

Percutaneous Interventional Treatment of Atrial Septal Defect Secundum in Macedonia

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Abstract

Citation: Milev I, Idrizi Sh, Zimbakov Z, Ampova-Sokolov V, Zafirovska P, Nikolov S, Angjuseva T, Mitrev Z. Percutaneous Interventional Treatment of Atrial Septal Defect Secundum in Macedonia. *OA Maced J Med Sci*. 2014 Mar 15; 2(1):62-67. <http://dx.doi.org/10.3889/oamjms.2014.011>

Key words: atrial septal defect; percutaneous intervention; atrial septal occluder; congenital heart disease; right ventricle overload.

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Received: 18-Dec-2013; **Revised:** 20-Jan-2014; **Accepted:** 21-Jan-2014; **Online first:** 30-Jan-2014

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Competing Interests: The authors have declared that no competing interests exist.

Background: Atrial septal defect (ASD) is a common congenital heart disorder (CHD). While conventional open surgical treatment is the standard procedure in our country, percutaneous device closure with implantation of an atrial septal defect occluder is a promising alternative with very few peri and post procedural complications.

Aim: The aim of the study was to present the rate of success and complications in percutaneous ASD closure with the implantation of an atrial septal defect occluder.

Material and Methods: We treated 153 patients (ages 2-76; 65% female) with ASD secundum with percutaneous trans catheter closure using a septal occluder. Follow up was on a 3 month interval and assessment included clinical, electrophysiological and echocardiographic status.

Results: The mean diameter of ASD obtained via balloon sizing was 16 ± 16 mm. Multiple ASDs were found in 20 (13%) patients and deficient aortic and anterior rim (< 5 mm) was present in 16 (10%) patients. Due to inadequate placement and/or sizing, the device was removed and replaced in seven patients (5%). During follow up, trivial shunt was present in 4 (2.6%) patients. The diameter of the right ventricle corrected for age was reduced by an average of 20% by the first month and in 130 (86%) of patients it had normalized by one year of follow up. During follow up, 16 (10%) patients reported transient headaches and 3 (1.9%) patients had transient atrial fibrillation (AF).

Conclusion: In conclusion, the implantation of a septal occluder was found to be a safe procedure that resulted in improved hemodynamic parameters that result from right ventricular volume overload with favorable short- and mid-term results.

Introduction

Congenital heart disease has a prevalence of 8-12 cases per 1000 live births. ASD is a common congenital heart disorder comprising of 10 % of all CHD [1-6]. In utero, heart tissue can be seen on the 18th or 19th day of fetal life. The atrial septum starts to form in the fourth week and is completely formed by the end of the fifth week of pregnancy, with formation of the septum primum, ostium primum and septum secundum.

There are four basic forms of ASD [1-9]. The ostium secundum defect (Figure 1), the most common and benign form originates in the region of the fossa ovalis and is believed to develop as a result of exaggerated fenestration or resorption of the septum primum, underdevelopment of the septum secundum

or a combination of the two. The underdevelopment of the septum secundum is often associated with atrial septal aneurysm (ASA). This is probably due to the extra tissue in the region of the fossa ovalis and it could be associated with a mitral valve prolapse or atrial arrhythmias.

The second type of ASD is an ostium primum defect thought to result from the inability of the endocardial tissue to close the ostium primum. This type of defect is almost always associated with a mitral valve cleft.

The third type of ASD is the sinus venosus defect. It is located in the posterior part of the septum, close to the superior vena cava and it could be associated with partial abnormal drainage of the upper right pulmonary vein or the inferior vena cava.

The fourth type of ASD is a coronary sinus septal defect. This is the most uncommon variation of ASD, also known as unroofed coronary sinus. Part of the roof of the coronary sinus is missing so there could be a shunt from the left atrium to the coronary sinus and then to right atrium. It is usually associated with anomaly of the superior vena cava.

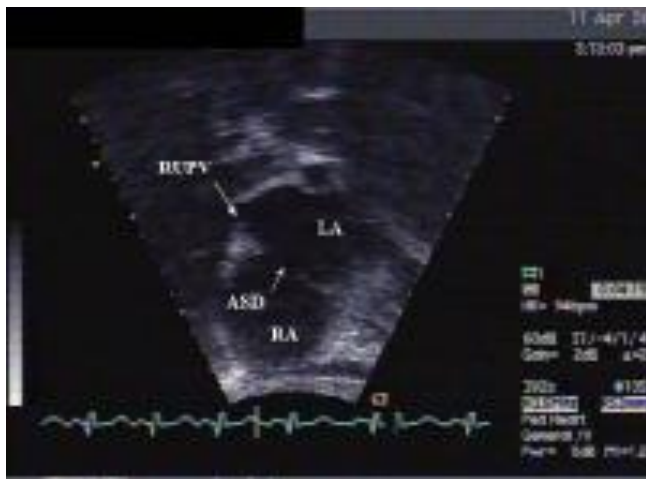


Figure 1: ASD ostium secundum type.

ASD is the second most common CHD and it is present in 0, 67-2 out of 1000 live births. Ostium secundum represents 90% of ASD cases. In 15-30% of adults there is an open persistent foramen ovale (PFO) with normal valve function and without spontaneous left to right shunt. Developed countries have a very low (<1%) mortality rate. In majority of cases the cause is a spontaneous malformation of the interatrial septum although genetic factors play a role in some syndromes (Holt- Oram Sy., Klinefelter Sy., Down Sy.) [1, 6].

Clinical effects from isolated ASD usually correlate with the size of the left to right shunt which depends on the size of the defect and relative compliance of the left and right ventricle and indirectly depends on the resistance of pulmonary and systemic circulation [10-14]. About 15% of ostium secundum ASD close spontaneously by the age of four and in some cases it retrogrades to a non-significant hemodynamic shunt that does not require intervention. The clinical manifestation usually belongs to one of three groups. First, babies with moderate or severe isolated ASD present with tachypnea, respiratory infections and failure to thrive. In these patients the pulmonary arterial pressure measured during catheterization or with Doppler echocardiography approaches or is equal to the systemic arterial pressure. The second category of patients is those in whom the ASD remains undiagnosed until adulthood and usually presents with pulmonary hypertension or arrhythmia (atrial fibrillation or atrial tachycardia). In elderly patients, the first manifestation might be chronic heart failure. Embolic cerebral stroke could be the first presentation in the third group of patients with ASD.

Diagnosis is usually made after detection of a murmur in babies and accidental or symptom related finding in adults where echocardiographic examination reveals a septal defect with or without right heart volume overload [15-18]. Transesophageal echocardiography (TEE) may be performed for a more precise evaluation and sizing of the defect as well as magnetic resonance and/or cardiac catheterization in some cases.

Medical treatment of a significant ASD with right ventricle volume overload should be according to heart failure guidelines. Arrhythmias (atrial fibrillation and atrio-ventricular blocks) associated with the defect are uncommon during childhood but their incidence increases with age (1-4%).

Surgical closure is the treatment of choice for most types of ASD except for ostium secundum. Dimensions of up to 6 mm and no progression of diameter ordinarily do not necessitate intervention and the likelihood of spontaneous closure is approximately 50%. Surgical treatment involves direct suture or patch plastic with autologous pericardium or synthetic patches made of polyester polymer (Dacron) or polytetrafluoroethylene. Surgery is indicated in those cases with clinically significant left-to-right shunt ($Q_p/Q_s \geq 1.5:1$) and is ideally performed between the ages of 2 and 4 years. Mortality rates in experienced centers are less than 1%.

Interventional trans-catheter treatment of patients in selected pediatric and adult populations is rising and is now the established practice in most cardiac centers in developed countries. Minimal invasiveness, avoidance of sternotomy and cardio-pulmonary bypass are some of the advantages over open surgical treatment. Potential disadvantages are residual shunt, embolization of the device and insufficient rims for proper implantation.

The aim of our study was to present the rate of success and complications in percutaneous ASD closure with the implantation of an atrial septal defect occluder done at our institution during a ten year period.

Materials and Methods

Between December 2003 and October 2013, 153 patients (ages 2-76; 65% female) with ASD secundum were treated with percutaneous trans catheter closure using a septal occluder. The body surface area (BSA) of patients was $1.2 \pm 0.6 \text{ kg/m}^2$ and 99 (65%) patients were younger than 14 years of age.

Inclusion criteria for intervention were presence of ostium secundum ASD with left-to right shunt; right ventricular volume overload with paradoxal septal motion; diameter of ASD less than 34 mm and length of interatrial septum 14 mm longer than the size of the ASD; sufficient rims with 5 mm minimal

distance from the surrounding heart structures.

The septal occluder device was made of a special nickel-titanium net. It is expandable and it is compressed in to an introducer. When the disc was released from the introducer it expanded to take its original shape. The central waist closed the defect and prevented shunts. The waist thickness was 4 mm and the length was between 6 and 40 mm. The left disc, the one that occluded the defect was 14 mm larger than the body of the device. The right disc was self-centering and had a screw that was released after implantation.

In eight children (5.2%) the procedure was performed under general anesthesia with TEE guiding the implantation. In 40 (26%) adults TEE was performed before unscrewing the device. After percutaneous puncture of the left or right femoral vein, a 5 or 6F introducer was placed. Using a multipurpose catheter, the ASD was crossed and positioned in the left upper pulmonary vein. Stiff guide wire was passed and through it a balloon catheter of a size corresponding to the size of the defect was placed in the middle of the opening. Using contrast, the edges of the defect were visualized through an impression from the balloon after the proper device size was chosen. The balloon catheter was pulled out and the implantation system consisting of the long guide-wire, long introducer, implantation cable and the occlude device was prepared. The guide-wire and the long introducer were positioned in the left atrium and then the wire and guide were carefully pulled out making sure not to create a vacuum that could lead to an air embolism. When the long introducer was released, an implantation cable with the device attached to it was passed through it. First, we opened the left disc in the left atrium and then the system was pulled back carefully and with echocardiographic control the right disc was released. With the implantation cable still attached, the position of the occluder was analyzed using the, Minesota maneuver in order to ensure the stability of the device after it is released (Figure 2).

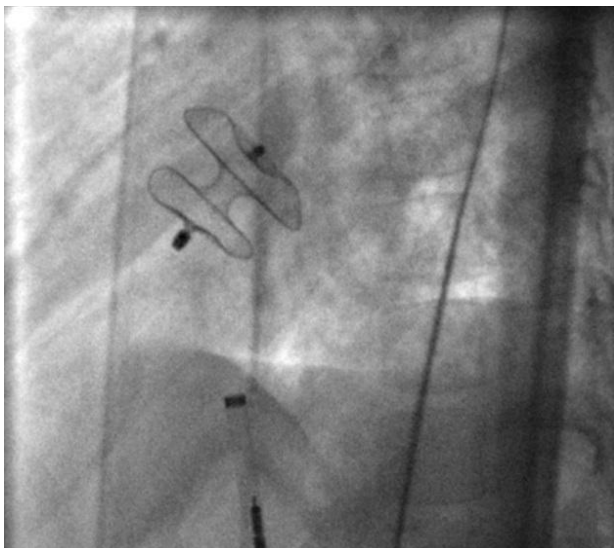


Figure 2: Implanted atrial septal defect occluder.

Medical management of all patients included one dose of pre-operative antibiotics and *aspirin* with the addition of *clopidogrel* daily for 6 months post intervention in higher risk patients. Post-interventional follow up was performed at a 3 month interval for a period of one year. It included clinical evaluation, echocardiographic examination and 24 h Holter monitoring in patients with evidence of or clinical suspicion of arrhythmias.

Results

All of the adults in our 153 patient cohorts went through a detailed TEE examination preinterventionally and in patients over 40 years of age with risk factors for coronary artery disease coronarography was performed.

The mean diameter of the defect as measured by TEE or TTE (transthoracic echocardiography) was 4 mm shorter than the angiographically-measured diameter. In 8 (5.2%) patients more than one defect was found. Right ventricle pressures were normal in all patients. Fluoroscopy time varied between 9-35 minutes. The size of the implanted occluders was 8-36 mm. In 7 (4.5%) patients the initial device was replaced with a bigger one while the long introducer was still in the left atrium.

Minor early complications (Table 1) occurred in 6 (3.9%) patients: 4 short episodes of supra ventricular tachycardia (TPSV) that was treated with Adenosin and 2 short episodes of ST segment elevation with spontaneous resolution. In 8 (5%) patients trivial left-to-right shunt remained and one patient had minor pericardial effusion. All but two patients were discharged from the hospital after 24 hours.

Table 1: Early complications in percutaneous ASD closure.

Early complications	Patients (9.8 %)
Short episodes of supraventricular tachycardia	4 (2.6)
Short episodes of ST segment elevation	2 (1.3%)
Remained trivial left-to-right shunt	8 (5.2%)
Minor pericardial effusion	1 (0.7%)

Follow up time postinterventionally was 12 months. On the last echocardiographic examination persistent small (less than 2 mm) left-to-right shunt was noted. Echocardiographic measurement of the right ventricle (RV) dimensions corrected for age showed a significant decrease (20% reduction in size from those before the intervention) by the first month. Paradoxal septal motion was present in 95% of patients before ASD closure and it persisted after one year follow-up in 2 (1.3%) patients (Figure 5). Two patients reported palpitations that needed 24 h EKG Holter monitoring that registered short episodes of atrial fibrillation. Nine (5.8%) patients reported transient headaches that significantly reduced in

intensity and frequency by the sixth month follow up. One patient reported transient sight changes that were further examined and did not show any significant cerebral ischemic involvement.

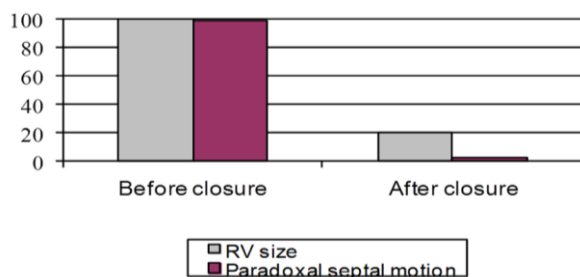


Figure 3: Percentage of patients with increased right ventricular dimension and paradoxal septal movement before procedure and after one year follow-up.

Discussion

In our study we documented short and mid-term results from trans-catheter closing of small, medium and large ASDs with intracardial prosthesis (Amplatzer or Cera atrial septal defect occluder). The procedure not only improved the hemodynamic but also the clinical status of all patients above 18 years of age and in younger ones prevented further right heart volume overload. The reduction in the size of the right ventricle could last 6-12 months and in some adult patients it could never be normalized. In patients with a persistent small shunt, despite the remaining defect there was substantial clinical improvement [18,19].

There is no doubt that the presence of an ASD is a risk factor for development of atrial fibrillation (AF) that may occur despite early closure. Prevalence of AF exponentially increases with age. In a study done by Roos-Hesselink, patients average age 33 years had a 3% prevalence of AF [20]. This is a 100-times higher frequency than what is normally found in the general population of people between 45-49 years of age.

In response to the above study, Swan and Gatzoulis proposed that early closure is the key to preventing late arrhythmias [21, 22]. Even though there are number of reasons for early closure of significant ASDs, there still is insufficient evidence that early closure plays a role in regressing arrhythmias. However, electrophysiological studies comparing patients with surgical ASD closure and those with percutaneous intervention showed significant reduction of incidence of late arrhythmias in the second group, suggesting that perhaps the absence of a surgical scar may reduce the predisposition to rhythm disturbances.

Percutaneous closure of larger and complicated ASDs is in need of special attention and interventional expertise. Undeveloped posteroinferior and anterosuperior septal rim are factors that influence the choice of interventional technique [23, 24]. During percutaneous ASD closure, the following complications have been described in the literature [25]:

- Malpositioning and embolization of the device. The incidence is mostly dependent on operator expertise and adequate selection of patients. With an experienced interventional cardiologist, the incidence is less than 1%. In the study done by Chessa and Carminati, of the 417 patients analyzed, 10 (2.4%) of them needed surgical intervention because of device migration and embolization [26]. In our study there were no such complications.

- The incidence of arrhythmias during the implantation process or after [27-29] is 1-4% and it involves supraventricular tachycardia (TPSV), atrial fibrillation and atrio-ventricular heart block from first, second or third degree. Usually the episodes were of short duration and did not require medical treatment. We report 4 (2.6%) patients with TPSV during the implantation process who were treated with adenosine and resolved a few minutes after application.

- Thrombus formation can be a fatal complication and it is dependent on anti-thrombotic medication in the treated patients. One study of 1000 patients showed that the incidence of thrombus formation is 1, 2% and usually forms between the fourth and the sixth week after the procedure. Risk factors are AF episodes, incomplete endothelialization of the device, non-compliance with therapy and hypercoagulability states and medication resistance [30-35]. In our series, all of the patients received Aspirin 5-10 mg/kg daily and 85% of adults received double antithrombotic therapy with *aspirin* 100 mg/day and *clopidogrel* 75 mg/day.

- Heart perforation, with incidence of 0, 1-0, 4%. The greatest risk for this devastating complication is over-sizing of the device and deficient rims. A retrospective study of 24 patients showed that all of the patients presented with chest pain, hemodynamic collapse and sudden death. Seventy five percent of patients were females and in 70% of them the complication presented after discharge [36, 37]. All of our patients had an echocardiographic examination before discharge and only one female adult was noted to have small pericardial effusion that was followed as an inpatient case. It resolved after 72 hours and the patient was discharged in good health.

- Increased troponin levels can occur as a result of minor myocardial lesions. The risk increases with the age of the patient and the size of the occluder. We had one patient with transitory ST segment elevation but without increased levels in the cardiac markers.

- Residual shunts persist in 20% of patients, 24

hours after intervention. Ninety percent of those are non-significant. We had four (2.6%) patients with residual shunt that was 2 mm or less [38].

- Transitory ischemic attack (TIA), cerebro-vascular insult (CVI) or sudden death happens rarely as a result of the procedure [39].
- The relatively high incidence of transient headaches (35% of adults according to Handke et al) after device implantation is a very interesting observation although the cause is unclear [39]. It is likely that these are a result of vasoactive substances released from platelets during the early period of endothelialization. Hemodynamic changes such as the increase in pressure in the left atrium as a result of distension caused by the implanted device can also be causing the release of vasoactive substrate [39-43].

Potential risk of paradoxical embolization in patients with a residual atrial septal defect after transcatheter closure remains speculative. Prewitt et al reported TIA incidences in patients six months after closure with the Clamshell device and residual bidirectional shunt. After surgical closure it has been verified incomplete device endothelialization [43].

The deal ASD closure device should have the following characteristics: simple implantation technique, possibility for re-implantation before detachment, stability during detachment, low complication rates for migration, thrombus formation, perforations and possibility for bio absorption.

The study by Berger and Vogel compared open surgical to percutaneous interventional closure of ASD in a series of 90 patients. The results in terms of complete closure and complications are similar but the duration of hospitalization was shorter in the second group. Avoidance of a surgical scar and extracorporeal circulation and shorter hospitalization period favours the use of percutaneous intervention [44].

In conclusion, percutaneous implantation of a septal occluder in patients with atrial septal defect corrects and prevents hemodynamic changes that would normally occur due to right ventricular volume overload with low peri- and short and mid-term post procedural complication rates.

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