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Editorial

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Echocardiographic Classification and Guidance for Transcatheter Closure of Ventricular Septal Defect

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Isolated ventricular septal defects (VSDs) are one of the most common congenital heart defects (CHD) and constitute 20% of all CHDs.[1)2)] Patients with a moderate-to-large shunt of VSDs usually are symptomatic, present with congestive heart failure, and eventually need surgical closure in infancy. On the other hand, relatively small or restrictive VSDs cause no symptoms, but they can create late problems like left ventricular enlargement, infective endocarditis, aortic valve insufficiency, and double chamber right ventricle.

Surgical closure has been the standard therapy for VSDs.[3)] Symptomatic neonates or infants with VSDs usually are treated by the surgical approach, but it does have potential risks of complications, including complete heart block (CHB) in 1–5% of cases,[4-7)] significant residual VSDs in 1–10% of subjects,[5)8-10)] need for re-operation in 2% of patients,[5)] and death in 0.6–5% of cases.[5)6)9-11)] Furthermore, infections, tachyarrhythmias, and neurological complications can occur after surgery.

After Lock et al.[12)] introduced transcatheter closure of VSDs, many congenital interventionists have been trying to perform percutaneous closure of VSDs by various devices in selective cases, especially in patients after the toddler period.

The indications for transcatheter closure of VSDs are similar to the surgical indications: cardiomegaly or left ventricular enlargement, pulmonary-to-systemic shunt flow ratio (Qp/Qs) greater than 1.5, failure to thrive, recurrent respiratory infection that requires hospitalization, or history of infective endocarditis. Also, postoperative VSDs with a significant leak or post-infract VSDs that occurred due to myocardial rupture can be treated by the transcatheter approach. However, transcatheter closure usually is contraindicated if patients show high pulmonary vascular resistance (PVR), irreversible pulmonary hypertension, active infection, inadequate rim below the aortic valve, or aortic valve prolapse. If patients show high PVR but pure left-to-right shunt, the vasoreactivity test has to be performed before closure.

There are several techniques for VSD device closure. The anterograde approach is the most common and usually is performed using an arteriovenous loop. In some cases, the anterograde approach can be performed by the direct selection technique from the right side of the heart. During wiring and looping, echocardiography must be employed to assess wire position and prevent injury to the tricuspid valve. According to the development of a

low-profile delivery system and devices like Amplatzer® Duct Occluder (ADO) II (Abbott; Plymouth, MN, USA), the retrograde technique can be conducted through the femoral artery. In addition, when small patients have a muscular VSD that is not suitable for the direct surgical approach, the hybrid or perventricular approach can be a good option.[13)14)]

Although recent reports have shown excellent results due to development of techniques and new devices, important issues surrounding transcatheter closure of VSDs remain, including CHB, aortic valve injury, residual shunt, hemolysis, infective endocarditis, and device embolization. The risk factors associated with complications are age and weight at the time of the procedure.[15)] Embolization of a device develops in 1% to 2% of cases and usually occurs within 24 to 48 hours. It usually can be retrieved by catheterization, but sometimes surgical removal is needed. After complete neo-endothelialization around the device, infective endocarditis is rare, but cases have been reported, including fatal results.[15)16)] The worst complication is CHB, especially in cases of perimembranous VSD with aneurysm, because of the course of the cardiac conduction tissue. The Amplatzer® perimembranous VSD device was abandoned in many centers due to the unacceptable rate of CHB (3.8–22%)[15)17)18)] The definite cause of CHB is unknown, but considerations include direct traumatic compression, inflammatory reaction, or scar formation in the conduction tissue. New devices, like Nit-Occlud Lê VSD (PFM AG, Köln, Germany), reduced the complication rate, but the residual shunt was not satisfactory.[19)] In addition, contrary to CHB that occurs early after surgical treatment, CHB after device closure is unpredictable and usually a late problem. Therefore, chronic long-term follow up is essential.

Unfortunately, the ideal occluder of VSD (low profile; easy to use, retrieve, reposition, and apply to multiform defect) does not exist. Such a tool has to occlude the defect completely without residual shunt. In addition, it must not cause CHB, hemolysis, or injury to adjacent structures, like the aortic or tricuspid valve. Therefore, it is essential to match the appropriate device to each defect. That is, thorough assessment and classification of VSD are essential before device closure.

In this view, echocardiography plays a key role for device closure of VSDs, diagnosis, hemodynamic status, and planning management. Furthermore, detailed information, like location, size, number, and adjacent structures, are provided by echocardiography. For this reason, Singhi and Sivakumar[20)] suggested classification of perimembranous VSDs according to transthoracic echocardiography (TTE). Recently, 3-dimensional, real-time, transthoracic or transesophageal, echocardiography-guided procedures have been increasing in the catheterization laboratory and demonstrating excellent results. Especially, transesophageal echocardiography can provide important information regarding device position, residual leak, valve touching, or injury. Some centers prefer TTE because it can be performed with local rather than general anesthesia.

A VSD closure device has to completely cover all exits, and it is recommended that the device diameter measure the same or 1–2 mm larger than the maximal exit diameter. One of the most important related issues is aortic rim deficiency. If there is no aortic rim or margin, implantation of the device can cause aortic valve injury or insufficiency. So, an asymmetric device or zero eccentricity occluder should be used for closure,[21)] and the device has to be located in the aneurysmal pouch. If there is an adequate aortic margin, the spectrum for choice of device is wide. Single- or double-disc occluders are available. The aortic skirts of most devices are 3 mm larger than the waist, so the minimal distance from the aortic valve is

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3–4 mm. When the right ventricular openings are multiple and concentrated, a thick-waisted, double-disc device is preferred. But when the distance between the openings is relatively large, a small waisted occluder is preferred.[22] If the aneurysm is formed from the tricuspid valve, the risk of injury increases. In this case, a single-disc device, like ADO I, is preferred for prevention of protrusion into the right ventricle. Also, a subarterial VSD is not indicated for device closure, although some centers have been performing closures using ADO II and show good early results.[23]

In conclusion, transcatheter closure of VSDs is safe and promising, although some complications exist. Therefore, thorough evaluation for morphology of the VSD and adjacent structures is essential before the procedure.

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