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Procedural and Short-Term Results of Percutaneous Ventricular Septal Defect Closure in Adolescents and Adults

Gençlerde ve Yetişkinlerde Perkütan Ventriküler Septal Defekt KapanmasınınProsedürel ve Kısa Dönem Sonuçları

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ABSTRACT

Introduction: Ventricular septal defect (VSD) is a congenital cardiac disease which is characterized by abnormal connection between left and right ventricle through interventricular septum. Untreated VSD patients may have experience complications such as heart failure, cardiac arrhythmia, infective endocarditis, and pulmonary hypertension. So, hemodynamical significant and symptomatic all VSDs should be closed in patients who are suitable for closure percutaneous. In this study, we aimed to evaluate the short-term results of patients who underwent percutaneous VSD closure.
Methods: Twenty-nine patients with VSD who underwent percutaneous closure in our hospital between September 2011 and January 2021 were retrospectively evaluated. Procedural success, device embolism, arrhythmia and residual shunt were assessed.
Results: The mean age was 28.79 ± 12.16 years and 17 (58.62%) of them were female. Twenty-six patients had perimembranous VSD. Successful percutaneous closure was achieved in 86.21% of the patients. Device embolism was observed during the procedure in one patient and the VSD closure device was successfully retrieved using with a snare system from the iliac artery. In one patient complete AV block developed and improved within 24 hours. In four patients, there was residual shunt in defects edges and three of them closed in one month follow-up.
Dsicussion and Conclusion: Percutaneous closure of perimembranous and muscular VSD is a safe, effective treatment method and should be performed in experienced centers by cardiologists specialized in the treatment of structural heart diseases.

Keywords: ventricular septal defect, percutaneous closure, complication

ÖZ

Giriş ve Amaç: Ventriküler septal defekt (VSD), sol ve sağ ventrikül arasında interventriküler septumda anormal bağlantı ile karakterize konjenital bir kalp hastalığıdır. Tedavi edilmeyen VSD hastalarında, kalp yetmezliği, kardiyak aritmi, enfektif endokardit ve pulmoner hipertansiyon gibi komplikasyonlar gelişebilir. Bu yüzden perkütan kapatmaya uygun hastalarda, hemodinamik olarak anlamlı ve semptomatik tüm VSD'ler kapatılmalıdır. Bu çalışmada perkütan VSD kapaması yapılan hastaların kısa dönem sonuçlarını değerlendirmeyi amaçladık.
Yöntem ve Gereçler: Hastanemizde Eylül 2011 ile Ocak 2021 tarihleri arasında perkütan kapama yapılan 29 VSD'li hasta retrospektif olarak değerlendirildi. İşlem başarısı, cihaz embolisi, aritmi ve rezidüel şant değerlendirildi.
Bulgular: Hastaların ortalama yaşı 28,79 ± 12,16 yıl olup bunların 17'si (% 58,62) kadındı. Yirmi altı hastada perimembranöz VSD vardı. Hastaların % 86.21'inde başarılı perkütan kapama yapıldı. Bir hastada işlem sırasında cihaz embolisi görüldü ve VSD kapama cihazı iliak arterden kapan sistemi ile başarıyla geri alındı. Bir hastada tam atriyoventriküler tam blok gelişti ve 24 saat içinde düzeldi. Dört hastada defekt kenarlarında rezidüel şant vardı ve üçü bir aylık takipte kapandı.
Tartışma ve Sonuç: Perimembranöz ve kaslı VSD'nin perkütan kapatılması güvenli, etkili bir tedavi yöntemidir ve deneyimli merkezlerde yapısal kalp hastalıklarının tedavisinde uzmanlaşmış kardiyologlar tarafından yapılmalıdır.

Anahtar Kelimeler: ventriküler septal defekt, perkütan kapama, komplikasyon

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INTRODUCTION

Ventricular septal defect (VSD) is a congenital cardiac disease, which is characterized by an abnormal connection between left and right ventricle through interventricular septum. Among congenital heart diseases, VSD is the most common type, accounting for 20-30% of all congenital heart diseases. It can found isolated or accompanied by other congenital cardiac abnormalities (1,2). The number of VSD patients who reach adulthood is limited, and perimembranous VSD and muscular VSD are the most common forms of VSD. Perimembranous VSD is the most common type of VSDs (80% of cases). The spontaneous closure rate of muscular VSD in the muscular region of the interventricular septum is very high and it can reach 75-80%. The spontaneous closure may vary depending on the location, size, and number of defects. The spontaneous closure rates of single, smaller-diameter VSDs which locate in the muscular region are much higher (3-5).

Untreated VSD patients may experience complications such as heart failure, cardiac arrhythmia, infective endocarditis, and pulmonary hypertension. So, hemodynamically significant and symptomatic all VSDs should be closed in patients who are suitable for closure either surgery or percutaneous (6). Although surgical closure is known as the gold standard therapeutic option, percutaneous approach is also recommended by current guidelines for the treatment of perimembranous and muscular VSDs (7,8). Percutaneous VSD closure is preferred an alternative therapeutic option due to its easy applicability, less invasive nature, low cost, low complication rates, less required hospital stay, and long-term successful results compared to surgery (9). In this study, we aimed to evaluate the early results of patients who underwent percutaneous VSD closure in the cardiology department of our hospital.

MATERIAL AND METHODS

Patient population

Twenty-nine patients with VSD percutaneous closure who underwent in our hospital between September 2011 and January 2021 were retrospectively evaluated. Clinical and echocardiographic data of patients who underwent VSD closure with percutaneous technique were assessed. All patients gave written informed consent prior to percutaneous closure of the VSD. Patients with perimembranous VSD unsuitable for device closure (aortic rims less than 5 mm and severe aortic regurgitation), post-traumatic ventricular septal defect, ventricular septal defect after myocardial infarction, Gerbode-type ventricular septal defect, residual defect who have undergone surgery for ventricular septal defects, inlet-type ventricular septal defect, outlet-type ventricular septal defect and Eisenmenger syndrome were excluded from the study. Moreover, patients with incomplete clinical follow-up data and patients with additional congenital cardiac disease requiring cardiac surgery were not included in the study. A successful procedure was defined as one in which a stable device was successfully positioned across the defect with no complications to adjacent structures and no significant residual shunt. This study was approved by the Sakarya University Faculty of Medicine Ethics Committee no:E-71522473-050.01.04-15128/143, date: 02.03.2021).

Echocardiography

All patients were evaluated with transthoracic and transesophageal echocardiography before the procedure. Echocardiographic examinations were performed using various devices, such as Vivid 3(General Electric, Haifa, Israel), Vivid S70 (General Electric, Horten, Norway) and Philips EPIC 7 (Philips Medical Systems, Bothell, WA, USA). Defect diameter, localization, number of defects, suitability of the rims and their relationship with neighboring structures (tricuspid and aortic valves) were evaluated. In some patients, aortic rims were evaluated through transesophageal echocardiography mid-esophageal five-chamber view and mid-esophageal aortic valve long axis view. Percutaneous closure decision was made for patients with signs of left ventricular volume overload and dilation with clear left-right shunt and QP/Qs>1.5. In addition, decisions about closure were also made for patients with a history of infective endocarditis

without signs of left ventricular volume overload and dilation. Percutaneous closure was performed under the guidance of transthoracic echocardiography. Clinical and echocardiographic follow-up the patients was performed according to the clinical protocol, including transthoracic echocardiography.

Device, Procedure, and Delivery Systems

All patients underwent endocarditis prophylaxis before the procedure. All patients were informed about the percutaneous closure procedure, and their informed consent was obtained. Percutaneous closure of the patients was performed under local anaesthesia under the guidance of transthoracic echocardiography using standard technique. After a 6F catheter sheath was inserted into both the femoral artery and the femoral vein, 100U/kg of heparin was administered for anticoagulation. Percutaneous closure of the patients was performed under local anesthesia under the guidance of transthoracic echocardiography. The muscular or membranous Amplatzer VSD occluder device (St. Jude Medical, St. Paul, Minnesota, USA) and Lifetech Cera VSD occluder device (Lifetech Scientific, Shenzhen, China) were used for closure in all patients as was described previously (1,2,9,10). Ventriculography was performed by advancing a pigtail catheter from the catheter sheath located in the femoral artery to the ventricle. Left ventriculography was performed at 50–70° left anterior oblique to 20-30° cranial pro jection. Defect diameter, defect localisation and defect-aortic valve relationship were evaluated through angiographic images. The shunt volume was calculated by echocardiographic and oximet ric measurements. The pigtail was then retrieved, and diagnostic coronary catheters were advanced to the left ventricle. A 260-cm, 0.035-inch or 0.038-inch floppy hydrophilic guide wire was used to pass from the left ventricle to the right ventricle. After passing through the VSD to the right ventricle with a guide wire, an arterio-venous loop was created by holding it with a catcher advanced through the venous path to the right ventricle. The wire was externalised through the venous route. Diagnostic coronary catheters were advanced to the left ventricle through this wire. The hydrophilic guide wire was later changed by an extra stiff wire with a soft end and stiff shaft. The delivery systems was advanced to the left ventricle via a stiff wire through the defect using the venous route. The delivery systemswas held 3-5 cm beyond the defect when slowly retracting the dilator to prevent traumatisation of the left ventricle. A device 1-to-2-mm larger than the diameter of the VSD, measured via angiography, was selected and advanced in the delivery systems. The left disc was released on the left ventricleside of the defect. The entire system was retracted and then the right ventricular disc was released un- der the guidance of fluoroscopy and transthoracic echocardiography. The device was placed in the interventricular septum. Control angiography was performed with a pigtail catheter sent from the left femoral artery to confirm the final position of the device before the device was released for closure. After the device was placed on the defect, the function of the tricuspid, mitral and aortic valves, as well as residual leakage, were evaluated by transthoracic echocardiography. Then, the device was safely placed on the defect and released after confirming that there were no valve pathologies. In retrogradepatients, first the right ventricular disc and then the left ventricular disc were released. Patients were followed up with in the hospital for 24 hours after the procedure and discharged after a control echocardiography and ECG. All patients underwent echocardiography in the first, third, sixth and twelfth months. All patients were recommended to take clopidogrel 75 mg/day and acetyl salicylic acid 100 mg/day for three months. From the third month to the sixth month, only acetyl salicylic acid 100 mg/ day was recommended.

Statistical Analysis

Statistical evaluation was performed using SPSS 16.0. Numerical variables were expressed as mean ± standard deviation, and categorical variables were expressed as percentages.

RESULTS

The mean age of patients was 28.79±12.16 years and 17 (58.62%) of them were female. Twenty-six patients had perimembranous VSD, while three had muscular VSD. Of the patients, 21 (72.41%) had symptom (shortness of breath and fatigue). Clinical and demographic data of the patients were shown

in table (Table 1).

Echocardiographic parameters of the patients were shown in table (Table 2). All patients had an evidence of left ventricular volume overload (left ventricular dilatation with increased stroke volume).

Table 1. Baseline Clinical Characteristics of the Patients with VSD

Age (years)	28.79 ± 12.16
Gender (female) n (%)	17 (58.62)
Symptom n (%)	21 (72.41)
Perimembranous VSD n (%)	26 (89.66)
Muscular VSD n (%)	3 (10.34)
Coexisting congenital heart diseases n (%	1 (3.45)

VSD: Ventricular septal defect

Table 2. Echocardiographic Parameters of the Patients with VSD

Ejection fraction (%)	62.21 ± 3.84
Left ventricular end-diastolic diameters (cm)	57.38 ± 1.88
Left ventricular end-systolic diameters (cm)	38.17 ± 2.35
Qp/Qs	1.97 ± 0.13
Aortic regurgitation n (%)	2 (6.90)
Systolic pulmonary artery pressure (mm Hg)	28.79 ± 12.16

VSD: Ventricular septal defect, Qp= Pulmonary flow, Qs= Systemic flow, Qp/Qs: Pulmonary to systemic blood flow ratio

Successful percutaneous closure was achieved in 86.21% of the patients and most frequently used technique was antegrade approach. A muscular VSD device was placed in most of the patients (92%). Table 3 presents data on operation success, type of device used and operation procedure.

Table 3. Procedural Data of Patients with Percutaneous Closure of VSD

Operation success n (%)	25 (86.21)
Antegrade approach n (%)	23 (92.00)
Defect size (mm)	6.16 ± 1.97
Device size (mm)	7.52 ± 2.45
Device type n (%)	25 (100.00)
Perimembranous VSD device n (%)	2 (8.00)
Muscular VSD device n (%)	23 (92.00)

VSD: Ventricular septal defect

Device embolism was observed during the procedure in one patient and the VSD closure device was successfully retrieved from the iliac artery using with a snare system. In one patient, a complete atrioventricular (AV) block occurred and normal sinusal rhythm was restored spontaneously after 24 hours follow-up. In four patients (trivial shunt), there was residual shunt and three of them closed in three months follow-up. Procedure was unsuc- cessful in a patient with midmuscular VSD be- cause the defect cannot be passed with the wire. Procedure was unsuccessful in the other two patients, where the device did not fully cover due to the large perimembranous defect. Complications associated with percutaneous VSD closure are presented in Table 4.

Table 4. Periprocedural Complications after the Percutaneous Closure of VSD

Arrhythmia n (%)	1(4.00)
Device embolisation n (%)	1 (4.00)
Residual shunt n (%)	4 (16.00)

VSD: Ventricular septal defect

DISCUSSION

This retrospective study showed a high success rate with very low complications for percutaneous VSD closure in a single center. Our study is one of the largest-scale studies conducted in our country in terms of the number of patients underwentpercutaneous VSD closure.

Percutaneous closure of the muscular and perimembranous VSDs was initially performed with atrial septal defect or patent ductus arteriosus de- vices (1,9-11). But specific devices developed andproduced for percutaneous closure of muscular VSDs (12). At the beginning of those devices for percutaneous VSD valvular regurgitations occur- red and asymmetric VSD closure devices were produced for perimembranous defects (6).

Procedural success rates obtained from previous studies of percutaneous VSD closure are ranging from 87% to 100% in published series (1,9-13). Furthermore, procedural success rates may

depend on the use of different devices (14). In our study group, the procedural success rate was 86.21%, which is slightly lower as compared to the literature. This lower procedural success rate may be a consequence of learning curve of the center.

In the published literature different type of arrhythmias, vascular access site complications, device embolism, cardiac perforation, hemolysis, and valve failure were reported before as complications for percutaneous VSD with varying rates (6,15,16).

The rate of complete AV block was reported as 0-6.4% (10,17-21) probably due to oedema and scar tissue inflammation that develops because of trauma and compression in the communication system close to VSD causes complete AV block (22,23). Complete AV block may be temporary or permanent (24). In one of our patients (4%), complete AV block developed and improved within 24 hours,with a rate like the published case report in the literature.

One of the most important complications of percutaneous VSD closure is device embolization. InEuropean and US registries, rates of embolization are 0.9% and 2.7%, respectively (15,24). Causes of device embolization include defect-related, device-related, and operator-related causes. A defect-related factors are location, size, and type of the defects. Device-related factors include device type and over or undersized device. Operator-related factors include inadequate experience, wrong placement of the device or improper device selection (25,26).
In our study group, device embolism was observed in one patient, and the embolized device was successfully re-captured and removed by the transcatheter technique. Patient with device embolism had large VSD associated with membranousseptal aneurysm.

In previous studies, rate of residual shunt after percutaneous VSD closure was described as 3-29% (24,28-30). In our study, the residual shunt rate was found to be 16%, which is similar to previous studies.

Our study has some distinct features in terms of baseline echocardiography and devices which were used for closure. Most of VSDs in our study group were initially defined as perimembranous VSD. But, after angiography and left ventriculography, defectswere seen more detailed by their rims, proximity to aortic valve and defect channel length. After that, VSD closure device either muscular or membranous was chosen. As a result of this, although first diagnosis was perimembranous VSD in the majority of the study group, finally, muscular VSD closure device was chosen in 92% of the patientsgroup.

The most important limitations of our study are the retrospective research design and the small number of patients. Additionally, we are unable to evaluate late complications because the examinations were made at an early period after closure and lack long-term follow-up data.

CONCLUSION

Percutaneous closure of perimembranous and muscular VSD is a safe, effective treatment method and should be performed in experienced centers by cardiologists specialized in the treatment of structural heart diseases.

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