The effect of percutaneous mitral balloon valvuloplasty on left atrial systolic functions

Wpływ przezskórnej komisurotomii mitralnej na czynność skurczową lewego przedsionka

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Abstract

Background: Conventional echocardiographic methods have already shown that successful mitral balloon valvuloplasty (MBV) can effectively increase left atrial (LA) functions.

Aim: To evaluate LA functions after MBV using colour tissue Doppler imaging.

Material and methods: Sixty-eight patients (58 females, mean age: 38 ±12 years) were included in the study. Within 24 h before MBV, all the patients underwent colour tissue Doppler study in addition to routine conventional echocardiographic examinations. Late diastolic velocities (A') measured at the LA wall adjacent to the septal and lateral annuli were recorded. All the measurements were repeated 24 h after MBV. The MBV was done using the Inoue technique. Successful MBV patients were included in group A and those who developed severe mitral regurgitation (MR) were included in group B.

Results: Sixty-one patients underwent successful MBV while 7 developed MR. Mitral valve areas (MVA) in both groups were significantly increased. Maximum and mean gradients, LA diameter, systolic pulmonary arterial pressure and mean LA pressures were decreased while septal and lateral A' were significantly increased in group A. In group B, no significant change in any variable was found except for the increase in MVA.

Conclusions: After successful MBV, increase in A' velocity was seen in parallel to the recovery of LA functions. Early improvements in left atrial systolic functions after successful MBV can easily be determined by colour tissue Doppler as a quick and reliable method.

Key words: mitral stenosis, valvuloplasty, left atrial functions, tissue Doppler echocardiography

Streszczenie

Wstęp: W standardowych badaniach echokardiograficznych wykazano, że po skutecznym zabiegu przezskórnej komisurotomii mitralnej (PKM) dochodzi do istotnej poprawy funkcji lewego przedsionka.

Cel: Ocena funkcji lewego przedsionka po PKM przy użyciu badania kolorowego dopplera tkankowego.

Materiał i metody: Do badania włączono 68 pacjentów (58 kobiet, średni wiek 38 ±12 lat). U wszystkich pacjentów, oprócz standardowego badania echokardiograficznego, wykonano badanie metodą dopplera tkankowego w ciągu 24 godzin przed zabiegiem PKM. Rejestrowano prędkość późnorozkurczową (A') mierzoną w ścianie lewego przedsionka przylegającej do przegrodowej i bocznej części pierścienia. Wszystkie pomiary powtórzono po 24 godzinach od PKM. Badanie to wykonano według techniki Inoue. Pacjentów, u których wykonano skuteczny zabieg PKM, włączono do grupy A. Osoby, u których po zabiegu wystąpiła ciężka niedomykalność zastawki mitralnej (ang. *mitral regurgitation*, MR), włączono do grupy B.

Wyniki: Skuteczne badanie PKM wykonano u 61 pacjentów, a u 7 osób wystąpiła MR. Pole powierzchni zastawki mitralnej (ang. *mitral valve area*, MVA) wzrosło istotnie w obu grupach. W grupie A zaobserwowano redukcję maksymalnego i średniego gradientu, wymiaru lewego przedsionka, skurczowego ciśnienia w tętnicy płucnej i średniego ciśnienia w lewym przedsionku oraz wzrost prędkości przegrodowej i bocznej (A'). W grupie B nie zaobserwowano istotnej zmiany w żadnym z analizowanych parametrów, z wyjątkiem wzrostu MVA.

Wnioski: Po skutecznym zabiegu PKM obserwowano wzrost prędkości A' oraz poprawę funkcji lewego przedsionka. Wczesna poprawa funkcji skurczowej lewego przedsionka po skutecznym zabiegu PKM może być łatwo oceniona w badaniu kolorowego dopplera tkankowego, które jest szybką i wiarygodną metodą.

Słowa kluczowe: zwężenie zastawki mitralnej, walwuloplastyka, funkcja lewego przedsionka, echokardiografia metodą dopplera tkankowego

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Introduction

Left atrial (LA) functions play an important role in patients with mitral stenosis. The contribution of the LA kick to cardiac output is 24% in mild mitral stenosis, decreasing to 15% in severe mitral stenosis [1-4]. Percutaneous mitral balloon valvuloplasty (MBV) is an effective therapeutic choice for suitable cases [5]. The MBV is ever effective in unsuitable situations for surgery [6]. The LA dysfunctions in mitral stenosis (MS) and subsequent recovery following successful MBV have been documented by conventional echocardiographic methods [4, 7]. However, there is currently no widely accepted non-invasive 'gold standard' method to evaluate atrial functions. In comparison to ventricular function, there is a paucity of literature regarding the evaluation of atrial functions [8]. Evaluation of LA functions by the conventional echocardiographic method is not only time-consuming but also has a low reproducibility [9, 10]. Mitral inflow late diastolic wave (A wave) determined by pulsed wave Doppler has been used to evaluate LA function. However, peak A wave velocity is influenced by heart rate, loading conditions and aging [11]. A relatively new method, tissue Doppler imaging (TDI), is less influenced by volume status, easy to apply and possesses a high reproducibility [12-15]. It has been reported that late diastolic wave is well correlated with LA systolic functions [16, 17].

Aim

We aimed to study the LA systolic functions early after MBV when there is a dramatic and substantial decrease in afterload with the use of TDI.

Material and methods

Sixty-eight consecutive patients (58 females, mean age: 38 ±12 years) who underwent MBV between January 2007 and June 2008 were included in the study. Patient selection for MBV was done according to the ACC/AHA guidelines [18]; symptomatic patients [New York Heart Association (NYHA) functional class ≥ II] with MVA ≤ 1.0 cm^2 or 1.0– 1.5 cm^2, MVA ≤ 1.0 cm^2 or 1.0-1.5 cm^2 with systolic pulmonary artery pressure greater than 50 mmHg at rest or greater than 60 mmHg with exercise, patients with appropriate mitral valve morphology for MBV, patients with no moderate to severe MR or left atrial thrombus or concomitant severe valvular disease. Moreover, patients with rhythm disorder, coronary artery disease, diabetes, hypertension and chronic obstructive or restrictive lungs disease were excluded from the study. Successful MBV patients without severe MR were included in group A, whereas those who developed severe MR after MBV were taken as group B. Written informed consent was taken from all patients, and the study was approved by the local ethics committee.

Procedure and echocardiographic examination

Detailed transthoracic echocardiographic examination (TTE) was performed within 24 h before MBV. Conventional Doppler examination was done in accordance with previously determined criteria [19, 20]. Using colour TDI, late diastolic wave velocities (A') of the left atrium adjacent to the septal and lateral annulus were measured (fig. 1). As far as possible, Doppler was placed perpendicular to the mitral annular plane, the depth was decreased to a minimum, and a narrow sector width with a high frame rate was used. All the measurements were repeated 24 h after MBV. The TTE was done using GE VingMed system 5 (GE, Horten, Norway) with a 2.5-3.5 mHz probe. Analysis was done with EchoPac version 6.5. MBV was performed using the Inoue technique with the help of TTE [21]. Increase of MVA over 1.5 cm^2 in the absence of severe MR or a drop of mean transmitral gradient below 10 mmHg was regarded as a successful MBV.

Statistical analysis

Parametric variables are given as mean ± standard deviation. Categorical variables are given as frequency and per-

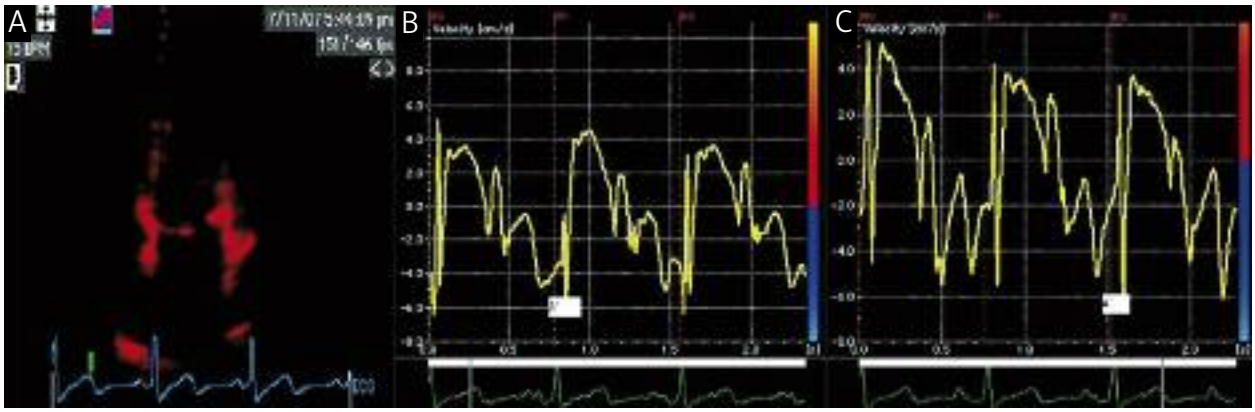

Fig. 1. Colour tissue Doppler image of left atrium in the apical 4-chamber view (**A**), TDI velocity of septal wall before (**B**) and after the procedure (**C**)

Ryc. 1. *Badanie przy użyciu kolorowego dopplera tkankowego. Projekcja koniuszkowa 4-jamowa (**A**). Prędkość TDI ściany bocznej przed zabiegiem (**B**) i po zabiegu (**C**)*

Table 1. Comparison of baseline properties of the two groups
Tabela 1. *Porównanie charakterystyki podstawowej obu grup*

Paramaters	Group A (n = 61)	Group B (n = 7)	Value of p
Age [years]	38 ±9	39 ±9	0.81
Female gender n (%)	52 (85)	6 (86)	0.85
Mitral valve area – planimetric [cm^2]	1.19 ±0.26	1.03 ±0.11	0.14
Maximum gradient [mmHg]	19.6 ±6.3	20.7 ±6.9	0.68
Mean gradient [mmHg]	11.3 ±4.6	12.2 ±4.4	0.63
Systolic pulmonary arterial pressure [mmHg]	48.1 ±12.0	45.1 ±6.8	0.59
Left atrial diameter [cm]	4.2 ±0.6	4.4 ±0.4	0.55
Mean left atrial pressure [mmHg]	25.4 ±3.3	25.6 ±1.1	0.45
Lateral annular A' wave velocity [cm/s]	5.32 ±1.17	5.34 ±1.57	0.98
Septal annular A' wave velocity [cm/s]	4.84 ±1.04	4.56 ±0.59	0.49

Table 2. Comparison of pre- and post-procedural parameters
Tabela 2. *Porównanie wskaźników przed zabiegiem i po zabiegu*

Parameters	Group A (n = 61)			Group B (n = 7)		
	Before MBV	After MBV	Value of p	Before MBV	After MBV	Value of p
Mitral valve area – planimetric [cm^2]	1.19 ±0.26	1.90 ±0.27	**< 0.001**	1.03 ±0.11	1.84 ±0.21	**< 0.001**
Maximum gradient [mmHg]	19.6 ±6.3	9.8 ±2.8	**< 0.001**	20.7 ±6.9	18.4 ±11.3	0.53
Mean gradient [mmHg]	11.3 ±4.6	4.9 ±1.8	**< 0.001**	12.2 ±4.4	8.6 ±5.1	0.14
Systolic pulmonary arterial pressure [mmHg]	48.1 ±12.0	34.6 ±9.5	**< 0.001**	45.1 ±6.8	42.7 ±11.2	0.59
Left atrial diameter [cm]	4.2 ±0.6	3.9 ±0.6	**< 0.001**	4.4 ±0.4	4.2 ±0.4	0.37
Mean left atrial pressure [mmHg]	25.4 ±3.3	14.8 ±3.1	**< 0.001**	25.6 ±1.1	26.1 ±1.4	0.59
Lateral annular A' wave velocity [cm/s]	5.32 ±1.17	6.04 ±1.23	**< 0.001**	5.34 ±1.57	5.50 ±1.04	0.67
Septal annular A' wave velocity [cm/s]	4.84 ±1.04	5.49 ±1.16	**< 0.001**	4.56 ±0.59	4.71 ±0.44	0.21

centage. Variables before and after the procedure in group A and B were compared using paired sample t-test. Pearson correlation coefficient was used for parametric variables, and Spearman correlation analysis used for categorical variables. Statistical analysis was performed using SPSS (version 17.0, SPSS inc., Chicago, IL, USA). A p value < 0.05 was considered statistically significant.

Results

The MBV was successful in 61 patients while 7 patients developed severe MR. Both groups were similar for age and gender. Also, they have similar MVA, maximum and mean transmitral gradients, LA diameter and pressure, systolic pulmonary arterial pressure (PAP), left ventricular (LV) functions and septal and lateral A' velocities (tab. 1). The MVA of both groups increased significantly after the procedure. Maximum and mean gradients, LA diameter, systolic PAP and mean LA pressure decreased significantly, and septal and lateral A' increased significantly in group A. As for group B, no significant change was observed apart from MVA (tab. 2). In correlation analysis, neither septal nor lateral A' was found to be correlated with age or gender (p > 0.05). Among pre-procedural parameters, septal and lateral A' showed mild to moderate correlation with MVA (r = 0.327, p = 0.017; r = 0.311, p = 0.022, respectively), and moderate inverse correlation with LA pressure (r = –0.662, p < 0.001; r = –0.599, p < 0.001, respectively) (fig. 2). Among post-procedural parameters, septal and lateral A' velocities were found to be moderately inversely correlated only with LA pressure (r = –0.448, p < 0.001; r = –0.476, p < 0.001, respectively).

Discussion

In our study, it was found that A' velocity, which is an indicator of LA systolic functions, increased with successful MBV. But no such increase was seen in patients who developed severe MR after the procedure.

It is known that systolic dysfunctions of the LA and LA appendage occur to a varying degree in patients with mitral stenosis, thereby forming spontaneous echo contrast and

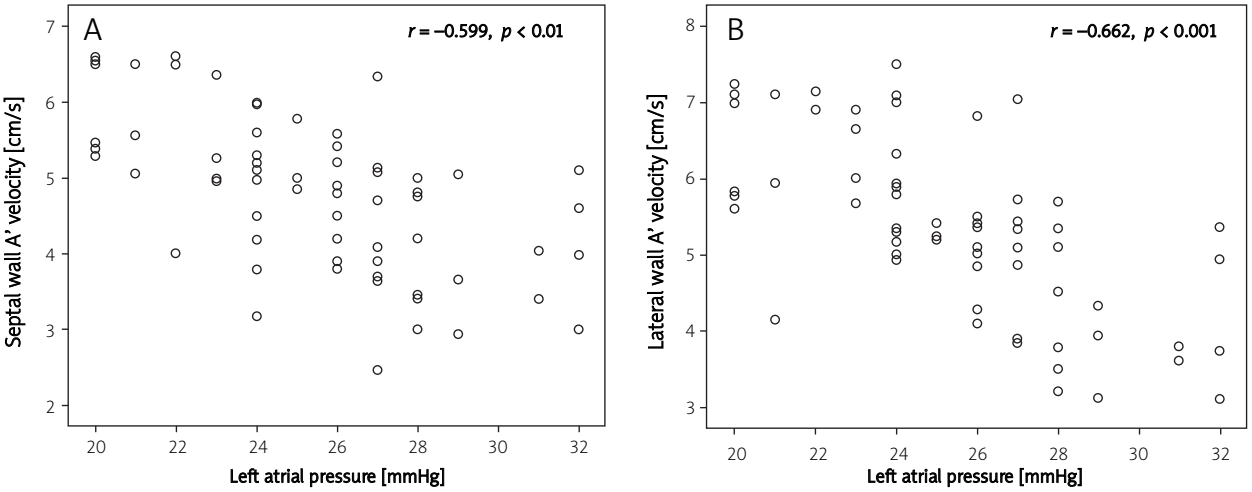

Fig. 2. Correlation between septal wall A' velocity and left atrial pressure (**A**) and correlation between lateral wall A' velocity and left atrial pressure (**B**)

Ryc. 2. *Korelacja pomiędzy prędkością A' ściany bocznej i ciśnieniem w lewym przedsionku (**A**) oraz pomiędzy prędkością A' ściany bocznej i ciśnieniem w lewym przedsionku (**B**)*

thrombus. This dysfunction has been shown by conventional [7] and TDI methods [15]. The same methods have also been used to show the improvement of LA functions after MBV [4, 7]. Conventionally, quantitative assessment of LA functions is made by measurements of area and volume at respective phases of the cardiac cycle. As a number of measurements and calculations are needed, reproducibility and clinical application are limited [22]. The efficacy of TDI has been shown, and its use is becoming more and more widespread. Being less affected by volume status, TDI has been shown to be more accurate in evaluation of myocardial systolic and diastolic functions, especially in patients undergoing valvuloplasty or haemodialysis and those with decompensated heart failure where rapid changes in preload and afterload are common [23-25]. It has been shown previously that late diastolic motion of the mitral annulus reflected LA and LA appendage functions [16]. In our study, it was found that septal and lateral A' velocity was increased in patients who had successful MBV, whereas no such increase was seen in patients who developed severe MR.

Bauer *et al.* showed that E' and A' velocity measured by TDI at the LA appendage was increased significantly at day one after MBV [26]. Karakaya *et al.* [27] found that systolic motion of the LA appendage at the late diastolic phase was significantly increased at the third day after MBV. Cianciulli *et al.* [28] performed transoesophageal echocardiography (TEE) at the sixth month after MBV to evaluate LA appendage functions by TDI, and improvement was seen. Our study showed that the evaluation could also be done by TTE instead of TEE. The results were supported by the absence of improvement in LA functions in patients who developed severe MR. In a study done with healthy subjects, A´ was found to increase with age [12]. However, such a finding was not seen in our study. This could probably be related to different degrees of valvular involvement.

Lateral and septal A' velocities were mild to moderately correlate with MVA, while no correlation was present with transmitral maximum and mean gradient and systolic PAP. As known, A' velocity was determined by afterload and intrinsic contractility of LA [28]. Afterload of LA is equivalent to the LA pressure before atrial systole. In patients with mitral stenosis, the presence and severity of MR and left ventricular end-diastolic pressure determine LA afterload in addition to MVA. Thus, a limited correlation between A' velocity and MVA and the lack of correlation with transmitral gradients are not unexpected. In our study, LA pressure measured invasively was found to be inversely related to A' velocity. This shows that even if MVA increases after MBV, the development of severe MR could prevent the fall in LA pressure and a notable increase in A' velocity.

Although an increase in A' velocity after MBV was shown, further studies are needed to find out its relationship with the decrease in the incidence of atrial fibrillation and thromboembolism and the effect on morbidity and mortality in the long run.

Limitations

In our study, measurement of A' velocity was not confirmed with other imaging modalities such as magnetic resonance imaging. However, the efficacy of TDI has been proved in different populations and different studies [26-29]. Moreover, LA segmental systolic functions were not studied. Nevertheless, annular velocity has been shown to be indicative of LA functions [12]. In our study, LA velocities were taken from an area adjacent to the annuli.

Conclusions

Left atrial septal and lateral A' velocities were shown to be increased after successful MBV. No increase of A' velocity was seen in those who developed severe MR. Tissue velocity measured in TTE could effectively show early changes in LA function after successful MBV.

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