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ОРИГИНАЛЬНЫЕ СТАТЬИ
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Short-to-mid-term follow-up results of transcatheter closure of atrial septal defect in patients older than 60 years

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Aim. To assess short-to-mid-term clinical and echocardiographic outcomes and identify factors associated with pulmonary arterial hypertension (PAH) in patients older than 60 years.

Material and methods. Retrospective single-center study of 51 consecutive patients (mean age 63,3±3,2 years, 76% females) undergoing percutaneous ASD closure. Functional status, right ventricular (RV) remodeling and pulmonary artery systolic pressure (PASP) was assessed before and 24 hours after the procedure, at 6 months and 12 months.

Results. The mean ASD size was 21,8±4,4 mm. Compared to before procedure, at 24 hours a significant improvement of NYHA class (NYHA II-III 7 (13,7%) vs. 34 (66,7%) patients, p<0,0001, respectively), RV size (26,9±5,7 vs. 31,3±5,7 mm, p<0,0001, respectively) and PASP (26,9±5,7 vs. 50,4±14,2 mm Hg, p<0,001) was detected. At 1 year, RV size and PASP decreased to 22±4,6 mm, p<0,0001 and 33,8±10,8 mm Hg, p<0,0001, respectively, compared to before ASD closure, PAH remained in 10 (19,6%) patients. Pre-intervention PASP ≥57,5 mm Hg was an independent predictor of residual PAH at 1 year (odds ratio 1,31, 95% confidence interval (CI) 1,04-1,67, p=0,024; c-statistics 0,939, 95% CI 0,865-1,0, p<0,001, sensitivity 80%, specificity 92,6%).

Conclusion. Percutaneous ASD closure in elderly patients was associated with regression of RV size and PASP, as well as symptomatic improvement in the short- and medium-term. Pre-intervention PASP was an independent predictor associated with residual PAH after one year.

Keywords: atrial septal defect, percutaneous closure, elderly, pulmonary arterial hypertension.

Relationships and Activities: none.

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Краткосрочные и среднесрочные результаты транскатетерного закрытия дефекта межпредсердной перегородки у пациентов старше 60 лет

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Цель. Оценить краткосрочные и среднесрочные клинические и эхокардиографические исходы и выявить факторы, связанные с легочной артериальной гипертензией (ЛАГ) у пациентов старше 60 лет.

Материал и методы. В ретроспективное одноцентровое исследование был последовательно включен 51 пациент (средний возраст 63,3±3,2 года, 76% женщины), перенесшего чрескожное закрытие дефекта межпредсердной перегородки (ДМПП). Функциональный статус, ремоделирование правого желудочка (ПЖ) и систолическое давление в легочной артерии (СДЛА) оценивали до и через 24 ч после процедуры, через 6 и 12 месяцев.

Результаты. Средний размер ДМПП составил 21,8±4,4 мм. По сравнению с состоянием до процедуры, через 24 часа наблюдалось уменьшение количество пациентов с NYHA II-III с 34 (66,7%) до 7 (13,7%) (p<0,0001), размеров ПЖ с 31,3±5,7 мм до 26,9±5,7 (p<0,0001) и СДЛА с 50,4±14,2 мм до 26,9±5,7 (p<0,001). Через 1 год размер ПЖ и СДЛА уменьшились до 22±4,6 мм (p<0,0001) и 33,8±10,8 мм рт.ст., (p<0,0001), соответственно, по сравнению с данными до закрытия ДМПП. ЛАГ сохранялась у 10 (19,6%) пациентов. До вмешательства СДЛА ≥57,5 мм рт.ст. было независимым предиктором резидуальной ЛАГ через 1 год (отношение шансов 1,31, 95% доверительный интервал (ДИ) 1,04-1,67, p=0,024; С-индекс 0,939, 95% ДИ 0,865-1,0, p<0,001, чувствительность 80%, специфичность 92,6%).

Заключение. Чрескожное закрытие ДМПП у пожилых пациентов ассоциировалось с уменьшением размера ПЖ и СДЛА, а также снижением выраженности симптомов в краткосрочной и среднесрочной перспективе. СДЛВ до вмешательства был независимым предиктором, связанным с резидуальной ЛАГ через год.

Ключевые слова: дефект межпредсердной перегородки, чрескожное закрытие, пожилой возраст, легочная артериальная гипертензия.

Отношения и деятельность: нет.

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Introduction

Atrial septal defect (ASD) is the most common congenital heart abnormality in adults, accounting for one-third of cases [1]. The safety and efficacy of the percutaneous ASD closure (ASDC) have been demonstrated with fewer complications and a shorter duration of hospitalization compared to surgery [2-4]. However, the advantage of percutaneous ASDC in adults, especially the elderly, remains controversial due to numerous concomitant diseases that can affect the outcome and prognosis. With age, the risk of complications associated with ASD and interventions such as arrhythmia, atrial fibrillation (AF) thromboembolism, right ventricular (RV) failure and pulmonary arterial hypertension (PAH) is also high [5]. The presence of PAH before and after the closure of ASD complicates the management of patients due to the associated increased mortality, functional limitations, heart failure, and atrial tachyarrhythmias [6-11]. However, there is limited data on the results of percutaneous ASDC in patients over 60 years of age and risk factors for the development of PAH [5, 12, 13]. In this study, we sought to (1) assess the short-to-mid-term clinical and echocardiographic outcomes of percutaneous ASDC in elderly patients on functional status, right ventricular remodeling, and PAH and (2) identify factors, associated with residual PAH.

Material and methods

Study design and participants. The study was designed as a retrospective case series investigation, and involved consecutive adult patients aged ⩾60 years with secundum ASD who underwent a procedure of percutaneous ASDC and be monitored for at least 1 year at the Heart Institute of Ho Chi Minh City from January 1, 2011, to May 31, 2020. Indications for percutaneous closure were significant left-to-right shunt via isolated secundum ASD with signs of RV volume overload, irrespective of the presence of symptoms, pulmonary and systemic blood flow (Qp/Qs) ratio ⩾1,5 measured invasively, clinical symptoms of dyspnea, or paradoxical embolism [14, 15]. Exclusion criteria were concomitant cardiac structural abnormalities requiring surgical intervention or not satisfied anatomic requirements such as sinus venosus primum, coronary sinus defects, or patients with severe pulmonary vascular disease (>5 Wood units). As this was a retrospective study based on data collected for routine clinical practice, individual informed consent was not required.

Data collection. Variables of interest including clinical characteristics, cardiovascular risk factors and comorbidities, NYHA functional class, and data on transthoracic, transesophageal echocardiography and coronary angiography (CAG) were obtained from medical records. RV failure is defined as the presence of jugular venous distension, hepatojugular reflux, peripheral edema, and hepatosplenomegaly on physical examination [16].

Echocardiography. A transthoracic echocardiographic (TTE) study was performed in all patients before ASD closure, at 24 hours after ASDC, and each follow-up visit, including M-mode, two-dimensional, continuous-wave, pulsed-wave, and colour Doppler echocardiography. Echocardiographic data recorded were left ventricular (LV) ejection fraction (LVEF), calculated by modified biplane Simpson's method, left atrial size, right ventricular mid-cavity end-diastolic diameter (RVEDd), pulmonary artery systolic pressure (PASP) (estimated from tricuspid regurgitation peak Doppler gradient), ASD size and tricuspid regurgitation (TR) level (mild, moderate, severe). RV dilatation is defined as an RV diameter greater than 35 mm at the mid-level of cavity [17, 18]. Residual interatrial shunt was assessed post-ASDC by color Doppler mode. According to our clinic protocol, all echocardiography was performed by two experienced sonographers, accredited at the expert level in echocardiography. The inter- and intra-observer coefficients of variation for all echocardiographic parameters were below 4% and 3%, respectively.

Percutaneous ASDC. All percutaneous ASD closures were performed under local anaesthesia (with endotracheal intubation), guided by fluoroscopy and TEE. TEE is routinely performed before during the implantation procedure. ASD size is identified by balloon sizing (Fig. 1). Amplatzer septal occluders were used to close the ASD. The device size selected was from 1 mm to 5 mm larger than the balloon stretched diameter. All patients received Aspirin (3-5 mg/kg/day) 48 hours prior and for 6 months after ASDC and were advised to receive antibiotic prophylaxis for endocarditis during this period.

Follow-up and endpoint measurements. The follow-up period was 1 year. The patients underwent serial follow-up including clinical and echocardiographic examination 24 hours after ASDC, at 6 months, and 12 months. Variables of interest included (1) functional status defined by NYHA class, (2) RV size change defined as a relative decrease in RV end-diastolic diameter of post-ASDC compared to the value before the intervention (3) residual PAH after ASDC. Normal PASP should be less than 30-35 mm Hg [18]. For this study, PAH was defined as PASP ⩾40 mm Hg (echocardiography) [18].

Statistical analysis. Statistical analysis was performed using IBM SPSS Statistics 26.0 (SPSS Inc., USA). Data are expressed as mean ± standard deviation (SD) or median and interquartile range (IQR) for continuous variables, while categorical variables are presented as numbers (percentages). Comparisons of categorical variables were performed by Chi-Square and Fisher's exact tests, while for continuous variables by using the unpaired Student t-test and Mann-Whitney U-test. A Spearman's correlation was used to determine the relationship between TTE, TEE, and balloon sizing in measuring ASD size. Univariate and Multivariate Logistic regression was performed to identify associations between patient

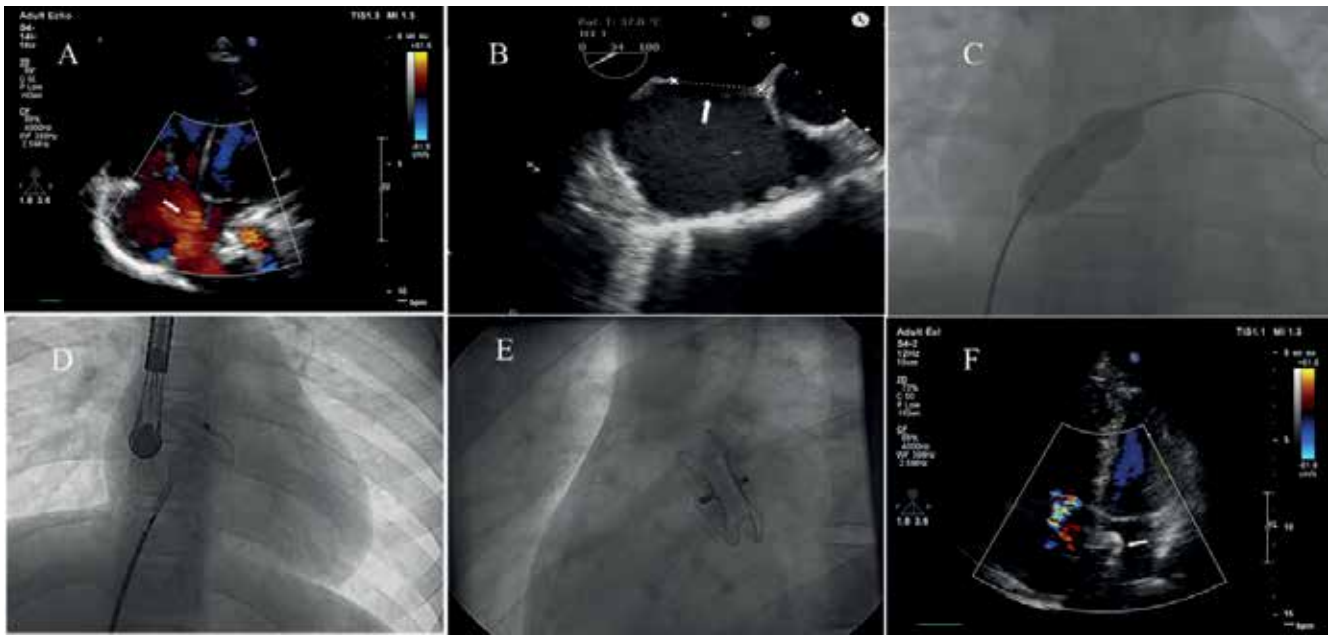

Fig. 1. The sequence of the procedure for closing the atrial septal defect. Atrial septal defect (ASD) had shown in an apical four-chamber view of transthoracic Doppler (**A**) and transesophageal B-mode (**B**) echocardiography (arrow). Balloon sizing during ASD closure intervention to choose device size (**C**). Deployment of ASD closure device under fluoroscopy and transesophageal echocardiography guidance (**D**). ASD closure device successfully deployed (**E**). After the device deployment, transthoracic echocardiography shows a complete closure of the ASD (arrow) (**F**).

characteristics and PAH after ASD closure, represented as odds ratio (OR), 95% confidence interval (CI), and p values. Then the Receiver Operating Characteristic (ROC) Curve Analysis was analyzed to determine an optimal threshold value of factors associated with residual PAH. The area under ROC curve (AUC) or c-statistic, sensitivity, specificity was calculated. Significance was used at p<0,05 for all analyses.

Results

Baseline clinical characteristics. In total, 51 patients (mean age 63,3±3,2 years (range: 60-73 years), 76% females) were included in the study. Baseline patient characteristics are shown in Table 1. Thirty-six patients (76%) were female. Nearly haft of patients has cardiovascular risk factors like arterial hypertension, and dyslipidemia. Diabetes mellitus had only in 10% of patients. There were 4 (7,8%) patients with atrial fibrillation, 1 patient with ASD diameter by balloon sizing of 15 mm, 1 patient of 20 mm, and 2 remaining cases of 24 mm. All 4 patients had RV dilatation and PAH. RV failure was observed in 6 (11,8%) patients. CAG was performed in 80% of cases, in which more than 90% had no significant coronary artery disease.

The mean ASD diameter measured by TTE, TEE, and balloon sizing was 18,9±4,6 mm, 20,2±4,7 mm, and 21,8±4,4 mm, respectively. There was a moderate correlation between TTE and balloon sizing (r=0,4372, p=0,0013) and a strong correlation between TEE and balloon sizing (r=0,7984, p<0,0001). Deployment was successful in 100% of the entire cohort of 51 patients with the median device size being 24 mm. No major procedural complications occurred. Pericardial effusion after ASDC was in 4 patients (7,84%), of which 3 patients had during 24 h after ASDC and persisted for up to 1 year, in 1 patient within 30 days after the procedure and disappeared at 6 months. All of pericardial effusion

Table 1

Baseline Demographic, clinical and procedural characteristics

Variables	n=51
Age (years), Mean±SD	63,3±3,2
Female gender, n (%)	36 (76)
Arterial hypertension, n (%)	28 (54,9)
Dislipidemia, n (%)	25 (49,2)
Diabetes mellitus, n (%)	5 (9,8)
Atrial fibrillation, n (%)	4 (7,8)
Right heart failure, n (%)	6 (11,8)
Coronary angiography, n (%)	41 (80,4)
Nonobstructive coronary artery disease, n (%)	38 (92,7), (n=41)
PCI, n (%)	2 (4,9), (n=41)
TTE: ASD diameter (mm), Mean±SD	18,9±4,6 (range: 1027)
TEE: ASD diameter (mm), Mean±SD	20,2±4,7 (range: 930)
Balloon sizing: ASD dimension (mm), Mean±SD	21,8±4,4 (range: 1329)
Device size, (mm) Me (IQR)	24 (21, 30) (range: 1833)

Abbreviations: ASD — atrial septal defect, PCI — percutaneous coronary intervention, TEE — transesophageal echocardiography, TTE — transthoracic echocardiography.

Table 2

Comparison of clinical and echocardiographic data before and 24 hours after ASDC procedure

Variables	Before ASDC (n=51)	24h after ASDC (n=51)	p-value
NYHA I, n (%)	17 (33,3)	44 (86,3)	<0,0001
NYHA II, n (%)	27 (52,9)	7 (13,7)	
NYHA III, n (%)	7 (13,7)	0 (0)	
RVEDd (mm), Mean± SD	31,3±5,7	26,9±5,7	<0,0001
LA (mm), Mean±SD	36,5±6,8	35,7±5,1	0,3989
LVEF (%), Me (IQR)	71 (62, 76)	70 (65, 76)	0,472
PASP (mm Hg), Mean±SD	50,4±14,2	35,3±11,2	<0,0001
PAH, n (%)	44 (86,3)	13 (25,5)	0,169
Tricuspid Regurgitation			
— Mild, n (%)	4 (7,8)	12 (23,5)	<0,0001
— Moderate, n (%)	21 (41,2)	26 (51)	
— Severe, n (%)	26 (51)	13 (24,5)	

Abbreviations: ASDC — atrial septal defect closure, LA — left atrial, LVEF — left ventricular ejection fraction, PAH — pulmonary arterial hypertension, PASP — pulmonary artery systolic pressure, RVEDd — right ventricular mid-cavity end-diastolic diameter.

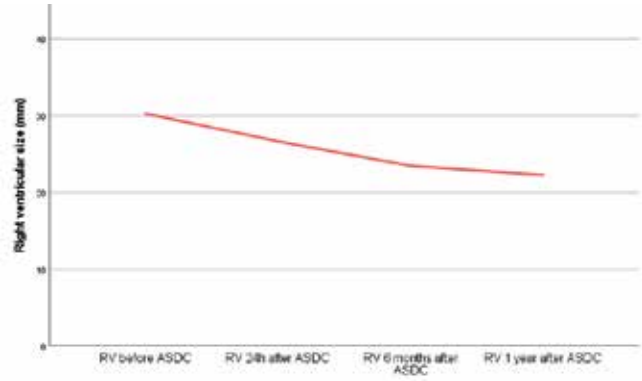

Fig. 2. Right ventricular (RV) size before, 24 hours, 6 months, and 1 year after atrial septal defect closure for patients older than 60 years.

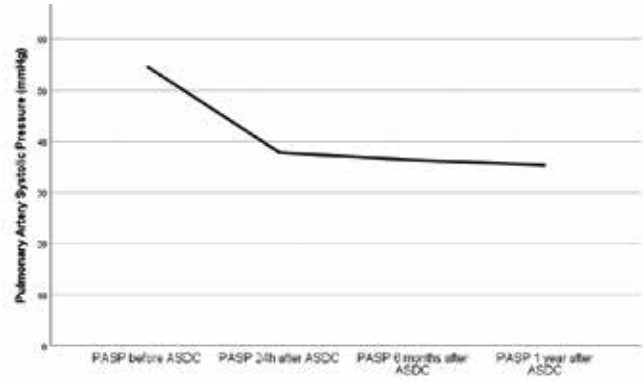

Fig. 3. Pulmonary artery systolic pressure (PASP) before, 24 hours, 6 months, and 1 year after atrial septal defect closure for patients older than 60 years.

was small (⩽6 mm). Residual shunt (mild/moderate) was observed in 9 (17,7%) patients at 6 months and remained at 1 year. No patients showed pericardial effusion or died at the end of the follow-up period.

Clinical and echocardiographic findings at 24h after percutaneous atrial septal defect closure. There was a significant improvement in clinical and echocardiographic figures after percutaneous ASDC. After 24 hours, 7 (13,7%) patients remained in NYHA II class in comparison with 27 (52,9%) patients before intervention (p<0,0001). None of them had NYHA III class (Table 2). RV diameter decreased from 31,3±5,7 mm to 26,9±5,7 mm on the 24h after post-ASDC intervention (p<0,001) (Fig. 2). The improvements were observed in reduction of PASP and severe TR rate (26,9±5,7 vs. 50,4±14,2 mm Hg, p<0,001, respectively and 13 (24,5%) vs. 26 (51%) patients, p<0,001, respectively). Pulmonary arterial hypertension remained in 13 (25,5%) patients. There were no statistical differences regarding to LVEF and LA diameter between pre- and post-ASDC intervention among these patients.

Echocardiographic findings at 6 months and 1 year after percutaneous atrial septal defect closure. Follow-up data at 6 months was available for 29 of 51 patients (57%), at 1 year — for 37 (73%) patients. Fourteen patients were lost to follow-up for different reasons (refusal by the patient or relocation with no forwarding contact information). There were insufficient data on NYHA functional class at last follow-up.

There were regression of RV size and pulmonary artery pressure after 6 months and 1 year after ASDC (Fig. 3 and Table 3). The degree of TR also decreased. Only 5 and 6 patients of originally 26 patients still had severe TR at 6 months and 1 year after ASDC, respectively. Pulmonary arterial hypertension remained in 10 (19,6%) patients at the end of follow-up.

Predictors of residual pulmonary hypertension. In univariate analysis, factors associated with residual PAH at 1 year were age (OR: 1,26, 95% CI 1,0-1,57, p=0,048), pre-intervention RVEDd (OR: 1,23, 95% CI 1,01-1,51, p=0,035), pre-intervention PASP (OR: 1,17, 95% CI 1,06-1,30, p=0,002), severe TR (OR: 8,0, 95% CI 1,4-

Table 3

Comparison of clinical and echocardiographic data before and 6 months, 1 years after percutaneous atrial septal defect closure

Variables	Before ASDC (n=51)	6 months after ASDC (n=29)	1 year after ASDC (n=37)	p_1-value	p_2-value
RVEDd (mm), Mean±SD	31,3±5,7	22,9±5,5	22±4,6	<0,0001	<0,0001
LA (mm), Mean±SD	36,5±6,8	35,9±4,3	38,2±5,4	0,777	0,447
LVEF (%), Me (IQR)	71 (62,76)	73 (68, 77)	72 (69, 77)	0,186	0,002
PASP (mm Hg), Mean±SD	50,4±14,2	34,1±8,4	33,8±10,8	<0,0001	<0,0001
PAH, n (%)	44 (86,3)	7 (24,1)	10 (19,6)	0,551	0,162
Tricuspid Regurgitation					
— Mild, n (%)	4 (7,8)	10 (34,4)	20 (54)	0,022	0,012
— Moderate, n (%)	21 (41,2)	13 (44,8)	11 (29,7)		
— Severe, n (%)	26 (51)	5 (17,2)	6 (16,2)		

Note: p_1 value for comparisons between before and 6 months after atrial septal defect closure; p_2 value for comparisons between before and 1 years after atrial septal defect closure.

Abbreviations: ASDC — atrial septal defect closure, LA — left atrial, LVEF — left ventricular ejection fraction, PAH — pulmonary arterial hypertension, PASP — pulmonary artery systolic pressure, RVEDd — right ventricular mid-cavity end-diastolic diameter, TR — tricuspid regurgitation.

Table 4

Predictors of residual pulmonary arterial hypertension after 1-year percutaneous atrial septal defect closure in multivariate logistic regression analysis

Variables	Univariate Analysis, OR (95% CI)	p-value	Multivariate Analysis, OR (95% CI)	p-value
Age	1,26 (1,0-1,57)	0,048	1,8 (0,8-4,0)	0,146
Female gender	3,15 (0,34-29,53)	0,315	–	
Arterial hypertension	2,51 (0,53-11,83)	0,244	–	
Atrial fibrillation	3,12 (0,4-25,92)	0,291	–	
ASD size (balloon sizing)	1,06 (0,89-1,27)	0,504	0,89 (0,58-1,36)	0,58
RVEDd	1,23 (1,01-1,51)	0,035	1,4 (0,97-2,05)	0,075
LA	0,99 (0,9-1,1)	0,919	–	
LVEF	0,99 (0,9-1,1)	0,430	1,12 (0,86-1,47)	0,389
Pre-intervention PASP	1,17 (1,06-1,30)	0,002	1,31 (1,04-1,67)	0,024
TR (severe)	1,4-45,7	0,019	4,79 (1,16-142,53)	0,365

Note: for continuous variables, odds ratios correspond to a 1-unit increase.

Abbreviations: ASD — atrial septal defect, CI — confidence interval, LVEF — left ventricular ejection fraction, OR — odds ratio, PASP — pulmonary artery systolic pressure, RVEDd — right ventricular mid-cavity end-diastolic diameter, TR — tricuspid regurgitation.

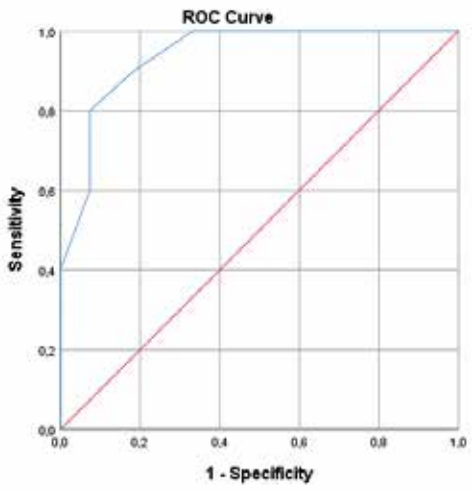

Fig. 4. Receiver-operating-characteristic (ROC) curve of pulmonary artery systolic pressure before percutaneous atrial septal defect closure, predicting residual pulmonary arterial hypertension at 1 year in patients over 60 years.

45,7, p=0,019) (Table 4). In multivariate analysis after adjusting LVEF and ASD size (balloon sizing), pre-intervention PASP independently predictor associated with residual pulmonary hypertension (OR: 1,31, 95% CI 1,04-1,67, p=0,024). In ROC curve analysis, pre-intervention PASP demonstrated excellent discrimination power in prediction of residual PAH (AUC 0,939, 95% CI 0,865-1,0, p<0,001, sensitivity 80%, specificity 92,6%) with cut-off value being 57,5 mm Hg (Fig. 4).

Discussion

There is a matter of debate regarding benefits of percutaneous ASD closure in the elderly [4, 19-21]. The present study confirmed the advantage of percutaneous ASDC in adults, particularly those of advanced age in a short-to-mid-term period in real-world clinical practice. The results from our study also revealed the presence of residual pulmonary hypertension after ASDC, even after

1 year, and the prognostic value of pre-intervention PASP in the prediction of this state.

Clinical benefits and changes in RV and PASP in the elderly has shown in several studies [5, 22-26]. Nyboe C, et al. [24] investigated symptoms, presence of atrial fibrillation, and RV dilation in 220 adult patients treated for ASD in both surgery and percutaneous catheter closure, of which 79 patients were over 50 years old. The authors found that the absolute risk reduction in dyspnea, RV dilation, and atrial fibrillation was 49% (p<0,001), 52% (p<0,001), and 20% (p<0,001), respectively in the group aged ⩾50 years old undergoing percutaneous ASDC. Swan L, et al. [22] reported greater baseline values of RV size and RV systolic pressure in the older group (aged >60 years, n=50) compared with the younger (n=134) and echocardiographic improvement following 6 weeks after ASD device closure procedure in reduction of RV size and PASP in the older group. In recent study [23], Giordano M, et al. studied 68 patients aged above 60 years at a mean follow-up of 4,3 years, reporting a greater reduction in RV dimension (mid-cavity 40,5±5,4 mm vs. 35,6±5,4 mm; p<0,01), PASP (44,3±12,2 mm Hg vs. 34,9±8,8 mm Hg; p<0,01) and a significant improvement of NYHA class (pre-interventional NYHA III-IV 21,5% vs. post- interventional NYHA III-IV 4,6%, p<0,01). Similarly, Humenberger M, et al. [5] studied 236 patients undergoing percutaneous ASDC with a mean follow-up time was 2,3 years, 74 patients older than 60 years, has shown symptomatic improvement after 3-6 months with 66% (n=49) being asymptomatic post-interventionally when compared with 16% (n=12) before (NYHA class I). Authors also found post-interventionally regression of RV size (45±6 mm to 37±5 mm, p<0,0001), PASP (53±17 mm Hg to 43±14 mm Hg, p<0,0001), and severe TR rate (from 7 patients originally to 2 patients). These results were consistent with our study.

Percutaneous ASD closure has the advantage of being significantly less invasive and decreased complication rates and shorter hospital stays than surgery [2-4, 27]. In a systematic review [3] including 13 observational studies with a total of 3082 patients, compared short-term follow-up outcomes (up to 18 months) following surgical and percutaneous ASDC, surgery was associated with a higher rate of total early complications and longer hospital stays than in the percutaneous group (31% vs. 6,6%; OR 5,4, 95% CI 2,96-9,84, p<0,0001 and 2,6 days, 95% CI 2,2 to 3,1 days, p<0,001, respectively). The safety and efficacy of percutaneous ASD closure have reported previously, even in elderly patients (⩾60 years) [12, 28]. Majunke N, et al. [28] analyzed the results of ASD closure in 650 patients, and 144 patients older than 60 years. During mean time follow-up of 36,3 months, complete closure was achieved in 96% of patients with a single ASD (547 of 572), and procedural complications were observed in 3 (0,5%) patients, including device embolization and transient ST depression. Pericardial effusion was not observed in this study unless within 30 days after the procedure occurred in 5 (0,8%) patients, contrary to our results. Device closure of ASD has also demonstrated efficacy even in elderly patients (⩾60 years old) complicated with permanent atrial fibrillation. In the study by Taniguchi M, et al. [29], 9 elderly patients (⩾60 years old) with permanent atrial fibrillation after ASD device closure has shown a symptomatic improvement (from 0 patients originally with NYHA I before to 8 patient after intervention) and significant improvement in RV dimension (42,8±6,4 to 33,3±6,3 mm, p=0,008), whereas LV dimension and LVEF did not change statistic significantly after 6 months. No hemodynamic and thromboembolic complications were observed during the follow-up period (mean 10,6 months). In the SWEDCON registry (Swedish National Registry on Congenital Heart Disease) from 1997 to 2014, the clinical and echocardiographic outcomes of percutaneous ASDC in148 patients ⩾65 years of age (71,6% female) were reported [25]. At the one-year follow-up, the NYHA witnessed significant improvement in functional class (NYHA I from 34% to 61%, p<0,001), and this improvement persisted to the latest follow-up more than 4 years after the intervention. Also were observed improvements in RV remodeling and reduction of PASP. Worsening of NYHA was found in 9 patients at the one-year follow-up compared to pre-intervention. Interestingly, this was not associated with gender, arterial hypertension, or atrial fibrillation but, with age. The authors explained by the presence of diastolic dysfunction that may be developed as result of heart failure with preserved LVEF, which was not aimed at our study.

The prevalence of PAH is reported in 6 to 35% of patients with ASD, both open and closed [30-32]. In our study, its prevalence before ASD closure was 86,3% and decreased to 25,5% after ASD closure and 19,6% after 1 year. In the study by Świątkiewicz I, et al. [33] in 184 transcatheter ASD closure, PAH (PASP ⩾40 mm Hg) was observed in 107 (58,1%) before ASDC, decreased to 46% (n=86) 24 h after ASDC and 36% (n=60) after 6 months. Veldtman GR, et al. [34] demonstrated a persistent elevation in PASP after percutaneous ASDC in 29% of their patients (n=40) at 12 months of follow-up. In the study by Humenberger M, et al. [5], this feature was observed up to 51% of patients over 60 years old (n=74). These results suggest a proportion of patients have elevated pulmonary vascular resistance before ASD closure, which may negatively affect the improvement of PASP and clinical symptoms after the procedure.

The relationship between age and persisted post-interventionally PASP has been found in several studies [5, 33, 35]. Humenberger M, et al. [5] showed a moderate correlation between age and persisted post-interventionally PAP (r=0,63, p<0,0001), and indicated that elderly patients (⩾60 years) were most likely to be left

with persistently elevated PAP after 6 months. In our study, factors associated with residual PAH at 1 year after ASDC were age, pre-intervention RV size, pre-intervention PASP, and severe TR. Yong G, et al. [35] studied risk factors associated with PAH in 215 patients with attempted percutaneous ASD closure in 15 months median duration of follow-up, they found that older age (OR: 1,1, 95% CI 1,06-1,11, p<0,001), larger ASD (OR: 1,13, 95% CI 1,04-1,23, p=0,0052), female sex (OR: 3,9, 95% CI 1,1-13,2, p=0,0313), and at least moderate tricuspid regurgitation (OR: 3,6, 95% CI 1,5-8,8, p=0,0043) were independent predictors of moderate or severe PAH (PASP ⩾50 mm Hg). These results were partly consistent with our results in univariate analysis. However, after adjusting LVEF and ASD size, we only found that pre-intervention PASP served as a unique factor associated with PAH at one year and demonstrated excellent discrimination power.

Elderly patients with ASD can present a high prevalence of comorbidities with advancing age. Cardiovascular risk factors such as arterial hypertension, and dyslipidemia was observed frequently in our study, which was comparable with other studies [5, 22, 28]. The prevalence of arterial hypertension was found to be 30-60% in patients with ASD closure [36-38]. It raised the question about its impact on hemodynamics and clinical outcome. However, in our study, we did not reveal a correlation between hypertension and residual PAH. In addition, less common other cardiovascular risk factors, such as diabetes mellitus or coronary artery disease were observed in our study, which was consistent with previous studies [2-5, 39, 40]. Atrial fibrillation was registered less frequently in our study, less than 10%, in contrast to the study by Humenberger M, et al. [5] and Swan L, et al. [22] being 51,3% (n=38) and 20% (n=10), respectively. This can be explained by the fact that our patients were in an earlier stage of cardiac remodeling with a small number of patients with LA enlargement. However, the presence of concomitant cardiovascular risk factors could affect the clinical status and outcome in the short-to-long-term period in patients with ASD, hence it is reasonable to manage these conditions according to appropriate guidelines.

Limitations. First, as a retrospective nature of the study, some cofounders and medical management could potentially influence the change of functional status and echocardiographic feature after percutaneous ASDC. Second, this was a single-center study, not all patients are followed up in our clinic. Data at the end of 1-year follow-up were available in 37/51 (73%) patients, which may affect the accuracy in the assessment of the prognostic value of pre-intervention PASP. However, echocardiographic characteristics of lost to follow-up were similar to those with late follow-up data. Third, cardiac catheterization and pulmonary function tests were not performed due to study design and ethical issues, the diagnosis of PAH based on echocardiography was less accurate than the reference ones. Fourth, this study aimed to focus on functional status and echocardiographic features after ASD closure. Therefore, a comprehensive assessment of early and late complications was not taken into account. Future studies should therefore involve larger multicenter patient cohorts to permit a more detailed assessment of complications and factors related to residual PAH after ASD closure.

Conclusion

Percutaneous closure in elderly patients with secundum ASD can be successfully performed and is associated with regression of RV size and PASP as well as symptomatic improvement in the short- and medium-term. Residual PAH remained common in one-fifth of adult patients after ASD closure and more frequent follow-up should be recommended for these patients. The PASP of pre-ASDC intervention was an independent predictor associated with residual PAH after one year.

Relationships and Activities: none.

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