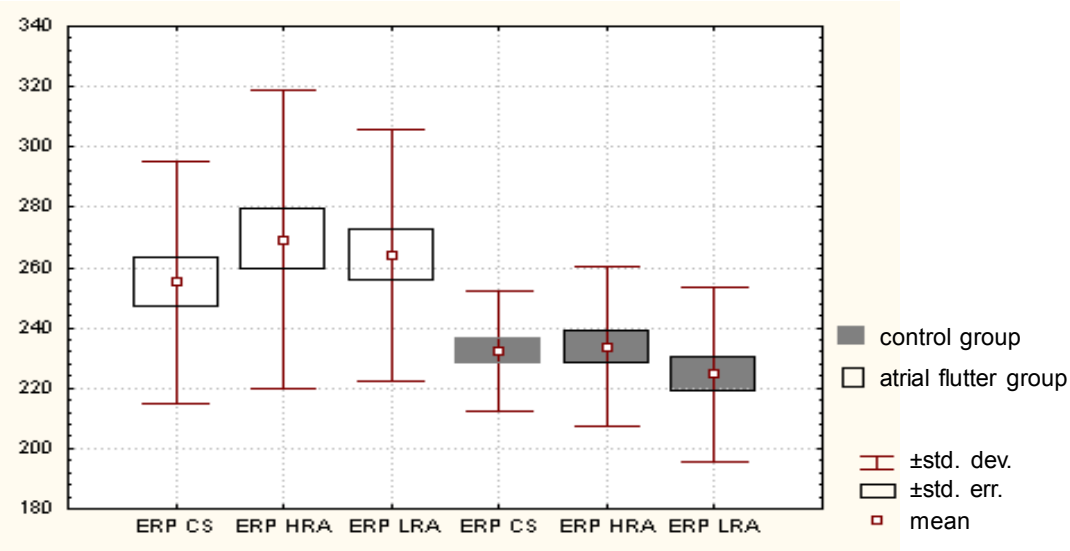

Fig. **Dispersion of measured refractory periods in the right atrium in atrial flutter and control groups**

ERP – effective refractory period, CS – coronary sinus, HRA – high right atrium, LRA – low right atrium.

grade way (v_a). There was no significant correlation among these parameters in control group.

Correlation analysis did not show any correlation between the right atrium dimensions and electrophysiological parameters.

Discussion

The electrical phenomena underlying AFL were first studied in experimental models. Several decades ago, Lewis had demonstrated the role of a single intraatrial circus movement in canine surgically induced AFL. The creation of lesions impairing conduction at the critical sites within the right atrium provided the basis for the initiation of reentry (10). More recently Allessie, using left atrium preparations in rabbits, stressed the possibility of stable reentry phenomena developed around functional obstacles, this being combined electrocardiographically to flutter-like rapid atrial rhythms (11). The upraise of endocardial mapping techniques was very important in explanation of the electrophysiological process involved in the arrhythmia. Puech's pioneer work in the late

Table 3. **Correlation coefficient between measured parameters**

Parameter	ERP CS	ERP HRA	ERP LRA	Stim $_{HRA}$ – LRA (ms)	Stim $_{LRA}$ – HRA (ms)	v_a
ERP CS	–	r^2=0.63*	r^2=0.44*	r^2=0.2*	r^2=0.64†	r^2=0.2*
ERP HRA	r^2=0.63*	–	r^2=0.44*	r^2=0.2*	r^2=0.45†	r^2=0.2*
ERP LRA	r^2=0.44*	r^2=0.44*	–	r^2=0.24*	r^2=0.35†	r^2=0.24*
Stim $_{HRA}$–LRA (ms)	r^2=0.2*	r^2=0.2*	r^2=0.24*	–	r^2=0.45*	r^2=0.62*
Stim $_{LRA}$–HRA (ms)	r^2=0.64†	r^2=0.45†	r^2=0.35†	r^2=0.45*	–	r^2=0.3*
v_a	r^2=0.2*	r^2=0.2*	r^2=0.24*	r^2=0.62*	r^2=0.3	–

RA – right atrium, ERP – effective refractory period, CS – coronary sinus, HRA – high right atrium, LRA – low right atrium, Stim $_{HRA}$–LRA (ms) – impulse propagation time from HRA to LRA, Stim$_{LRA}$–HRA (ms) – impulse propagation time from LRA to HRA, v_a – impulse propagation speed in anterograde way.

*P<0.05; †P>0.05.

1950s set the foundations of our current knowledge of atrial flutter (12). Subsequently Cosio's studies opened the way to electrical ablation of this disorder (13).

Our study revealed a significant difference in measured refractory periods between AFL group and controls. Effective refractory periods in different sites of the right atrium were significantly longer in AFL group than in control group. That suggests that the presence of AFL might be induced by the heterogeneous texture of right atrium or critical changes (prolongation) of refractory periods. Prolongation of refractory periods inducing the slowdown of impulse propagation speed along the wall of right atrium can set conditions for stable AFL. A significant correlation between the values of refractoriness in AFL group was observed and this lets us to propose that the presence of AFL requires diffuse alterations of the atrium, but not focal or single changes of refractoriness.

Assuming the presence of a significant relation between the atrial refractory parameters we affirm that in most cases it is enough to check refractoriness in one position (CS, HRA or LRA) in order to demonstrate critical changes of the atrial tissue.

Dispersion of the refractory may be one of the factors determining macroreentry mechanism (but not single pathological focus) in the right atrium inducing AFL. That requires further examinations.

Conclusions

1. The effective refractory period measured in several atrial locations in atrial flutter group was significantly longer than in control group.
2. There is a strong correlation between measured atrial refractory periods and impulse propagation speed in the right atrium.
3. The presence of atrial flutter requires diffuse alterations of the atrium, but not focal or single changes of refractoriness.
4. Right atrium dimensions were significantly larger in atrial flutter group than in control group but there was no correlation between right atrium dimensions and measured electrophysiological parameters.

Elektrofiziologinių parametrų pokyčiai sergant prieširdžių plazdėjimu

Diana Žaliaduonytė-Pekšienė[1], Tomas Kazakevičius[1, 2], Vytautas Zabiela[1, 2], Vytautas Šileikis[1, 2], Remigijus Vaičiulis[1], Martynas Virketis[1], Aras Puodžiukynas[1]

Kauno medicinos universiteto [1]Kardiologijos klinika, [2]Kardiologijos institutas

Raktažodžiai: prieširdžių plazdėjimas, elektrofiziologiniai parametrai, refraktoriškumas, impulso sklidimo greitis.

Santrauka. *Tyrimo tikslas.* Ištirti kai kurias anatomines ir elektrofiziologines dešiniojo prieširdžio savybes, galinčias turėti įtakos prieširdžių plazdėjimui.

Metodika. Į tyrimą įtraukti 45 ligoniai (23 ligoniai, sirgę prieširdžių plazdėjimu, 22 ligoniai sudarė kontrolinę

grupę). Atlikus širdies echoskopiją, išmatuoti ilgasis ir trumpasis dešiniojo prieširdžio matmenys. Visiems ligoniams atliktas intrakardinis tyrimas prieš numatytą radiodažninę abliaciją.

Rezultatai. Intrakardinio tyrimo metu išmatuotas efektyvus refrakterinis laikotarpis koronariniame sinuse, dešiniojo prieširdžio viršutinėje bei apatinėje dalyse. Minėti refrakteriniai laikotarpiai buvo statistiškai reikšmingai ilgesni prieširdžių plazdėjimo grupėje lyginat su kontroline ($p<0,05$). Impulso, plintančio dešiniojo prieširdžio šonine siena, sklidimo greitis, stimulo–atsako, plintančio retrogradine bei anterogradine kryptimis, laikas taip pat statistiškai reikšmingai skyrėsi prieširdžių plazdėjimo bei kontrolinėje grupėse ($p<0,05$). Nustatyta koreliacija tarp efektyvaus refrakterinio laikotarpio matavimų skirtingose prieširdžio vietose (atitinkamai, $r^2=0,64, 0,44, 0,44$). Efektyvus refrakterinis laikotarpis buvo susijęs su stimulo–atsako, plintančio anterogradine kryptimi ($p<0.05$), laiku bei impulso sklidimo greičiu ($p<0.05$). Ligonių, sergančių prieširdžių plazdėjimu, dešiniojo prieširdžio matmenys buvo didesni. Šių matmenų ryšys su išmatuotais elektrofiziologiniais parametrais nenustatytas.

Išvados. Galime teigti, kad difuziniai dešiniojo prieširdžio audinio pokyčiai, bet ne pavieniai ar židininiai refrakterinių savybių pokyčiai sudaro sąlygas kilti prieširdžių plazdėjimui.

Adresas susirašinėti: D. Žaliaduonytė-Pekšienė, KMU Kardiologijos klinika, Eivenių 2, 50009 Kaunas
El. paštas: dianazal@yahoo.com

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