Transcatheter Closure of Multiple Membranous Ventricular Septal Defects with Giant Aneurysms Using Double Occluders in Four Patients

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The transcatheter closure of perimembranous ventricular septal defect (pmVSD) has become a promising treatment modality. However, transcatheter closure of multiple pmVSDs with giant aneurysm is still very challenging. We present our preliminary experiences.

Transcatheter device closure was performed under general anesthesia in all the patients. The interventional treatment modality was approved by the ethics committee of our hospital, and informed consent was obtained before the procedure. Femoral artery and vein was routinely punctured. Left ventricular angiography was performed at 60° left anterior oblique and 20° cranial tilt position. The entrance diameter of the septal aneurysm and the maximum exit diameter were measured. A proper domestic membranous septal occluder was selected according to anatomy feature of septal aneurysm. A cut pigtail catheter was carefully manipulated to pass through VSD into right ventricle, and 0.035 inch noodle wire was advanced into pulmonary artery or superior vena cava. The trapper was then advanced via the femoral vein to entrap the wire and pull it outside of the body to establish a femoral artery–vein loop (A-V loop). The delivery sheath was advanced into left ventricle through A-V loop, and then the first device was deployed from venous side. If control angiography and transthoracic echocardiography (TTE) showed incomplete closure and significant residual shunt (RS) which was difficult to be closed by another device replacement, the second occluder was tried to completely close the residual defects. We usually preferentially select Amplatzer Ductal Occluder II (ADO II) to close residual defect from arterial side. However, if the aneurysm cavity was large enough to accommodate another device, membranous septal occluder can also be considered.

After satisfactory outcome confirmed by control angiography and TTE, the devices were released.

From July 2012 to April 2016, four patients with multiple pmVSDs underwent transcatheter closure with double occluders successfully. The clinical data are listed in Table 1. Angiography and TTE both showed large septal aneurysms with multiple disperse exits in patient 1, 2, 4 and relatively smaller aneurysm with centralized downward exits in patient 3. Two 4-mm symmetric pmVSDOs were sequentially implanted in patient 1. One 7 mm small-waist pmVSDO and one 4 mm symmetric pmVSDO were implanted in patient 2. One 5 mm symmetric pmVSDO and one 6–4 mm ADO II were implanted in patient 3. One 10 mm small-waist pmVSDO and one 6–4 mm ADO II were implanted in patient 4. Instant complete closure achieved in patients 1, 2, and 4. Patient 3 developed trivial RS (about 1 mm) and disappeared during 6-month follow-up. Minor arrhythmia occurred in patients 1 and 2. They were junctional rhythm in patient 1 and incomplete right bundle branch block in patient 2. Both were transient and automatically resolved before discharge from hospital [Table 1 and Figure 1].

Patients 1–4 were followed up for 52, 36, 30, and 3 months, respectively. No new-onset complications, such as valvular...
regurgitation or conduction block, occurred in any of the patients during the follow-up time.

It is still a great challenge for cardiologists to transcatheter close multiple pmVSDs with giant aneurysm due to anatomic complexity and variation. Although some modified devices such as small-waist occluder may help cure this kind of disease, it still probably failed due to a significant RS. We made an attempt to close a giant aneurysmal VSD using more than one device. The first two patients had similar aneurysm anatomy features according to angiography. Both had giant aneurysms with two main exits located on the upper and lower sides. The single occluder failed to close all defects completely in both patients. We noted that a giant aneurysm can provide sufficient space to hold two devices while avoiding aortic valve interference. Thus, we established another venous access and created another A-V circuit after detachment, and significant RS occurred according to TTE and electrocardiogram monitoring during the procedure. One should be cautious not to have the chordae tendineae convolved while performing A-V loop reestablishment. TTE and electrocardiogram monitoring during the procedure is indispensable for the timely detection of arrhythmias and valve insufficiency.

Table 1: Clinical characteristics of patients

| Patient No. | Gender | Age (years) | Weight (kg) | TTE | Occluders                  | Fluoroscopy time (min) | Complications    |
|-------------|--------|-------------|-------------|-----|---------------------------|------------------------|------------------|
| 1           | Male   | 6           | 20          |     | Large aneurysm with multiple exits, the diameter of base and largest exit was 12.7 mm and 2 mm | 4 mm symmetric pmVSDO/4 mm symmetric pmVSDO | 33               | Transient junctional rhythm |
| 2           | Female | 3           | 16          |     | Large aneurysm with multiple exits, the diameter of base and largest exit was 14.3 mm and 2.5 mm | 7 mm small-waist pmVSDO/4 mm symmetric pmVSDO | 26               | Transient IRBBB          |
| 3           | Male   | 3           | 12.5        |     | Large aneurysm with multiple exits, the diameter of base and largest exit was 8.7 mm and 3.3 mm | 5 mm symmetric pmVSDO/6–4 mm ADO II | 42               | Trivial RS               |
| 4           | Female | 5           | 17          |     | Large aneurysm with multiple exits, the diameter of base and largest exit was 14 mm and 3 mm | 10 mm small-waist pmVSDO/6–4 mm ADO II | 31               | -                          |

pmVSDO: Perimembranous ventricular septal occlude; ADO II: Amplatzer Ductal Occluder II; IRBBB: Incomplete right bundle branch block; RS: Residual shunt; TTE: Transthoracic echocardiography.

Our experiences in the four patients are as follows: First, the inlet of the aneurysm should be occluded to reduce the risk of RS. If this is not possible, the largest exit is the next preferable occlusion site, but A-V loop establishment often requires patience and greater manipulation skills from the operator. Second, if the anchor site is an aneurysmal exit and the retention disc is inside the aneurysm, attention should be paid because that device may shift after detachment. Third, ADO II has advantages in that it is a simple and flexible implantation technique without A-V loop requirement and it can be appropriately applied to close defects smaller than 2 mm. Finally, it should be emphasized that an individual strategy is essential in the percutaneous closure of pmVSD. Strict control of indications and accurate device selection according to anatomic features are crucial to a successful procedure. One should be cautious not to have the chordae tendineae convolved while performing A-V loop reestablishment. TTE and electrocardiogram monitoring during the procedure is indispensable for the timely detection of arrhythmias and valve insufficiency.

To the best of our knowledge, reports on successful transcatheter closure of multiple pmVSDs with giant aneurysm using more than one devices were very rare. Our experiences confirmed that it is feasible to close multiple aneurysmal pmVSDs using double ocluders in selected patients. However, because the sample is very small, further studies are still needed to verify the findings.

Transcatheter closure of multiple pmVSD with giant aneurysms using double devices is feasible and safe in selected patients. However, the indications for the technique should be controlled strictly, and the long-term effects need further observation.

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Conflicts of interest
There are no conflicts of interest.
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Figure 1: Patient 1- (a-c) 6-year-old boy weighing 20 kg, (a) angiography shows giant aneurysmal VSD with two exits. (b) Angiography shows minor residual shunt still exists after one device deployed. (c) Angiography reveals no residual shunt after the second device deployed. Patient 2 - (d and e) 3.2-year-old girl weighing 16 kg, (f) giant pseudoaneurysm with multiple exits through ventriculography. (g) Control angiography shows no residual shunt after the two devices were deployed. Patient 3 - (f-i) 3-year-old boy weighing 12.5 kg, (j) ventriculography shows pmVSD with one main tunnel-like downward outlet. (k) Control angiography shows no residual shunt after the first device was implanted. (h) The device shifted slightly after detachment, and significant shunt recurrence was observed through angiography. (i) Ventriculography revealed no residual shunt after another device was implanted. Patient 4 (j-l) 5-year-old girl weighing 17 kg, (j) giant pseudoaneurysm with multiple exits, as observed through ventriculography. (k) Control angiography shows a residual shunt in the lower defect after one of the devices was deployed. (l) Angiography showed no residual shunt after both devices were implanted. pmVSD: Perimembranous ventricular septal defect.