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Percutaneous mitral balloon valvuloplasty beyond 65 years of age

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Abstract

Background: *The profile of subjects undergoing percutaneous mitral balloon valvuloplasty (PMBV) in developed countries has shifted toward the elderly. In the group of elderly patients long-term results after PMBV, as well prognostic factors that may improve patient selection for this procedure have not been fully elucidated. Aim of the study was to evaluate the safety and efficacy of PMBV for the treatment of mitral stenosis in patients older than 65.*

Methods: *The studied group consists of 132 consecutive patients aged > 65, who underwent PMBV. All PMBV procedures were performed by the antegrade transvenous approach using the Inoue balloon system.*

Results: *Procedural success, defined as mitral valve area ≥ 1.5 cm^2 and mitral regurgitation ≤ 2+, was obtained in 105 (79.5%) patients. Mean follow-up was 6.25 ± 4.33 years. Echo score > 8 and higher mean mitral valve gradient were significant independent predictors of inadequate immediate result. Survival curves showed that for the whole studied group after PMBV the 3-, 5-, and 10-year overall survival rates were significantly better in patients with left atrium diameter ≤ 5.0 cm before intervention (95.4%, 91.3% and 80.5% vs. 89.6%, 69.5%, and 53.7%, respectively; p = 0.002). Survival free of mitral valve intervention or heart failure ≥ NYHA III was significantly better for patients with good immediate result and mean pulmonary artery pressure after PMBV < 25 mm Hg.*

Conclusions: *PMBV is safe and efficacious in elderly patients with symptomatic mitral stenosis. Long-term results are good and related mainly to the quality of the procedure.* (Cardiol J 2013; 20, 1: 44–51)

Key words: mitral stenosis, elderly, valvuloplasty

Introduction

Percutaneous mitral balloon valvuloplasty (PMBV) is safe and effective for selected symptomatic patients with mitral valve stenosis [1, 2]. In developed countries during the last decades the profile of subjects undergoing this procedure has shifted toward the elderly [3, 4]. These patients in

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many cases have less favorable mitral valve anatomy, but because of comorbidities their surgical risk is high. In effect, many elderly patients are referred for less invasive treatment, despite suboptimal valve anatomy [5–7]. Careful patient selection is crucial for successful PMBV [8–10]. Age has been found a predictor affecting late results in a series of patients after balloon commissurotomy, but data from previous studies are inconsistent [2, 10, 11]. Furthermore, the long-term results after PMBV as well prognostic factors that can improve patient selection for this procedure have been not fully elucidated in the elderly [11–14]. To address this issue we have conducted an observational study in a group of consecutive mitral stenosis patients older than 65 treated with PMBV.

Methods

Patient population

There were 1564 PMBV procedures performed at the Warsaw Institute of Cardiology from September 1988 through December 2007. The studied group consists of 132 patients, who at the time of the procedure were over 65 years of age. There were 114 (86.4%) female and 18 (13.6%) male patients. Their mean age was 68.8 ± 3.63 years (median 68, range 65–80).

Indications for PMBV were symptomatic (≥ NYHA class II) mitral valve stenosis with mitral valve area (MVA) < 1.5 cm^2. Patients were selected for PMBV based on suitable mitral valve morphology. Percutaneous treatment was not recommended if any of the following were present: flexural rigidity of valve leaflets, extensive valve calcifications; changes in the subvalvular apparatus, mitral valve regurgitation > 2+, presence of thrombus in the left atrium. These subjects were referred for surgical valve replacement or in cases of high surgical risk medical therapy was recommended.

Thirty-four (25.8%) patients had previous surgical and 2 (1.5%) percutaneous mitral commissurotomy. Atrial fibrillation was present in 91 (68.9%) patients. Each patient underwent 2-dimensional echocardiographic examination before PMBV and 24 h to 48 h after the procedure. Echocardiographic score was used to assess the severity of pathological lesions in the valve and subvalvular apparatus [15]. The gradient across mitral valve was measured using Doppler method, and MVA was determined by planimetry. Left atrium diameter was measured from the parasternal long-axis view at end-systole. The mean ECHO score was 7.49 ± ± 1.46 (median 8, range 3–11). Thirty-five (26.5%) patients had ECHO score > 8. The mean left atrium diameter before PMBV was 5.2 ± 1.1 cm (median 5.0 cm).

The study was approved by the local Ethics Committee and all patients gave written informed consent to undergo the procedure and for the use of the collected data for scientific purposes.

Technique of PMBV

All PMBV procedures were performed by the antegrade transvenous approach using the Inoue balloon system (Toray Industries, Inc., Tokyo, Japan). Mean balloon diameter used during the procedure was 27.7 ± 1.19 mm. Hemodynamic measurements including pulmonary artery pressure, left atrial pressure, left ventricular pressure as well as cardiac output were done prior to and after valvuloplasty. Mitral regurgitation was assessed during left ventriculography using the Sellers classification [16].

Data collection and follow-up

Clinical assessment was carried out 6 months after repeat PMBV and annually thereafter. Clinical evaluation was done by direct interview during a clinic visit. Patients who failed to report for follow-up were contacted by phone or responded to mailed questionnaires. If necessary, local physicians, "contact person" or family member were contacted to obtain detailed information. In 8 cases, data were obtained from the Death Registry of the Ministry of Internal Affairs and Administration of Poland.

End points

The endpoints assessed were: a) all-cause survival, b) survival considering the need for mitral valve intervention (surgery or repeat PMBV), c) survival considering only cardiovascular death and the need for mitral valve intervention, d) "good functional result" — survival free of mitral valve intervention or heart failure ≥ NYHA III.

Statistics analysis

Categorical variables were presented as percentages and compared with the χ^2 test. Continuous variables were expressed as means ± standard deviations. For comparison of continuous parameters before and after the procedure a paired Student t-test or Wilcoxon test was used (depending on data distribution).

All baseline characteristics were tested independently by univariate logistic regression as a potential predictor of immediate procedural success. Variables which achieved a significance level

Table 1. Hemodynamic and echocardiographic findings before and after percutaneous mitral balloon valvuloplasty (PMBV).

	Before PMBV	After PMBV	P
Mean transmitral gradient (Doppler) [mm Hg]	7.74 ± 3.76	4.15 ± 1.89	< 0.001
Maximal transmitral gradient (Doppler) [mm Hg]	16.09 ± 5.46	10.03 ± 3.61	< 0.001
Mitral valve area (planimetry) [cm^2]	1.19 ± 0.28	1.83 ± 0.38	< 0.001
Pulmonary artery systolic pressure [mm Hg]	48.47 ± 15.13	39.53 ± 13.88	< 0.001
Mean pulmonary artery pressure [mm Hg]	31.55 ± 10.24	26.47 ± 9.12	< 0.001
Transmitral gradient (hemodynamic) [mm Hg]	12.29 ± 5.24	4.84 ± 3.09	< 0.001
Cardiac output [L/min]	4.37 ± 1.14	4.72 ± 1.36	< 0.001
Mean left atrial pressure [mm Hg]	23.2 ± 7.18	17.45 ± 7.62	< 0.001
Mitral regurgitation (Seller's class):			
0	76 (57.6%)	63 (47.7%)	
1	46 (34.8%)	43 (32.6%)	
2	10 (7.6%)	15 (11.4%)	< 0.001
3	0	10 (7.6%)	
4	0	1 (0.8%)	

of $p < 0.1$ were incorporated into a multivariate logistic regression model. To identify the best cut-off point of mean mitral valve gradient (MVG) for predicting immediate procedural success the receiver operating characteristic (ROC) curve was constructed. Next, depending on the severity of ECHO score and mean MVG patients were divided into 4 groups: 1) ECHO score ≤ 8 and mean MVG ≤ 10 mm Hg, 2) ECHO score ≤ 8 and mean MVG > 10 mm Hg, 3) ECHO score > 8 and mean MVG ≤ 10 mm Hg, 4) ECHO score > 8 and mean MVG > 10 mm Hg. The percentage of patients with good immediate result was calculated in each group.

Separate univariate Cox logistic regression analyses were performed for all baseline and post-procedural variables. Potential independent predictors of death and combined endpoints were identified by means of step-down modeling in a multivariable Cox model adjusting for baseline variables with a significance of less than 0.1 in univariable analysis. Kaplan-Meier method was used to determine total survival and event-free survival curves. Groups were compared using the log-rank test. Differences were considered significant at $p < 0.05$. Statistical analyses were performed with the SPSS (version 9.0) statistical package.

Results

Immediate results

PMBV was completed in all 132 patients. Table 1 presents baseline patient characteristics and measurements performed during the procedure. PMBV resulted in an increase of MVA and cardiac output, and a decrease of transmitral gradient, mean pulmonary artery pressure (mPAP) and mean left atrial pressure. The median mPAP after PMBV was 25 mm Hg. Procedural success, defined as MVA ≥ 1.5 cm^2 and mitral regurgitation ≤ 2+, was obtained in 105 (79.5%) subjects. An inadequate immediate result was related to mitral regurgitation ≥ 3+ in 10 (7.6%) patients, MVA < 1.5 cm^2 in 16 (12.1%) patients, and MVA < 1.5 cm^2 with mitral regurgitation ≥ 3+ in 1 (0.8%) patient.

Of the 5 variables found significant in univariate analysis only ECHO score > 8 and higher mean MVG remained statistically significant predictors of inadequate immediate result in multivariate analysis (Table 2). The best cut-off point of mean MVG predicting procedural success was 10.5 mm Hg. The rate of procedural success was significantly higher in the group of 86 patients with ECHO score ≤ 8 and mean MVG ≤ 10 mm Hg than those (12 patients) with ECHO score > 8 and MVG > 10 mm Hg (86% vs. 41.7%, $p = 0.001$) (Fig. 1).

There were two severe procedure-related complications. One patient required emergency mitral valve surgery due to significant mitral regurgitation. Another patient experienced perforation of the inferior vena cava while removing the Inoue catheter post dilation. She underwent urgent vascular surgery followed by disseminated intravascular coagulation and death. There were no cases of pericardial tamponade or thromboembolism.

Table 2. Predictors of good immediate result of percutanoeus mitral balloon valvuloplasty in univariate and multivariate analysis.

Variable	Odds ratio	95% confidence interval	P
Univariate analysis			
Mean mitral gradient (Doppler)	1.19	1.06–1.32	0.028
Max. mitral gradient (Doppler)	1.10	1.02–1.19	0.018
Echocardiographic score > 8	2.86	1.18–7.14	0.020
Systolic pulmonary artery pressure	1.03	1.01–1.06	0.035
Mean pulmonary artery pressure	1.04	1.01–1.09	0.033
Multivariate analysis			
Mean mitral gradient (Doppler)	1.16	1.05–1.30	0.005
Echocardiographic score > 8	2.56	1.01–6.67	0.049

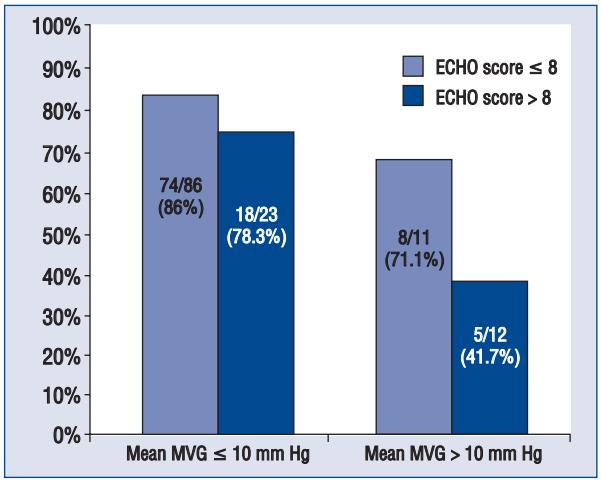

Figure 1. Relationship between the echocardiographic score (ECHO score), mean pre-percutaneous balloon mitral valvuloplasty mitral valve gradient (MVG) and procedural success.

Long-term follow-up

The mean follow-up was 6.25 ± 4.33 years. Patient survival, need for mitral valve replacement or repeat PMBV and functional status are presented in Figure 2.

Survival

One patient died due to periprocedural complications described above. Additional 32 patients died during follow-up: 18 due to cardiovascular reasons, 4 due to unknown causes and 10 due to non-cardiac causes (2 — liver cirrhosis, 4 — cancer, 1 — renal failure, 2 — pneumonia, 1 — acute pancreatitis). Four deaths of unknown cause were considered cardiovascular related.

The indpendent predictors of all-cause mortality were higher age (OR 1.14, 95% CI 1.02–1.26, p = 0.017) and larger left atrium diameter before PMBV (OR 1.29, 95% CI 1.05–1.57, p = 0.013).

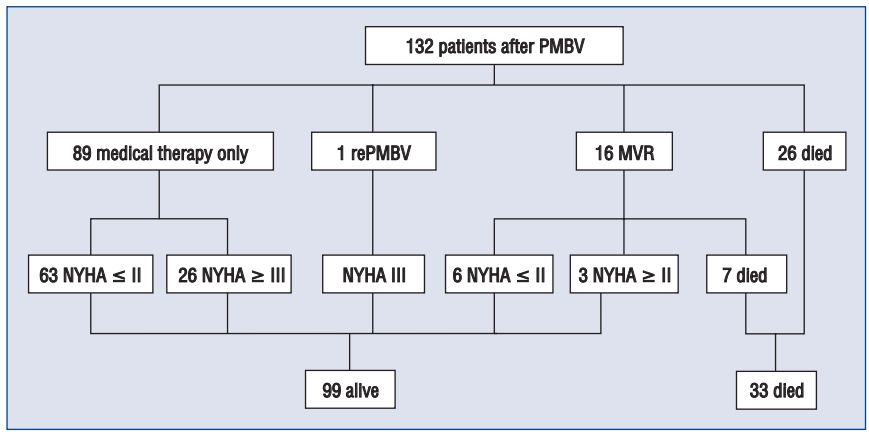

Figure 2. Patient survival, need for mitral valve replacement (MVR) or repeat percutaneous mitral balloon valvuloplasty (PMBV) and functional status after PMBV; NYHA — New York Heart Association.

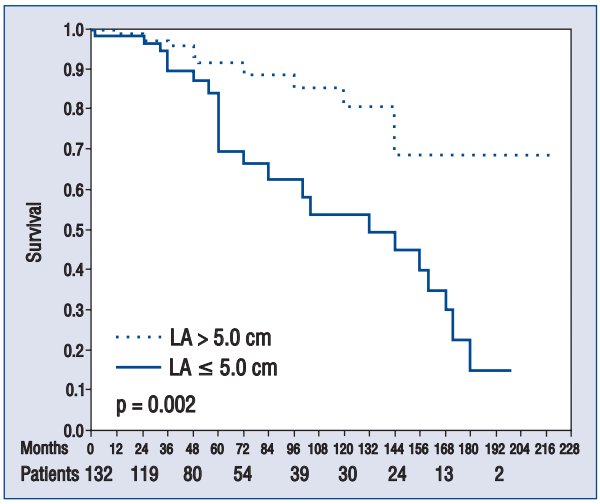

Figure 3. Kaplan-Maier survival curves after percutaneous balloon mitral valvuloplasty for patients with left atrium (LA) ≤ 5 cm and > 5 cm.

Kaplan-Meier survival curves showed that for the whole studied group after PMBV, the 3-, 5-, and 10-year overall survival rates were 92.8%, 81.6% and 68.4%, respectively and were significantly better in patients with left atrium diameter ≤ 5.0 cm before intervention (95.4%, 91.3% and 80.5% vs. 89.6%, 69.5%, and 53.7%, respectively; p = 0.002; Fig. 3).

Survival considering mitral valve intervention

Sixteen patients underwent mitral valve replacement after PMBV. Ten had a suboptimal immediate PMBV result (6 patients with mitral regurgitation ≥ 3+ and 4 with MVA < 1.5 cm^2). Six other patients developed mitral valve restenosis after successful PMBV. In addition, 1 patient underwent repeat PMBV due to restenosis 4 years after initial procedure.

The independent predictors of all-cause death and mitral valve replacement were larger left atrial diameter before PMBV (OR 1.23, 95% CI 1.01–1.51, p = 0.044) and higher mPAP after PMBV (OR 1.06, 95% CI 1.02–1.10, p = 0.003).

Suboptimal immediate result was a predictor of death and mitral valve intervention in univariate analysis only (OR 2.64, CI 1.28–5.42, p = 0.006), in multivariate analysis it did not achieve statistical significance.

Survival considering mitral valve intervention and repeat PMBV for the entire group at 3, 5, and 10-years was 87.5%, 71.9%, 57.1%, respectively. The survival was significantly better in patients with mPAP after PMBV < 25 mm Hg (92.0% vs. 82.3% at 3, 79.8% vs. 60.9% at 5 and 68.4% vs. 37.0% at 10 years, p = 0.003) (Fig. 4A) and good immediate result (89.0% vs. 81.0% at 3, 76.9% vs. 50.9% at 5, and 62.3% vs. 25.5% at 10 years, p = 0.002) (Fig. 4B).

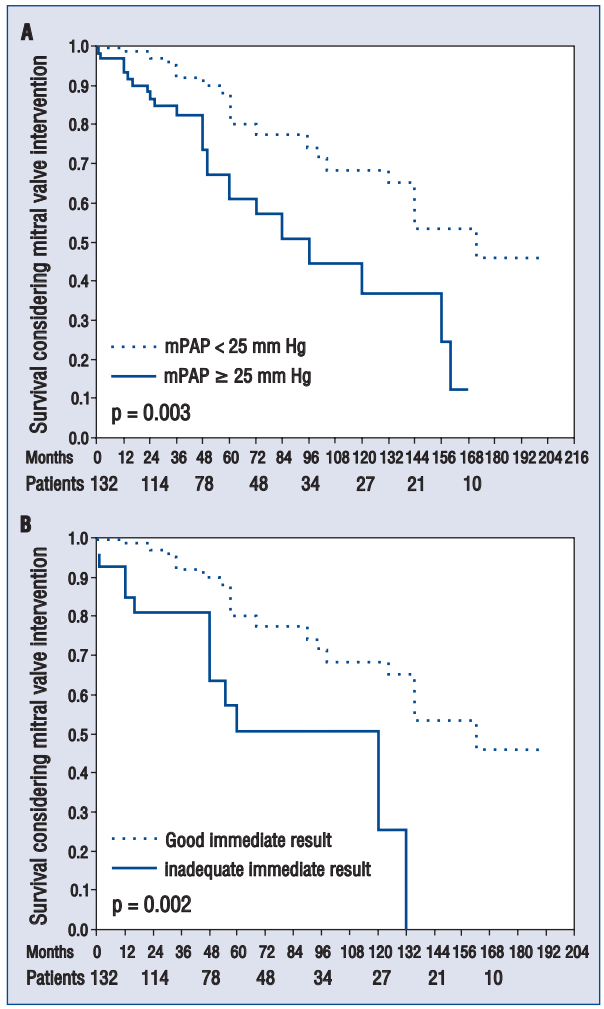

Figure 4. Kaplan-Maier event-free (death, mitral valve replacement, redoPMBV) survival curves for patients with mean pulmonary artery pressure (mPAP) after percutaneous balloon mitral valvuloplasty < 25 mm Hg and ≥ 25 mm Hg (**A**) and for patients with good and inadequate immediate result (**B**).

Taking into account cardiovascular death and mitral valve interventions only, the independent predictors of worse outcome were suboptimal immediate result (OR 2.94, CI 1.28–6.67, p = 0.011), previous commissurotomy (OR 2.38, CI 1.15–4.93, p = 0.020), and higher mPAP after PMBV (OR 1.05, CI 1.00–1.09, p = 0.037).

Good functional result

Sixty-three (47.7%) patients were alive, without mitral valve intervention and in NYHA class I

or II (good functional result) when follow-up was concluded.

The independent predictors of death, mitral valve intervention or severe heart failure (NYHA III or IV) were suboptimal immediate result (OR 1.92, CI 1.02–3.57, p = 0.045), higher age (OR 1.13, CI 1.06–1.22, p < 0.001), and higher mPAP after PMBV (OR 1.04, CI 1.1–1.07, p = 0.018).

Survival with good functional result for the entire group at 3, 5, and 10-years was 81.8%, 64.7% and 42.0%, respectively, and was significantly better for patients with mPAP after PMBV < 25 mm Hg (90.7% vs. 71.1% at 3, 74.0% vs. 52.7% at 5 and 54.6% vs. 23.9% at 10 years, p = 0.001) (Fig. 5A) and good immediate result (84.1% vs. 72.2% at 3, 69.4% vs. 45.4% at 5, and 48.4% vs. 13.0% at 10 years, p < 0.001) (Fig. 5B).

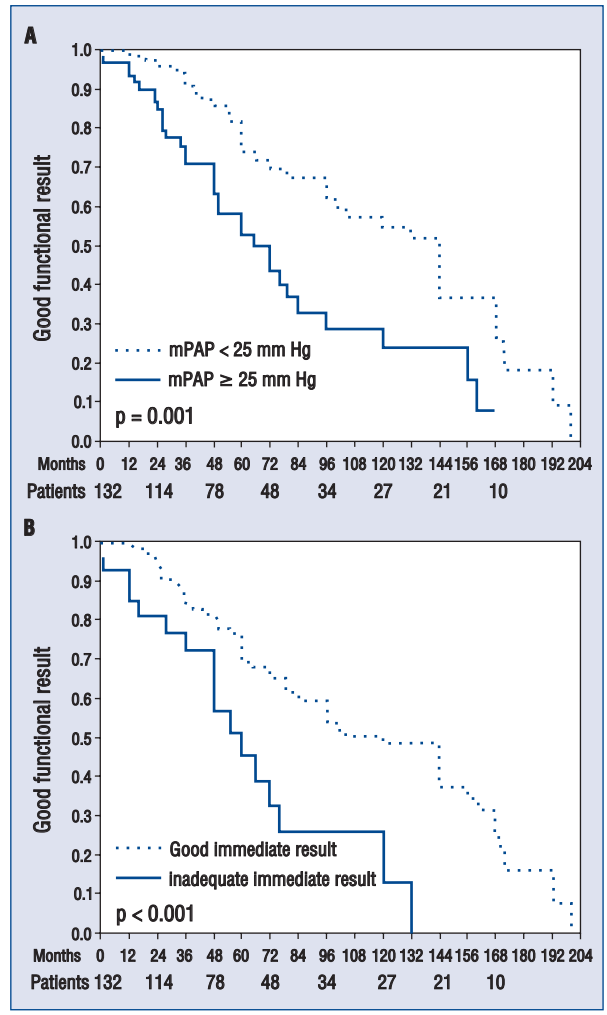

Figure 5. Good functional results (event-free survival in New York Association Class I or II) for patients with mean pulmonary artery pressure (meanPAP) after percutaneous balloon mitral valvuloplasty (PMBV) < 25 mm Hg and ≥ 25 mm Hg (**A**) and for patients with good and inadequate immediate result (**B**).

Discussion

The results of this study show that PMBV is safe and effective also in patients older than 65 years of age. The complication rate in this age group was similar to that reported in other studies [11–13]. Understandably, it has been shown that the number and probability of complications tends to increase along with increasing age [5, 17, 18]. From the technical point of view the procedure is comparatively age-independent. However, older patients often have more vessel tortuosity, larger rotated heart and large atria, making the procedure more demanding even for an experienced operator.

The immediate results obtained in this study are good. The percentage of patients in whom a good immediate result was achieved is even larger than in previous studies with similar definitions of procedural success [12–14, 19, 20]. It may be the consequence of the fact that patients included in this study had somewhat less advanced valve pathology compared to other studies. Mean ECHO score in this cohort was 7.5 and only 25% of patients had an ECHO score above 8. In contrast, in the work of Tuzcu et al. [12], who analyzed a cohort of 99 patients older than 65, the mean ECHO score was 9.2, and two-thirds of patients had a score above 8. Krasuski et al. [14] in a group of 55 patients > 65 years old also report a high ECHO score of 9.9. On the other hand, in one German study [17] only 12% of 146 patients older than 70 treated with PMBV had an ECHO score > 8.

The technique of the procedure could also influence immediate results. In all patients analyzed in this report Inoue balloon was used, while in the report by Tuzcu et al. [12] a double-balloon technique was employed. According to Iung et al. [13] the Inoue balloon technique "tended to yield better immediate results". However, in one randomized study the Inoue and double-balloon techniques were equally effective [21].

In our whole cohort of patients the elderly subgroup constituted less than 10% of all PMBV treated patients, whereas in the cohorts from the United Kingdom or United States this age group constituted around 30% of all treated patients [5, 12]. However, in papers published by French and German researchers on large cohorts (1285 and 1123, respectively), the percentages of elderly reported (defined as older than 70 in those studies) were similar to ours (5.8% and 13%, respectively). The varia-

bility of these percentages likely resembles differences in the course and treatment of rheumatic disease [1]. One may speculate that some elderly mitral stenosis patients due to comorbidities and poor performance status were not referred for any kind of intervention, whereas patients with lower operative risk and advanced disease were referred for mitral valve replacement. PMBV patients from developing countries are substantially younger [22, 23].

It is of note that in the cohort analyzed in this study prior commisurotomy patients with mitral restenosis were comparatively numerous. Earlier studies have shown that PMBV in these patients is effective irrespectively of age [24, 25]. However, in this study, it was the subgroup with higher risk of cardiovascular death and reintervention.

Two factors significantly affecting the PMBV immediate result were identified in the present analysis: ECHO score above 8 and higher pre-procedure Doppler MVG. In an earlier report an ECHO score > 8 was independently related to a worse immediate result of PMBV in a large cohort [2]. In a group of 44 patients with the age ≥ 75 years procedural success was greater in patients with ECHO score ≤ 8 although significance level was not achieved [26]. We have not found any data from the literature indicating that pre-procedure MVG predicts PMBV result in the elderly. In our analysis 86% of patients with a ECHO score ≤ 8 and MVG ≤ 10 mm Hg experienced a good immediate PMBV result. This percentage was over twice lower in the subgroup with a ECHO score > 8 and MVG > 10 mm Hg. We believe that these two parameters, measurable during a standard non-invasive echocardiographic evaluation, may be of value when considering treatment options for the individual patient.

The long-term results achieved in the analyzed cohort are favorable. Age was shown to be an independent predictor of all-cause mortality and good functional result, but not of the combined endpoint consisting of mortality and mitral valve reintervention. Previous studies had generally, but not uniformly shown that patients over 65 had worse long-term outcomes than younger patients [14, 27]. Pre-procedure left atrium (LA) diameter also turned out to have prognostic significance. On long-term follow-up patients with LA < 5 cm had better survival than patients with LA ≥ 5 cm. LA diameter and volume had also been proven an adverse prognostic factor in previous works [27, 28].

On univariate analysis good PMBV immediate result was a predictor of mitral valve intervention-free survival. This, however, was not confirmed on multivariate analysis. The reason may be a limited sample size. Also, almost a third of total mortality was due to non-cardiovascular reasons. Considering only cardiac mortality and valve reinterventions, good PMBV immediate result was a strong independent factor favoring better prognosis. It was also an independent prognostic factor of good functional result.

Mean pulmonary artery pressure after PMBV, reflecting the efficacy of the procedure, was also a strong independent predictor of better survival without reintervention. Accepting the median mPAP post-procedure as the cutoff point, patients with mPAP < 25 mm Hg fared better with respect to survival without reintervention and with respect to good functional result. This finding remains consistent with the study by Meneveau et al. [27], which demonstrated that patients with mPAP < 25 mm Hg post PMBV have a better event-free survival in long-term follow-up.

Limitations of the study

It must be acknowledged that the study has several limitations. This is a retrospective analysis with prospective data acquisition. Consecutive mitral stenosis patients older than 65 selected for PMBV are analyzed. We have no data on patients that were operated or treated conservatively. Therefore, we may not extrapolate the results of this analysis to describe the whole population of elderly mitral stenosis patients. We have been unable to analyze follow-up echocardiographic parameters as some data were unavailable. The age cut-off point selected may also be considered somewhat arbitrary. In prior studies, researchers accepted either 65 or 70 years of age for defining the group of the elderly. We have chosen the age of 65 as perhaps more universal, although contemporary definition of the word "elderly" is undoubtedly evolving. We have not compared the efficacy of PMBV in different age subgroups either.

Conclusions

PMBV is safe and efficacious in the subgroup of elderly (over 65) patients with symptomatic mitral stenosis. Procedural success is most likely in patients with ECHO score < 8 and lower MVG. Good immediate PMBV result and post-procedure mPAP < 25 mm Hg predict better long-term prognosis.

Conflict of interest: none declared

References

1. Chandrashekhar Y, Westaby S, Narula J. Mitral stenosis. Lancet, 2009; 374: 1271–1283.
2. Palacios IF, Sanchez PL, Harrell LC et al. Which patients benefit from percutanous mitral balloon valvuloplasty? Prevalvuloplasty and postvalvuloplasty variables that predict long-term outcome. Circulation, 2002; 105: 1465–1471.
3. Iung B, Nicoud-Houel A, Fondard O et al. Temporal trends in percutaneous mitral commissurotomy over a 15-year period. Eur Heart J, 2004; 25: 701–707.
4. Chmielak Z, Karcz K, Kruk M et al. Twenty years' experience with percutaneous mitral commissurotomy. Post Kardiol Interw, 2008; 4: 89–96.
5. Shaw TR, Sutaria N, Prendergast B. Clinical and haemodynamic profiles of young, middle aged, and elderly patients with mitral stenosis undergoing mitral balloon valvotomy. Heart, 2003; 89: 1430–1436.
6. Shaw TRD, Elder AT, Flapan AD et al. Mitral balloon valvuloplasty for patients aged over 70 years: an alternative to surgical treatment. Age Ageing, 1991; 20: 299–303.
7. Sutaria N, Elder AT, Shaw TR. Long term outcome of percutaneous mitral balloon valvotomy in patients aged 70 and over. Heart, 2000; 83: 433–438.
8. Cruz-Gonzalez I, Sanchez-Ledesma M, Sanchez PL et al. Predicting success and long-term outcomes of percutaneous mitral valvuloplasty: A multifactorial score. Am J Med, 2009; 122: 581e11–581e19.
9. Prendergast BD, Shaw TRD, Iung B, Vahanian A, Northridge DB. Contemporary criteria for the selection of patients for percutaneous balloon mitral valvuloplasty. Heart, 2002; 87: 401–404.
10. Iung B, Garbarz E, Michaud P et al. Late results of percutaneous mitral commissurotomy in a series of 1024 patients. Analysis of late clinical deterioration: Frequency, anatomic findings and predictive factors. Circulation, 1999; 99: 3272–3278.
11. Ramondo A, Napodano M, Fraccaro C et al. Relation of patient age to outcome of percutaneous mitral valvuloplasty. Am J Cardiol, 2006; 98: 1493–1500.
12. Tuzcu EM, Block PC, Griffin BP et al. Immediate and long-term outcome of percutaneous mitral valvotomy in patients 65 years and older. Circulation, 1992; 85: 963–971.
13. Iung B, Cormier B, Farah B et al. Percutaneous mitral commissurotomy in the elderly. Eur Heart J, 1994; 16: 1092–1099.
14. Krasuski RA, Warner JJ, Peterson G et al. Comparison of results of percutaneous balloon mitral commissurotomy in patients aged ≥ 65 years with those in patients aged < 65 years. Am J Cardiol, 2001; 88: 994–1000.
15. Wilkins G, Weyman A, Abscal A, Block P, Palacios I. Percutaneous balloon dilatation of the mitral valve: an analysis of echocardiographic variables related to outcome and the mechanism of dilatation. Br Heart J, 1988; 60: 299–308.
16. Sellers RD, Levy MJ, Amplatz K, Lillehei CW. Left retrograde cardioongiography in acquired cardiac disease. Am J Cardiol, 1964; 14: 437–447.
17. Neumayer U, Schmidt HK, Fassbender D, Mannebach H, Bogunovic N, Horstkotte D. Early (three-month) results of percutaneous mitral valvotomy with the Inoue balloon in 1123 consecutive patiets comparing various age groups. Am J Cardiol, 2002; 90: 190–193.
18. Chen CR, Cheng TO. Percutaneous balloon mitral valvuloplasty by the Inoue technique: A multicenter study of 4832 patients in China. Am Heart J, 1995; 129: 1197–1203.
19. Seggewiss H, Fassbender D, Terwesten HP et al. Percutaneous mitral valvulotomy with the Inoue balloon in over 65-year-old patients: Acute results and short-term follow-up in comparison with younger patients. Z Kardiol, 1995; 84: 255–263.
20. Shapiro LM, Hassanein H, Crowley JJ. Mitral balloon valvuloplasty in patients > 70 years of age with severe mitral stenosis. Am J Cardiol, 1995; 75: 633–636.
21. Kang DH, Park SW, Song JK et al. Long-term clinical and echocardiographic outcome of percutaneous mitral valvuloplasty: Randomized comparison of Inoue and double-balloon techniques. J Am Coll Cardiol, 2000; 35: 169–175.
22. Fawzy ME, Hegazy H, Shoukri M, El Shaer F, ElDali A, Al-Amri M. Long-term clinical and echocardiographic results after successful mitral balloon valvotomy and predictors of long-term outcome. Eur Heart J, 2005; 26: 1647–1652.
23. Arora R, Kalra GS, Singh S et al. Percutaneous transvenous mitral commissurotomy: immediate and long-term follow-up results. Catheter Cardiovasc Interv, 2002; 55: 450–456.
24. Chmielak Z, Ruzyllo W, Demkow M et al. Late results of percutaneous balloon mitral commissurotomy in patients with restenosis after surgical commissurotomy compared to patients with 'de-novo' stenosis. J Heart Valve Dis, 2002; 11: 509–516.
25. Chmielak Z, Klopotowski M, Kruk M et al. Repeat percutaneous mitral balloon valvuloplasty for patients with mitral valve restenosis. Catheter Cardiovasc Interv, 2010; 76: 986–992
26. Sanchez PL, Rodriguez-Alemparte M, Inglessis I, Palacios IF. The impact of age in the immediate and long-term outcomes of percutaneous mitral balloon valvuloplasty. J Interven Cardiol, 2005; 18: 217–225.
27. Meneveau N, Schiele F, Seronde MF et al. Predictors of event-free survival after percutaneous mitral commissurotomy. Heart, 1998; 80: 359–364.
28. Kim KH, Kim YJ, Shin DH et al. Left atrial remodelling in patients with successful percutaneous mitral valvuloplasty: Determinants and impact on long-term clinical outcome. Heart, 2010; 96: 1050–1055.