Original Article

Transcatheter closure of ventricular septal defect in aortic valve prolapse and aortic regurgitation

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ABSTRACT

Objective: To report intermediate follow-up result of transcatheter closure of ventricular septal defect (VSD) in presence of aortic valve prolapse (AVP) with or without aortic regurgitation (AR).
Method: This is a retrospective review of 19 patients with VSD with AVP with AR who underwent transcatheter closure in between September 2011–July 2014. Mean age was 8 years (1–16 years, standard deviation [SD] 4.08 years) and mean weight was 26.03 kg (9–81.5 kg, SD 16.57 kg). Among them 2 had subarterial VSD, 6 had subaortic VSD and 11 had perimembranous VSD. All of them had mild AVP and 13 of them had AR (trivial or mild). Median VSD size was 4.3 mm (4–6 mm). Transcatheter closure was done either by retrograde technique using the Amplatzer Duct Occluder-II in 17 patients or antegrade technique using the Duct Occluder-I in 2 cases. Mean follow-up period was 18 months (12–36 months).
Result: Immediate major complications were encountered in 2 (10.5%) cases. Significant aggravation of device related AR was seen in one case & device embolised to right pulmonary artery in another case and both of them were managed surgically.
During follow up, 1 child had significant additional VSD requiring device closure. One child developed moderate AR, requiring surgery. None of the other had shown any increase in severity of AR.
Conclusion: Device closure of VSD in presence of mild AVP and mild AR appears to be safe. Longer follow-up is necessary to draw final conclusion.
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1. Background

Ventricular septal defect (VSD) is the most common form of congenital heart defect accounting for about 20% of all forms of defects.[1] Perimembranous, subaortic and doubly committed subarterial VSD are found to be associated with aortic valve prolapse (AVP).[2] Long term follow-up studies have shown that transcatheter closure of VSD is a feasible alternative of surgery.[3] Taking into account increasing of potential risk of aggravation of aortic regurgitation (AR), device closure with VSD accompanied with AVP and AR still represents a challenging issue. Majority of the available reports in literature have been excluded these patients from their studies.[4] In this article, we summarized our intermediate-term follow-up results of trans-catheter closure of VSD in the presence of AVP with or without AR.

2. Materials and methods

This retrospective study was done in the Department of Pediatric Cardiology in Apollo Children's Hospital, Chennai. All the patients who had VSD with AVP with or without AR and those who underwent VSD closure by transcatheter device from September 2011 to August 2014 have been included in this study.

2.1. Patient population

2.1.1. Inclusion criteria
VSD with mild AVP with trivial-mild AR or without AR.

2.1.2. Exclusion criteria
(i) VSD with right to left shunt; (ii) Body weight <5 kg; (iii) VSD diameter >20 mm by Trans Thoracic Echocardiography (TTE); (iv) Severe AVP; (vii) Moderate-severe AR.

Total 19 patients who had fulfilled the inclusion criteria and underwent VSD device closure were included in this study. Pre intervention assessment of size of VSD, degree of aortic valve

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prolapse and severity of the AR was assessed by TTE. Mean age of the study population was 8 years (Range-1–16 years) and mean body weight was 26.03 kg (9–81 kg). Among the 19 patients 11 of them had perimembranous VSD; 6 of them had subaortic VSD and 2 of them had doubly committed subarterial VSD. All of the patients had mild AVP and 13 of them had trivial to mild AR. One patient with perimembranous VSD had noncoronary cusp prolapse and other 18 patients had right coronary cusp (RCC) prolapse. The degree of RCC prolapse was classified according to 3-point scale.[5,6] Tear drop shaped aortic valve cusp was considered as mild AVP. Median size of the VSD was 4.3 mm (4–6 mm) measured by TTE.

2.2. Device and technique

All patients were administered with 100 IU/kg heparin and antibiotics prophylaxis intravenously before the procedure. Procedures were performed under local anesthesia and intravenous sedation.

We have used Amplatzer Duct Occluder I (St. Jude Medical, St. Paul, Minnesota) (ADO-I) and Amplatzer Duct occlude II (St. Jude Medical, St. Paul, Minnesota) (ADO-II) in these patients. ADO-II device has been used for the VSDs measuring less than 5 mm in diameter and we have used retrograde technique to place the device. For VSDs measuring more than 5 mm, we have used ADO-I device by antegrade technique. We have used standard antegrade and retrograde techniques Fig. 3 that have already been described in literature.[7,8] We have done the procedure under the guidance of TTE. We have looked for any change in geometry of aortic valve, impingement of aortic valve cusp by the disc of the device and any increment in severity of AR before or after releasing the device by TTE. During antegrade technique, we have taken left ventricular (LV) angiogram retrogradely to assess the device position in relation to the aortic valve cusp before releasing the device. In case of retrograde technique, we injected dye by hand injection though a long Touhy-Borst (Y connector) attached to the end of right coronary artery guiding catheter and position of the LV disc in relation to the aortic valve cusp was assessed before releasing the

device Fig. 3. The patients were sent for surgery in case of any increment in severity of AR. Mean fluoroscopy time for retrograde technique was 7.5 min and for antegrade technique was 13.2 min.

2.3. Follow up

Tablet aspirin was given at a dose of 3–5 mg/kg/day to all the patients after VSD device closure for 6 months. Clinical examination, electrocardiographic monitoring and TTE were performed on the day of discharge (first post intervention day), on 7th day post device closure, 3 months and 1 year after device closure and yearly after that/SOS basis.

## 2.4. Definition of complications

A major complication was defined as an event that resulted in death, long-term sequelae, need for immediate surgery, potentially life-threatening events, persistent arrhythmias needing pacemaker placement, ongoing haemolysis requiring blood transfusion, thrombosis that required thrombolytic therapy, and increased valvar regurgitation needing device removal or drug therapy.

A minor complication was defined as an event that required drug therapy but was not life-threatening, with no long-term (>6 months) sequelae, and which did not require long-term therapy. The following were also included in this group-haematoma of the groin, cardiac arrhythmias that required cardioversion or drug therapy during the procedure, minor degree atrio-ventricular blocks, and transient loss of peripheral pulse needing only heparin therapy.

2.5. Definition of outcome

Procedural success: Procedural success was defined by device implantation in the appropriate position with no need for surgery/re intervention (for example due to significant residual shunt or significant valve regurgitation).

Residual shunt: A residual shunt was considered to be present if color-Doppler flow mapping showed a left to right shunt across the
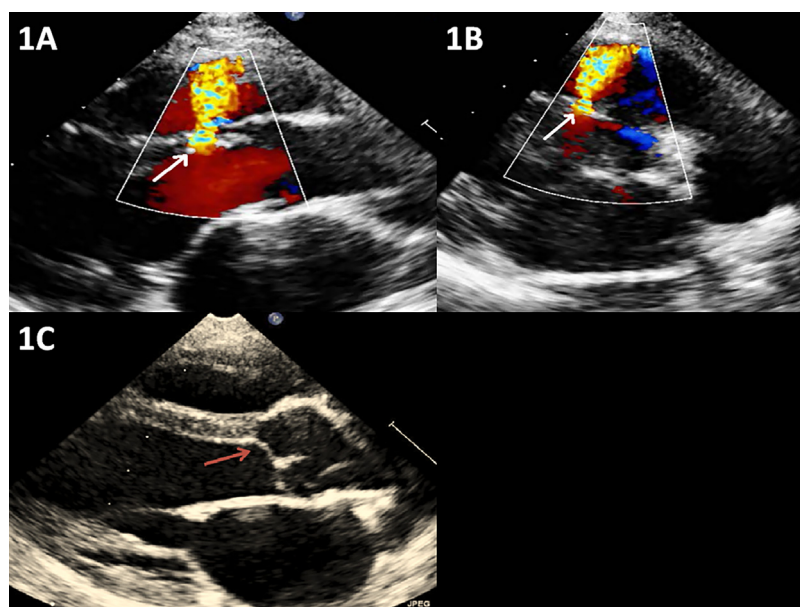
Fig. 1. Pre-procedure Echocardiogram- Parasternal long axis view showing subaortic ventricular septal defect (VSD) (white arrow) with deficient subaortic rim **(1A)**, Parasternal long axis cranially tilted view showing subpulmonic VSD (white arrow) **(1B)**, Parasternal long axis view showing prolapsed right coronary cusp of aortic valve (red arrow) **(1C)**.

device in the interventricular septum. It was classified as follows; trivial (<1 mm color jet width), small (1–2 mm color jet width), moderate (2–4 mm color jet width), or large (>4 mm color jet width).

Additional defect: An additional defect was considered to be present if color-Doppler flow mapping showed a left to right shunt across the interventricular septum, but not through the device.

3. Result

Device placement was successful in 17 cases. Immediate major complication occurred in two patients. One patient with subaortic VSD had developed acute severe AR after device placement due to impingement of right coronary cusp (RCC) to the left ventricular disc. That patient was managed by emergency surgical removal of the device and surgical closure of VSD. In another patient with subaortic VSD, the device was embolised in right pulmonary artery. Transcatheter retrieval of VSD device was done and the child was send for surgical VSD closure. None of the patient had any other major or minor complication.

Mean follow up period of this study was 20 months (12–36 month). During follow-up, one patient of perimembranous VSD was found to have moderate AR due to impingement of RCC by LV disc of the device after 18 months of VSD device closure. This patient was managed with partial amputation of device with surgical closure of VSD with aortic valve repair (perforation was noted in RCC). On reviewing the data we found that the patient had a new onset mild AR immediately after device closure, which had progressed over time. Thus we have changed our strategy not to accept any increment in severity of AR after device deployment. One of the patient with inlet perimembranous VSD with septal aneurysm had significant additional VSD. Transcatheter closure of the VSD was done by another ADO-I device after 20 months of the first intervention. None of the other children had shown any increase in severity of AR. None of them was found to have any residual VSD during follow-up. None of the child had left ventricular or right ventricular outflow tract obstruction due to the VSD device during follow-up. None of them had any hemolysis, thromboembolic event or endocarditis. None of them had shown any arrhythmia.

4. Discussion

AVP and AR are well known to be associated with VSDs. Incidence of AVP is 5–8% in case of perimembranous VSD and as high as 30% in doubly committed subarterial VSD.[9] In case of perimembranous VSD, AVP occurs initially during diastole due to Venturi effect produced by the left to right shunting of the blood. During later phase, prolapse occurs during systole also; because, damaged aortic valve becomes unable withstand the high aortic pressure. In cases of doubly committed subarterial VSD, AVP occur due to lack of support structure in subaortic area as there is complete deficiency of conal septum. The development of AVP is a risk factor for increasing AR.[10] So, early closure of these defect can prevent further damage of aortic valve and can prevent progression of AR.

Traditionally, surgery is the treatment of choice for VSD with AVP with or without AR. But, it does have some potential risks of complications, including coronary heart block in 1–5% of the cases,[11–14] significant residual VSD in 1–10% of the subjects,[12,15–18] the necessity for re-operation in 2% of the patients,[12] and even death in 0.6–5% of the cases.[12,13,16,17] Furthermore, infections, tachyarrhythmias, and neurological complications may occur after surgery.[12]

Considering the fact that transcatheter closure of VSD is less invasive than surgery we have attempted to do trans-catheter closure for the patients with VSD in presence of mild AVP Fig. 3. The intermediate term follow-up study has shown good outcome with
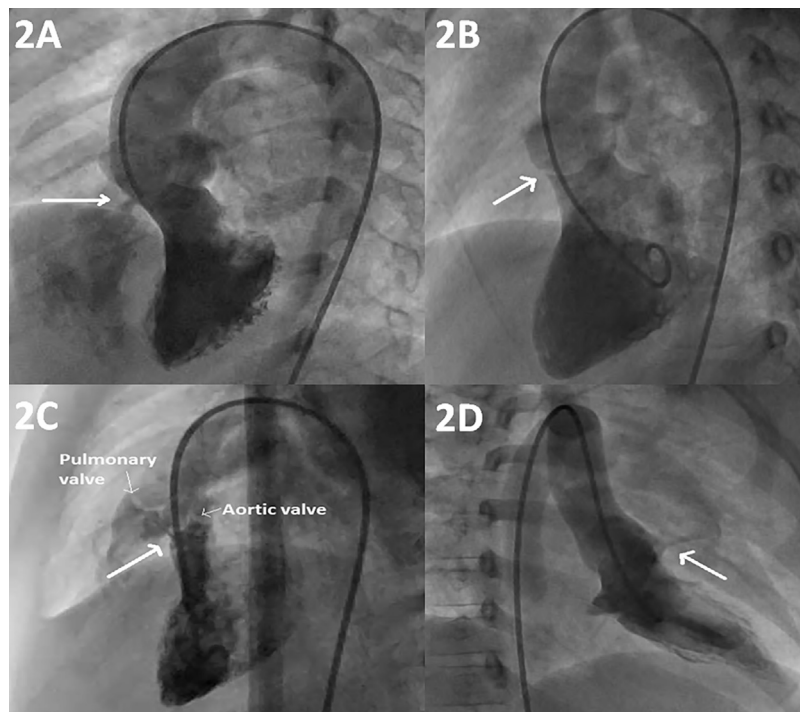
Fig. 2. Left ventriculogram to profile VSD- left anterior oblique (50°) cranially tilted (20°) view showing small subaortic VSD (white arrow) **(2A)**, prolapsed right coronary cusp of aortic valve (white arrow) **(2B)**, left anterior oblique (75°) cranially tilted (20°) view showing small doubly committed subarterial VSD (thick white arrow) **(2C)**, right anterior oblique (30°) cranially tilted (30°) view showing small doubly committed subarterial VSD (white arrow) **(2D).**
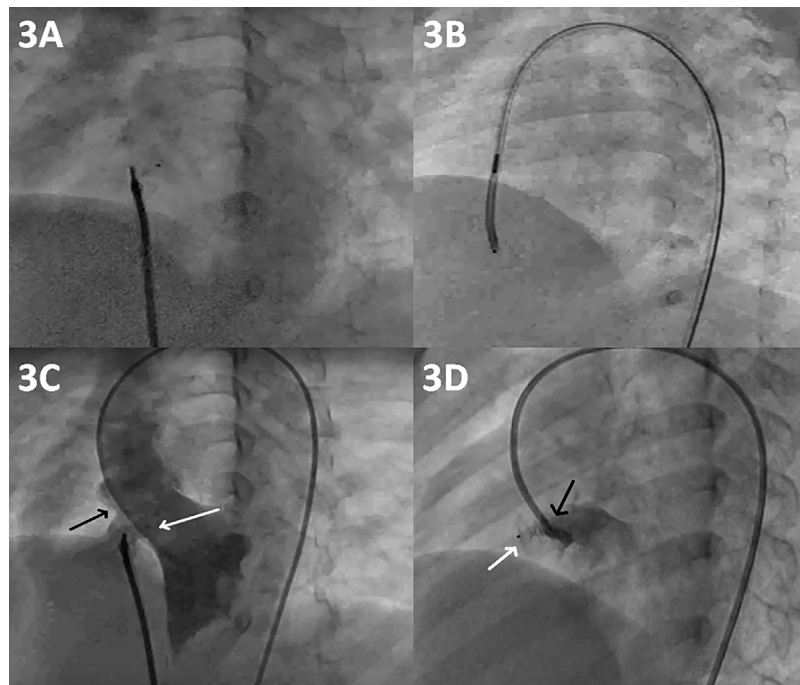
Fig. 3. Technique of VSD devioce closure- antegrade technique- device is across the VSD from right ventricular side **(3A)**, retrograde technique- catheter is across the defect from left ventricular side **(3B)**, left ventriclogram before releasing the device during VSD closure by antegrade technique showing the left ventricular disc of the device (white arrow) is away from aortic valve cusp (black arrow) **(3C)**, dye injected through the guiding catheter before releasing the device in retrograde technique showing device (white arrow) is under the aortic valve (black arrow) but not impinging on it **(3D)**.

a success rate of 79%. Our result is comparable with the study done by Feng Chen et al[19] and Guan-Liang Chen et al.[20] where VSD device closure was done in VSD with AVP.

In our experience, proper patient selection is most important factor for procedural success. For successful VSD device closure, pre intervention profiling of VSD by TTE and intraoperative profiling during LV angiography are important. Parasternal long axis view, apical 5 chamber view and subcostal long axis views are most important for profiling these VSDs Fig. 1. For perimembranous VSD with AVP, we have measured the true size of the defect from tip of subaortic rim to crest of interventricular septum, which is sometime difficult in presence of significant AVP. In these VSDs
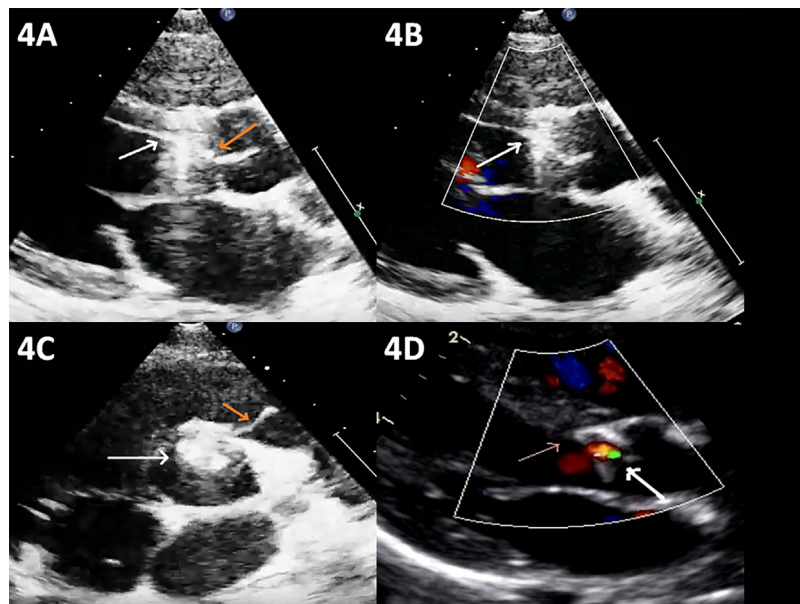
Fig. 4. Transthoracic echocardiogram after the procedure- parasternal long axis view showing the device (white arrow) is bending to the plane of aortic valve (red arrow) without impinging on it **(4A)**, colour Doppler image showing the device (white arrow) is sitting under the aortic valve which is coapting normally in diastole without any aortic regurgitation **(4B)**, parasternal short axis view of aortic valve in a case of doubly committed subarterial VSD showing the device (white arrow) is in very close proximity to the pulmonary valve (red arrow) which is coapting normally **(4C)**, colour Doppler image showing the device (thin arrow) near right coronary cusp of aortic valve with trivial aortic regurgitation (thick arrow) following the closure of subaortic VSD with **(4D)**.

we have used ADOI or ADOII device depending on the size of the defect when the size of the subaortic rim was adequate (≥3 mm). If the defect is more than 5 mm we use ADO I. In case of subaortic VSD, if AVP is mild and size of true VSD is small (≤5 mm), then device closure was attempted. In this condition, true VSD size was measured from crest of interventricular septum to aortic valve annulus. We have used ADO II in these cases, as there is no adequate subaortic rim. In case of subarterial doubly committed VSD, in our experience, if the weight of the child is more than 20 kg, size of the defect is ≤5 mm and AVP is mild, then device closure can be attempted. In this condition, the infundibular septum between the aortic valve and pulmonary valve is absent and there is a fibrous continuity between these two valves. True VSD size in this condition was measured from the tip of interventricular septum to the tip of fibrous continuity. We used ADO-II device in subarterial VSD. While selecting the device, we have oversized the defect by 1 mm (as per example, we have selected ADO-II 6/4 device for 5 mm VSD).

During LV angiography for profiling the VSD, we have used left anterior oblique (LAO) 50° with 20° cranially tiled view for perimembranous and subaortic VSD. For doubly committed subarterial VSD, we have used stiff LAO (LAO-70–80°) with cranial 20° and right anterior oblique with cranially tilted view Fig. 2. We have used 5 Fr Judkins right coronary catheter for crossing the defect from LV side in cases of perimembranous and subaortic VSD. In case of doubly committed subarterial defect while crossing the VSD, we have used 5 Fr Pigtail catheter cut in fashion so that it faces the defect from left ventricular side.

We have used ADO-II device for closure of subaortic and subarterial VSD where the subaortic rim is inadequate (<3 mm) and the defect is very close to the aortic valve. The ADO-II is very low profile device devoid of fabric patch and it bends to the plane of the Aortic valve without distorting the coaptation mechanism Fig. 4 and can be used in cases of VSD very close to aortic valve where subaortic rim is deficient.

In other studies, where VSD has been closed with transcatheter technique in presence of AVP and AR, VSD membranous asymmetric occluder and zero eccentricity VSD occluder were used.[19,20] We have used ADO II device because as it is very soft, low profile device and bends to the plane of the AV valve. But the restriction is that we can't use it for defects more than 6 mm and further modifications in the device structure can help us to overcome this in future.

5. Study limitations

Our study was done at single center. Also the study population was small and the follow-up duration was less. The population was heterogeneous in terms of age, type of defect and device. The results of this study should be supported by a multicenter study involving many operators with a bigger number of patients.

6. Conclusion

Present study shows that mild AVP with or without AR is not a contraindication for VSD device closure, however, longer term follow-up with bigger sample size is required to draw final conclusion. Success depends on proper case selection and operator's experience.

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