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# 9

# Atrial Septal Defect Closure in Geriatric Patients

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## 1. Introduction

The prevalence of adults with congenital heart disease is rising in the general population (1). Similarly, the number of geriatric patients with congenital heart disease, such older than 70 years old, is also rising. Furthermore, mortality rates in congenital heart disease have shifted away from the young and towards adults, with a steady increase in age at death. Actually, the mortality of congenital heart disease in patients whose age 60 years or more is increasing during past few decades reported in Japanese nationwide survey (2). Atrial septal defect (ASD) is the one of the most common congenital heart lesions in adults, and the most influenced heart disease for the death in geriatric population. Prevalence of ASD in children is noted to be 11.4% within the congenital heart defects (3). Majority of these children are asymptomatic and diagnosed by school physical examination, heart murmur detected primary care pediatrician, cardiac echo screening in the newborn period. If defect is smaller than 6 mm, spontaneous closure can be expected. Operation is scheduled based on children's body size, usually before the elementally school with very low incidence of mortality rate (4).

Although the pediatric or young adult ASD population has attracted research interest over the last 2 decades, the geriatric ASD population has yet to be characterized. Extrapolation of studies on younger patients is not appropriate in the geriatric patients. First, geriatric patients with ASD acquire comorbid conditions such as arrhythmia, hypertension, respiratory distress, kidney disease, etc., that always influence on significant role in their heart conditions. Second, geriatric ASD patients may have inherently superior resiliency, milder disease, or balanced physiology in contrast to those not surviving to an advanced age (5). Therefore, geriatric patients with ASD represent a distinct population for which focused studies are needed.

Again, clinical features of atrial septal defect (ASD) in the elderly are significantly different from those in children and young adults. Elderly patients with ASD frequently present with hemodynamic abnormalities such as pulmonary hypertension, atrial arrhythmias, and valvular regurgitation, which cause congestive heart failure. Moreover, various comobidities, such as hypertension, chronic obstructive pulmonary disease, coronary artery disease and left ventricular diastolic dysfunction often complicate the clinical features in this population. Left ventricular diastolic dysfunction, which is also seen as part of normal aging and frequently occurs in elderly individuals with hypertension or increased arterial stiffness [6,7], may cause acute congestive heart failure after ASD closure [8].

After the introduction of Amplatzer Septal Occluder, transcatheter ASD closure has become a well-established treatment for secundum-type ASD, with hemodynamically significant left-to-right shunt in children and young adults. Several studies and our own experience have demonstrated clinical benefits and positive right-heart remodeling, with reduction of the right ventricular end-diastolic diameter.(8-17) However, few studies were published considering geriatric patients, who older than 70 years.(18–21) In this aged population, not only catheter closure of ASD but also surgical closure has been reported very limited experiences, little data are published on functional results. In this chapter, I would like to report our current experience of catheter closure of ASD in geriatric patients (70 years or more), and its long-term outcome.

## 2. Patient's background

From 2005 to 2010, transcatheter closure of ASD was attempted in 420 patients in our hospital. Of those patients, 30 patients who were older than 70 years were retrospectively assessed. Patient characteristics, clinical, hemodynamic and echocardiographic data, and ASD morphology are shown in Table 1. There were 10 males and 20 females with a mean

| | |
|---|---|
| *Total patients* | *30* |
| *Gender, F/M* | *20/10* |
| *Age, (range), yrs* | *75.8 ± 3.8 (70-85)* |
| *BSA, m²* | *1.5 ± 0.2* |
| *Hypertension* | *12 (40%)* |
| *Stroke* | *4 (13%)* |
| *CAD* | *2 (7%)* |
| *COPD* | *5 (17%)* |
| *Atrial fibrillation* | *16 (53%)* |
| *Paroxysmal* | *3 (10%)* |
| *Permanent* | *13 (43%)* |
| *RBBB* | *22 (74%)* |
| *Systolic PAP *, mmHg* | *35.6 ± 11.8* |
| *PAH* | *16 (53%)* |
| *E', cm/s* | *7.1 ± 1.9* |
| *E/E`* | *11.0 ± 3.9* |
| *Diuretic use* | *17 (57%)* |
| *Hospitarization for HF* | *9 (30%)* |
| *NYHA functional class, I / II / III* | *5 /17 / 8* |
| *Qp/Qs** | *2.4 ± 0.7* |
| *ASD size, mm* | *20.3 ± 6.4* |
| *Rim type* | |
| *Sufficient rim, n (%)* | *8 (27%)* |
| *Aortic rim deficient, n (%)* | *19 (63%)* |
| *Aortic and anterosuperior rim deficient, n (%)* | *1 (3%)* |
| *IVC rim deficient, n (%)* | *2 (7%)* |

BSA, body surface area; CAD, coronary artery disease; COPD, chronic obstructive pulmonary disease RBBB, right bundle branch block; PAP, pulmonary artery pressure; PAH, pulmonary artery hypertension
E, early diastolic mitral valve flow velocity; E', early diastolic mitral annular velocity; HF, heart failure NYHA, New York Heart Association; Qp, pulmonary flow; Qs, systemic flow; IVC, inferior vena cava

Table 1. Patients Characteristics

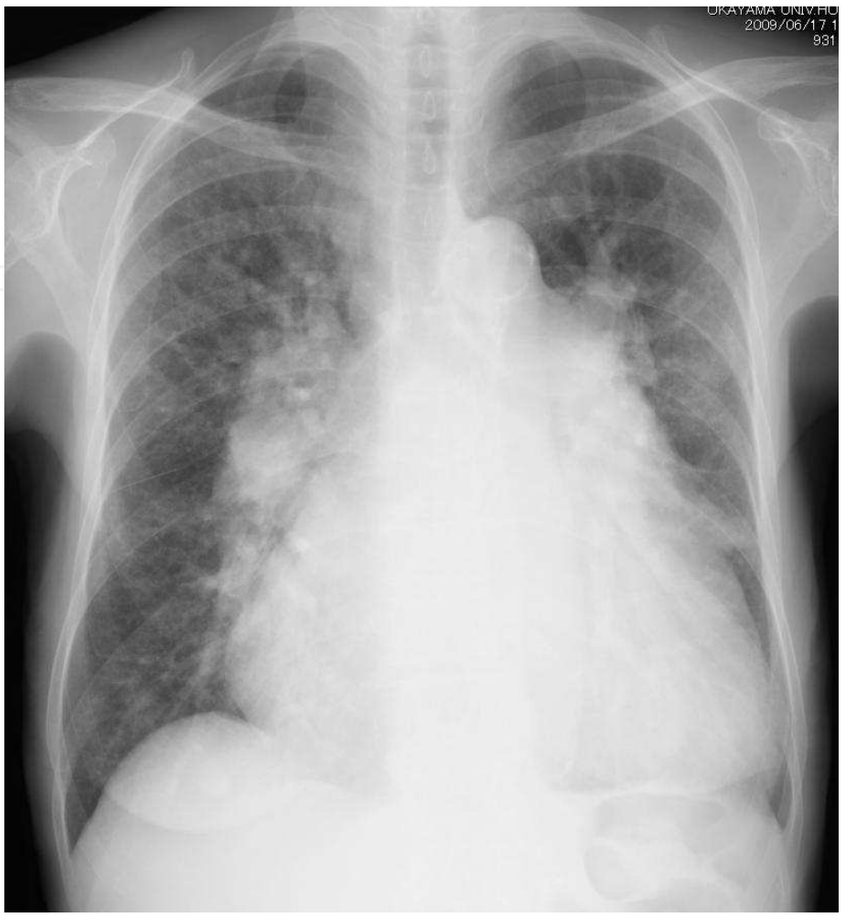
age of 75.8 ± 3.8 years and age range of 70 to 85 years. Eighteen of the 30 patients had been diagnosed with ASD within 2 years before transcatheter closure was attempted but the others well before that. Most of the patients had at least one major comorbidity, including systemic hypertension, stroke, coronary artery disease, and atrial fibrillation. Mean systolic pulmonary artery pressure at the time of diagnostic catheterization was 35.6 ± 11.8 mmHg. Mean early diastolic mitral annular velocity (e') and the ratio of early diastolic mitral valve flow velocity (E) to e' (E/e') suggested that our cohort generally had impaired myocardial relaxation.(22,23) Twelve patients had been diagnosed with ASD well before transcatheter closure was attempted but they had refused or hesitated to receive ASD closure. We think that this was partially because they had no recognizable symptom, but mainly because surgical closure was the only treatment at the time when they had been first diagnosed with ASD. More than half of the patients were being treated with a diuretic for congestive heart failure, and 30% of the patients had a history of hospitalization due to heart failure. Seventeen patients were classified as NYHA functional class II and 8 patients were classified as class III. Only 5 patients had no symptoms despite significant shunt flow and were classified as NYHA functional class I. One patient had two defects. Mean defect diameter was 20.3 ± 6.4 mm, and a circumferentially sufficient rim (> 5 mm rim around the defect) was observed in only 8 patients. Mean pulmonary-systemic flow ratio (Qp/Qs) calculated by using the Fick principle was 2.4 ± 0.7.

## 3. Hemodynamic features during ASD closure in geriatric patients

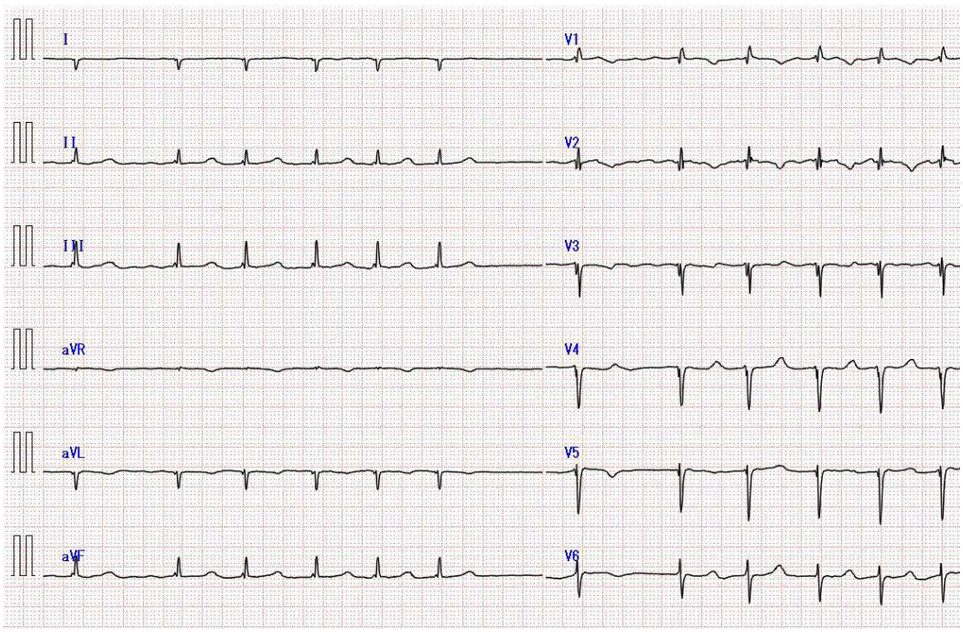
Previous studies have suggested that development of acute congestive heart failure is due to abrupt elevation in left ventricular preload following transcatheter ASD closure, especially in elderly patients with impaired left ventricular systolic or diastolic function (6,24,25) In our experience, despite the fact that our patients had impaired left ventricular diastolic function estimated by decreased e' and increased E/e' (23,26) as well as various comorbidities such as systemic hypertension, pulmonary artery hypertension and atrial fibrillation, acute congestive heart failure after the ASD closure did not develop in any of the patients except in one patient in whom the procedure was abandoned due to PCWP elevation during test balloon occlusion. Schubert et al. reported that peri-procedural anticongestive medication was effective in preventing congestive heart failure after ASD closure in elderly patients (27). In our experience, 57% of the 30 patients previously used oral diuretics, and this high rate of diuretic usage might have contributed to prevention of acute congestive heart failure after closure.

## 4. Transcatheter ASD closure

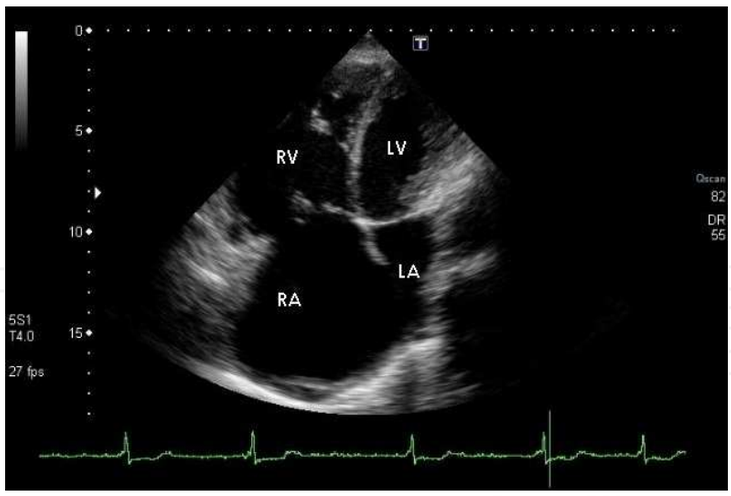
Transcatheter ASD closure was conducted under general anesthesia with the guidance of fluoroscopy and TEE. Amplatzer® Septal Occluder (St. Jude Medical, St. Paul, MN) was used for all closures, and the procedure was performed as previously described (28). For patients who had a history of heart failure and were considered to be hemodynamically high-risk, we placed a Swan-Ganz catheter into pulmonary artery from the internal jugular vein or femoral vein and monitored pulmonary artery wedge pressure (PCWP) during subsequent procedure. If mean PCWP increased > 5 mmHg from the baseline value during balloon occlusion of the defect (test balloon occlusion), we judged the procedure should not be indicated. (Fig. 1) Medications such as diuretics, warfarin, and antihypertension and antiarrhythmia drugs were continued at the same doses after the procedure.



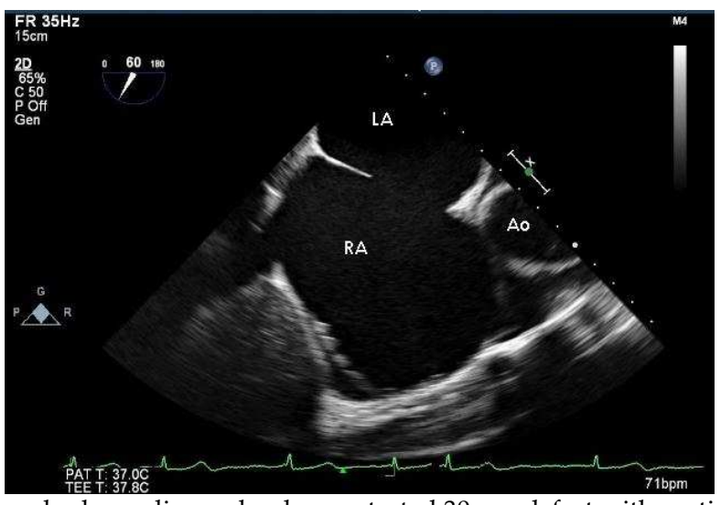

(a) Chest x ray before the procedure




(b) ECG finings before the procedure



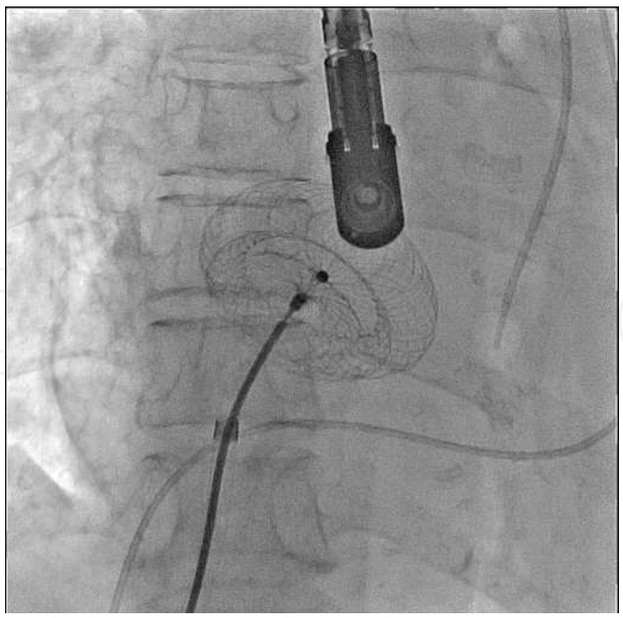

(c) apical 4 chamber view of transthoracic echocardiography: RA and RV are significantly enlarged



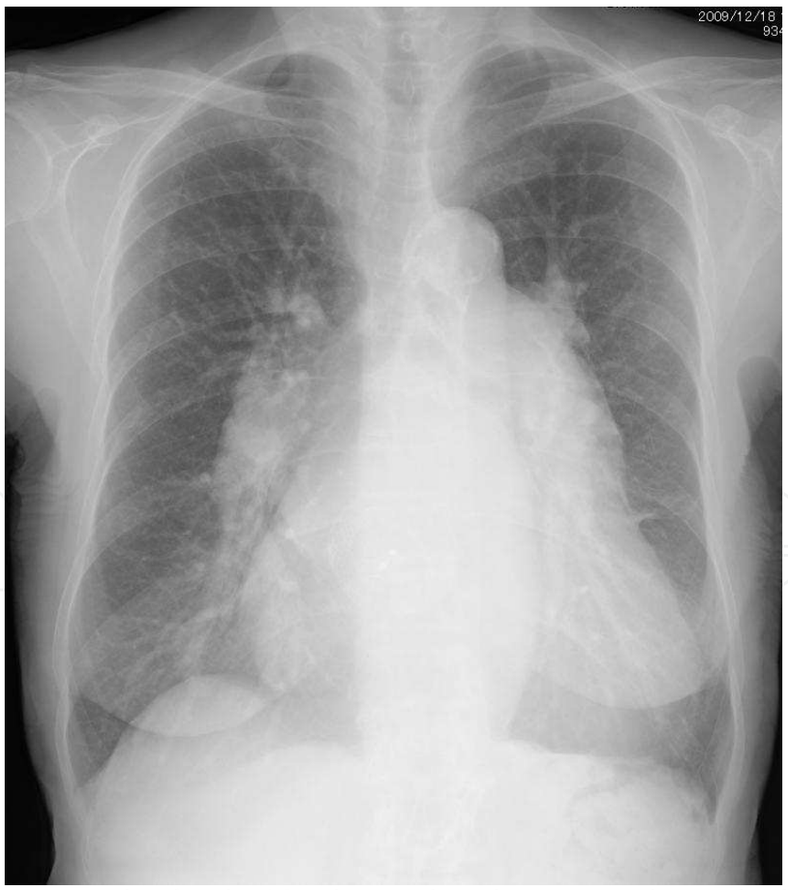

(d) transesophageal echocardiography demonstrated 30mm defect with aortic rim deficiency




(e) 3d transesophageal echocardiography demonstrated the elliptical shape of ASD



(f) Catheter closure of ASD using 34mm device, PCW pressure monitored continuously




(g) Chest x-ray 6 months after the ASD closure, clinical symptoms also resolved completely

Fig. 1. 82 years old female, ASD with permanent atrial fibrillation.

Prior to ASD closure, test balloon occlusion were performed in 7 of 30 cases. As a result, the procedure was abandoned in one case due to a significant elevation of PCWP during test occlusion of the ASD. This patient was an 84-year-old thin woman who had permanent atrial fibrillation, hypertension, chronic kidney disease, chronic anemia and severe TR. She had been repeatedly hospitalized with congestive heart failure in past years. Her ASD diameter was 24 mm and Qp/Qs was 2.6. During test balloon occlusion, her PCWP immediately increased from 8 mmHg to 22 mmHg and remained at 16 mmHg after 20 minutes, thus procedure was abandoned. In the other 2 cases, the device was difficult to deploy because of large size defect. One of those cases proceeded to surgical closure, and the other case was successfully closed in the second attempt of catheter intervention on a later day. Finally, 28 (93%) of the 30 patients were treated successfully by catheter closure. A single device was placed in 27 patients. In the remaining patient with multiple defects, 2 devices were deployed at the time of the same procedure. Mean device diameter was 23.3 ± 6.0 mm. Mean follow-up period was 19.1 ± 11.3 months.

## 5. Procedural outcomes

Table 2 shows the procedural and mid-term results. Device closure was successfully performed in 28 (93%) of the 30 patients without acute complications. In the other 2 patients, the procedures were abandoned because of technical issues. While only 8 (27%) of the 30 patients had sufficient rim type ASD, 19 (63%) had aortic rim deficient type. However, there was not much difference in our device selection between sufficient rim and aortic rim deficient type. Therefore, we think that the small percentage of patients with sufficient rim did not have a great impact on device size selection in the present study. Although the majority of our patients were complicated with various comorbidities, such as pulmonary artery hypertension, systemic hypertension and atrial fibrillation, high procedural success rate can be expected even in this aged group. Also, significant improvement of NYHA functional class was observed after closure even though about 30% of the patients in this

| | |
|---|---|
| *Procedural results (n=30)* | |
| *Success deployment, n (%)* | *28 (93%)* |
| *Device size, mm* | *23.3 ± 6.0* |
| *Acute complication, n (%)* | *0 (0%)* |
| *Mid-term results (n=28)* | |
| *Meam follow-up period, m* | *19.1 ± 11.3* |
| *Residual shunt, n (%)* | *2 (8%)* |
| *Major events* | |
| *Death, n (%)* | *2 (8%)* |
| *sudden death, n* | *1 (4%)** |
| *prostate cancer, n* | *1 (4%)* |
| *Pacemaker implantation, n (%)* | *1 (4%)* |
| *TIA, n (%)* | *1 (4%)** |
| *Persistent AF, n (%)* | *1 (4%)* |
| | ** the same case* |

TIA, transient ischemic attack; AF, atrial fibrillation

Table 2. Procedural and Mid-term Results

study had a history of hospitalization for congestive heart failure. No patient required additional hospitalization for congestive heart failure during the follow-up period. The first procedure was successful in 27 of 30 cases in which transcatheter ASD closure was attempted. On the other hand, the procedure was abandoned in 3 cases.

Two patients died during the follow-up period. One died of prostatic cancer 20 months after ASD closure. The other patient died 2 months after the procedure. This patient was a 70-year-old woman who had permanent atrial fibrillation, severe chronic obstructive pulmonary disease, mild left ventricular dysfunction, history of pacemaker implantation for sick sinus syndrome, and mitral valve replacement and was in NYHA functional class III. Her ASD was 22 mm with a sufficient atrial rim, and a 26 mm device was used for closure. She died from unknown cause at home; however, a history of transient cerebral ischemic attack was reported one week before her death. Autopsy was not performed. During the follow-up period, 3 complications occurred. One patient who was complicated with several cardiac comorbidities died 2 months after the procedure. An autopsy was not performed and it was therefore not known whether the cause of sudden death was ASD device-associated.

## 6. Atrial arrhythmias

Two patients were complicated with new arrhythmia. One patient who had permanent atrial fibrillation underwent pacemaker implantation for slow ventricular response 6 months after ASD closure. The other patient with paroxysmal atrial fibrillation before ASD closure developed persistent atrial fibrillation during the follow-up period. The remaining 24 patients had no late complication during the follow-up period. No patient had hemodynamically significant residual shunt.

Table 3 shows time course changes in clinical and echocardiographic parameters. Follow-up data (at more than 6 months after the procedure) were available in all of the 28 patients with exception of one patient who died 2 months after the procedure. NYHA functional class was significantly improved in 20 (74%) of the 27 patients at the latest follow-up (Fig. 2). One patient who remained in NYHA class III was complicated with severe chronic obstructive pulmonary disease. There was also a significant improvement in plasma BNP level (175.9 ± 64.7 vs. 99.2 ± 83.2 pg/ml, P=0.013). Resting heart rate also decreased significantly (74.4 ± 14.5 vs. 66.7 ± 8.7 beats/min, P=0.005), although no cardiac chronotropic drug was administered to any of the patients. Pacemaker implantation was required in one patient 6 months after the procedure, even though bradycardia was not observed before or just after ASD closure. In one patient, paroxysmal atrial fibrillation progressed into persistent atrial fibrillation 2 years after ASD closure. In previous studies, the incidence of atrial fibrillation in patients after transcatheter ASD closure was estimated to be 5% to 18% (29-31), however, especially in elderly patients, atrial fibrillation is one of the expected findings for their natural course after ASD closure.

## 7. Cardiac remodeling

RVEDD and estimated systolic pulmonary artery pressure decreased significantly (40.8 ± 6.0 vs. 31.6 ± 4.5 mm, P<0.001, 38.5 ± 12.7 vs. 27.2 ± 7.3 mmHg, P<0.001, respectively). At the

| | Pre-procedure (n=27) | Follow-up (n=27) | p Value |
|---|---|---|---|
| NYHA functional class, n (%) | | | < 0.001 |
| I | 3 (11%) | 21 (78%) | |
| II | 17 (63%) | 5 (18%) | |
| III | 7 (26%) | 1 (4%) | |
| Plasma BNP level, pg/mL | 175.9 ± 249.7 | 99.2 ± 83.2 | 0.013 |
| HR at rest, bpm | 74.4 ± 14.5 | 66.7 ± 8.7 | 0.005 |
| Estimate systolic PAP, mmHg | 38.5 ± 12.7 | 27.2 ± 7.3 | < 0.001 |
| RVEDD, mm | 40.8 ± 6.0 | 31.6 ± 4.5 | < 0.001 |
| LVEDD mm | 39.7 ± 4.8 | 45.3 ± 4.6 | < 0.001 |
| RVEDD/LVEDD ratio | 1.05 ± 0.24 | 0.70 ± 0.12 | < 0.001 |
| LAD, mm | 46.1 ± 9.9 | 44.3 ± 9.3 | 0.128 |
| LVEF, % | 70.5 ± 6.1 | 70.5 ± 5.7 | 0.611 |
| TR, n (%) | | | 0.002 |
| ≤ mild | 10 (37%) | 20 (74%) | |
| moderate | 13 (48%) | 7 (26%) | |
| severe | 4 (15%) | 0 (0%) | |
| MR, n (%) | | | 0.004 |
| none or trivial | 18 (67%) | 8 (30%) | |
| mild | 6 (22%) | 16 (59%) | |
| > moderate | 3 (11%) | 3 (11%) | |

BNP, brain natriuretic peptide; PAP, pulmonary artery pressure; RVEDD, right ventricular end-diastolic dimension; LAD, left ventricular dimension; LVEF, left ventricular ejection fraction; TR, tricuspid regurgitation; MR, mitral regurgitation

Table 3. Changes of Clinical Echocardiographic Parameters

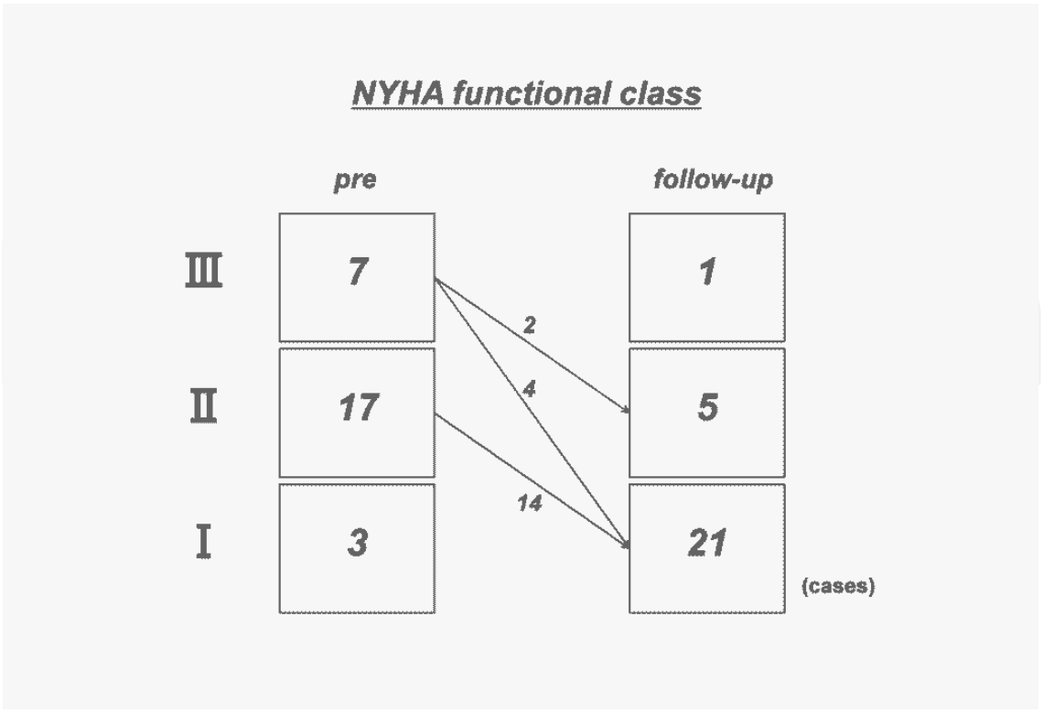



Fig. 2. NYHA functional class before the procedure and at follow-up.

same time, LVEDD increased significantly (39.7 ± 4.8 vs. 45.3 ± 4.6 mm, P<0.001). Therefore, the RVEDD/LVEDD ratio significantly decreased (1.05 ± 0.24 vs. 0.70 ± 0.12 mm, reduction of 67%, P<0.001), indicating ventricular reverse remodeling. Left atrial dimension, above the normal level at baseline, did not change significantly during the follow-up period. Left ventricular ejection fraction also did not change. During the follow-up period, NYHA functional class significantly improved in 20 (74%) of the 27 patients. Our data also demonstrated significant decreases of heart rate, pulmonary artery pressure and plasma BNP level, and these changes contributed to the improvement of NYHA functional class. Decrement of heart rate is presumably evidence of increment of left ventricular stroke volume following increased left ventricular preload after abolishment of left-to-right shunt. Significant decrease in RVEDD/LVEDD ratio was observed even in our geriatric patients, although RVEDD did not reach the normal level. Interestingly, percentage change in RVEDD/LVEDD ratio in our cohort was equivalent to results of other studies in younger populations (25,32). Furthermore, it was revealed that RVEDD/LVEDD ratio was independently correlated with NYHA functional class in the follow-up period.

## 8. AV valve regurgitation

Improvement of TR was observed in 11 of 17 patients (65%) with moderate or severe degree of regurgitation during the follow-up period (Fig. 3). On the other hand, MR was increased in 10 (37%) of the 27 patients and was unchanged in the others (63%) during the follow-up period (Fig. 4). In our cohort, there was no patient with mitral valve prolapse as a cause for MR. In this study, the degree of TR was decreased in 11 patients (41%) and exacerbation of

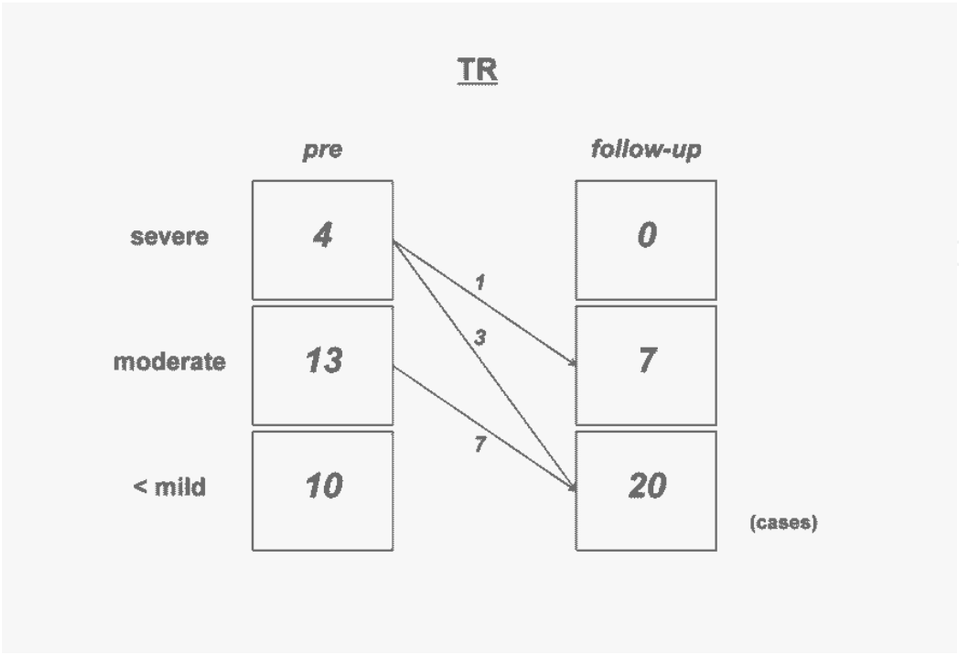



Fig. 3. Degrees of TR before the procedure and at follow-up.

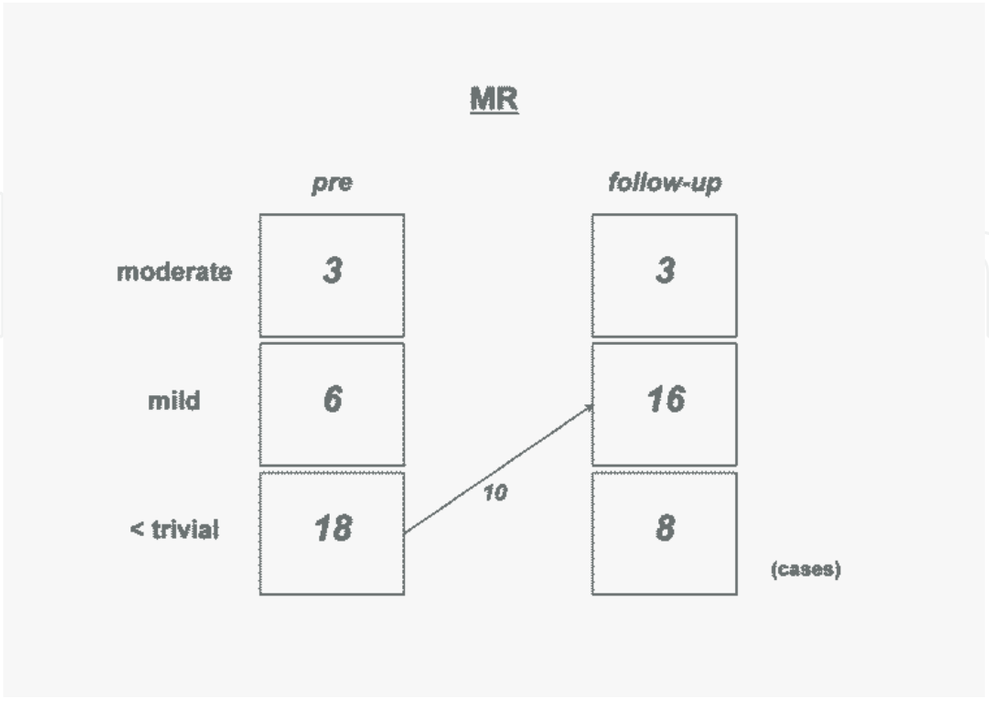



Fig. 4. Degrees of MR before the procedure and at follow-up.

TR was not observed during the follow-up period. Interestingly, in the case of moderate or severe TR before ASD closure, the degree of TR was improved in 11 (65%) of the 17 patients. TR can be improved functionally following decrement of right ventricular preload after ASD closure. Improvement of TR also can be expected following improvement of right ventricular geometric abnormality (33,34). Our results suggest that TR can be improved even in geriatric patients and that the severity of TR does not become a factor to exclude them as candidates for transcatheter ASD closure. On the other hand, the degree of MR was slightly increased in 10 patients (37%) and unchanged in the others (63%) during the follow-up period. Wilson et al. reported that the degree of MR was unchanged in 83% and increased in 10% of their 194 patients, including 78 patients aged younger than 15 years, after transcatheter ASD closure (35). In elderly ASD patients, the severity of MR might be masked by the presence of ASD effectively reducing left ventricular preload. Additionally, degenerated change of the mitral valve leaflet also influenced the increase in MR. Although the degree of MR and the increase in MR were not associated with NYHA functional class in the follow-up period in our study, further long-term follow-up is mandatory.

Associations between NYHA functional class and echocardiographic parameters in the follow-up period

Table 4 shows associations of clinical and echocardiographic parameters with NYHA functional class. In the follow-up period, RVEDD/LVEDD ratio was identified as a factor associated with NYHA functional class. On the other hand, E/e', e', degree of TR or MR and increase in MR were not associated with NYHA functional class.

| Variable | r | Univariate p Value | Multivariate p Value |
|---|---|---|---|
| Age | | 0.349 | |
| Qp/Qs | | 0.807 | |
| HR at rest | | 0.260 | |
| plasma BNP level | | 0.146 | |
| Estimate systolic PAP | | 0.382 | |
| RVEDD/LVEDD ratio | 0.491 | 0.009 | 0.009 |
| LVEF, % | | 0.971 | |
| E/e' | | 0.688 | |
| e' | | 0.962 | |
| Degree of TR | | 0.282 | |
| Degree of MR | | 0.682 | |
| increase in MR | | 0.764 | |

Table 4. Association betwwen Clinical and Echocardiographic Parameters and NYHA class at Follow-up Period

## 9. Conclusions

Although our experience is still small, even in elderly patients older than 70 years, transcatheter closure of ASD can be performed safely and contributes to significant improvement of NYHA functional class and positive cardiac remodeling. Further investigation is required especially for the outcome of MR

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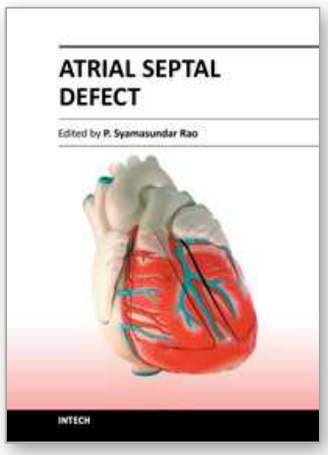
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**Atrial Septal Defect**

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Atrial Septal Defects (ASDs) are relatively common both in children and adults. Recent reports of increase in the prevalence of ASD may be related use of color Doppler echocardiography. The etiology of the ASD is largely unknown. While the majority of the book addresses closure of ASDs, one chapter in particular focuses on creating atrial defects in the fetus with hypoplastic left heart syndrome. This book, I hope, will give the needed knowledge to the physician caring for infants, children, adults and elderly with ASD which may help them provide best possible care for their patients.

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