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Review Article

Recent review of transcatheter closure of atrial septal defect

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KEYWORDS
Atrial septal defect;
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Indication

Abstract Atrial septal defect (ASD) is one of the two most common congenital heart diseases in children and adult. After the application of catheter intervention for ASD, this became an alternative treatment other than surgery from late 1990. In 2001, the procedure was further approved by the US Food and Drug Administration (FDA), and become the first choice for most cases of secundum type of ASD worldwide. The success rate is more than 98% in literature reviews, with low complication rates in percutaneous ASD closure. Major complications are around 1%, including device embolization, cardiac erosions, new-onset atrial arrhythmia, and other comorbidities. We reviewed indications for percutaneous secundum type ASD closure, technique, successful rate and major complications in this article. To complete the catheter intervention with difficult ASD conditions, various procedural techniques have been developed recently. We also report a challenging case by a current balloon-assisted technique for huge ASD closure.

Introduction

The Taiwan National Health Insurance database has reported the prevalence of congenital heart disease was 13.08 per 1000 live births [1]. Ventricular septal defect was the most common congenital heart disease, followed by secundum atrial septal defect (ASD). The reported prevalence of secundum ASD was 3.2 per 1000 live births [1]. There are four kinds of ASD, including primum, secundum, sinus venosus and unroofed coronary sinus types. King and Mills demonstrated the feasibility of ASD closure by using a device in 1974 [2]. Since the application of balloon dilation treatment for congenital pulmonary stenosis and aortic stenosis in the early 1980s, interventional therapies for congenital heart diseases have developed rapidly including patent ductus arteriosus, atrial septal defect and ventricular septal defect [3,4]. The Amplatzer ASD occluder is a self-expandable, double-disc device with a short connecting waist in the middle that was first made from a nitinol

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wire with mash in 1997. Amplatzer septal occluder was approved for percutaneous closure of atrial defect by the U.S. Food and Drug Administration in 2001. Over the past 17 years, percutaneous closure of ASD has become the treatment of choice in secundum type ASD. We reviewed the indications of transcatheter ASD closure, success rate and major complications following catheter closure. We also share our successful experience in treating a challenging huge secundum type ASD with deficient aortic rim.

Method

Techniques of percutaneous ASD closure

The procedure of percutaneous ASD closure required TEE or intracardiac echocardiography (ICE) monitoring. TEE or ICE was performed to determine the accurate ASD size, length of different surrounding rims and pre-implantation mitral regurgitation. The device size selected was 1–2 mm larger than the maximal color width of ASD measured on TEE. Balloon sizing with stop-flow technique, which was not routinely used [5], may be required in selected cases with a floppy atrial septum or large defect. The device waist size should be equal to sizing balloon diameter or 1 device size larger if there was no identical device size.

The long delivery sheath is advanced to left upper pulmonary vein under fluoroscopy. The left disk is deployed in the left atrium and pulled back against the atrial septum, followed by deployment of the right atrial disk while feeling the resistance of atrial septum; wiggling of the device is usually performed to increase the stabilization of the ASD device. TEE is then performed to check post-implantation mitral regurgitation, or mitral valve impingement or impingement of disk tip to aortic root. Electrocardiography should be carefully monitored because atrioventricular block might occur immediately after device implantation or during the follow-up period.

Challenging ASD case presentation

We report a 54-year-old male with chest tightness and exercise intolerance over the previous 6 months. He had grade 3/6 systolic ejection murmur with accentuated splitting P2 at left upper sternal border. Electrocardiography disclosed right QRS axis and right ventricular hypertrophy. Chest x-ray showed mildly increased cardiothoracic ratio, moderate convex of the pulmonic trunk and moderately increased pulmonary vascularity. Transthoracic echocardiography revealed a large secundum ASD, measuring 38 mm (Fig. 1A). Cardiac catheterization revealed Qp/Qs ratio of 3.1: 1. Mild pulmonary hypertension was documented with pulmonary arterial pressure 39/12 mmHg (mean 25 mmHg). Under general anesthesia, the two–dimensional transesophageal echocardiography (TEE) at 0° revealed the ASD was 33.7 mm in length with complete aortic rim deficiency (Fig. 1B). The maximal ASD length could not be well obtained because the defect could not be revealed on the same plane at 60 degrees of TEE. We tried to use Amplatzer sizing balloon II (9-SB-034, maximal size 40 mm) to measure the accurate defect size, but the balloon kept slipping from the defect because of a very large defect size and large atrial left-to-right flow.

We then chose the largest Amplatzer atrial septal occluder (9-ASD-040, waist diameter 40 mm, Fig. 2). The Mullin's delivery sheath was manipulated over a 260 cm-long guidewire into the left upper pulmonary vein, and then pulled back to the left atrium. We tried to pull the left atrial disk followed by pulling of the sheath under fluoroscopy and 2D TEE guidance. It was difficult to maintain the device at the left atrium because the left disk kept herniating to the right atrium during the procedure. Then, we applied the currently-developed balloon-assist technique [6]. The sizing balloon was partially inflated to prevent left atrial disk prolapse to the right atrium during deployment. Initially, we kept the balloon catheter anterior superior to the long delivery sheath system. While deploying the left disk, the large left disk protruded to the mitral valve and impinged the mitral leaflet (Fig. 3A).

We repositioned our long delivery sheath and deployed again. With this second attempt, there was no further mitral valve impingement during the procedure (Fig. 3B). During deployment of the left and right atrial disks under fluoroscopy, the balloon catheter was gradually deflated and then it was retrieved slowly until the device was adjusted. The whole process was monitored by TEE to adjust the position of the device and to stop the flow across the ASD. After retrieving the balloon catheter, the Amplatzer atrial septal occluder was maintained at the proper place.

After ASD closure, both TEE and transthoracic echocardiography showed optimal device position without residual shunt or mitral valve impingement (Fig. 4). The patient described improvement of chest tightness and exercise intolerance one week after ASD closure, and his condition remained stable during the 4-month follow-up period.

Discussion

Indications of transcatheter closure of ASD

According to a scientific statement from the American Heart Association (AHA) in 2011, the following indications for atrial septal defect closure are described as follows [7].

1. Hemodynamically significant secundum type ASD with Qp/Qs $\geq$ 1.5: 1.
2. Stroke or recurrent transient ischemic attack caused by transient right-to-left ASD shunt.
3. Cyanosis-related symptoms caused by transient right-to-left ASD shunt.

Evidence shows transcatheter ASD closure is beneficial in patients with hemodynamically significant secundum type ASD. Hemodynamically significant ASD refers to pulmonary-to-systemic ratio (Qp/Qs) $\geq$ 1.5: 1. For those with defects larger than 38 mm, or lack of sufficient rims supporting septal occluders, transcatheter secundum ASD closure is not regarded as an optimal management.

In patients with cryptogenic embolic stroke and patent foramen ovale (PFO) or right-to-left ASD shunt, benefits of closing ASD/PFO are greater than risks. There are two

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