

Indications and Evaluation for ASD Closure

Performing detailed hemodynamic evaluation of secundum atrial septal defects using current imaging modalities and closure devices.

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Atrial septal defect (ASD) is one of the most common types of congenital heart defects.¹ It accounts for 6% to 10% of all cardiac anomalies and occurs in one of every 1,500 live births. An ASD is a communication between right and left atria. There are several types of interatrial communications. The most common communication is the patent foramen ovale (PFO). This defect exists in utero and seals off after birth, although the time of sealing of this defect is variable. The PFO is not a true opening in the atrial septum; rather, it is a slit or flap-like separation between the septum primum and secundum. As the left atrial pressure increases after birth, the opening closes because of the apposition of the septum primum to the septum secundum.

A small, probe patent opening may remain despite excellent apposition, which is termed as *PFO*. A PFO may become a true opening if left or right atrial enlargement occurs and if the overlapping of the septum primum to the septum secundum disappears. Regardless, the location and the type of opening tend to solve the enigma of whether the defect is a PFO or a true ASD. Figure 1 shows the anatomy of the atrial septum with the flap-like septum primum.

If there is a true deficiency of the septum primum that results in communication between the two atria, it is called *secundum ASD*. The size of the defect is primarily based on the extent of septum primum deficiency. The septum secundum is always present in these patients, although it could be deficient in some areas. When deficiency of the secundum is present, the defect can be very large and technically difficult to close. The septum secundum constitutes the atrial septal rims. The aortic, superior, superior vena cava (SVC), posterior, inferior vena cava (IVC), and atrioventricular (AV) valve rims all compose the septum secundum.¹ Figure 2 shows a depiction of the atrial septal rims.

In addition to secundum ASD, there are other types of

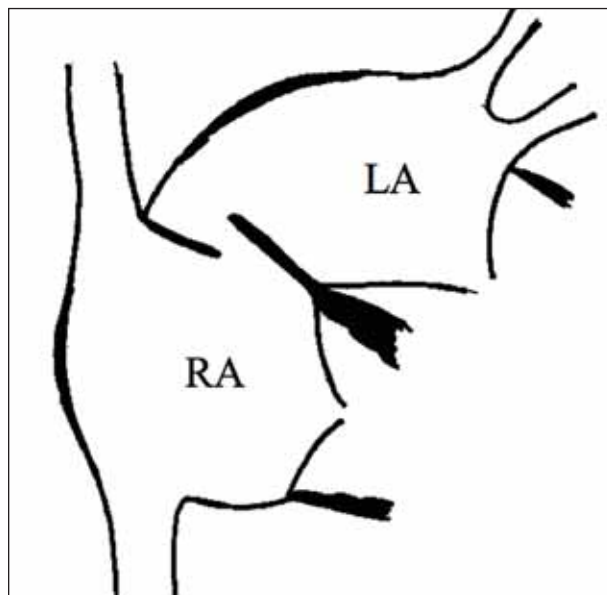


Figure 1. The anatomy of the atrial septum. The flap-type opening is the PFO. LA, left atrium; RA, right atrium.

atrial communications that are not amenable to device closure, and hence a thorough knowledge of these defects is needed in order to rule them out before embarking on intervention. These defects include sinus venosus ASD, primum or partial AV canal ASD, and coronary sinus ASD. Sinus venosus ASD is located close to the SVC or the IVC and is commonly associated with partial anomalous pulmonary venous return. This defect is not amenable to device closure. Primum or partial AV canal ASD is located very close to the mitral and tricuspid valves and therefore is also not amenable to device closure. In addition, primum ASD is associated with a cleft in the anterior mitral valve leaflet. Coronary sinus ASD is not a defect in the atrial sep-

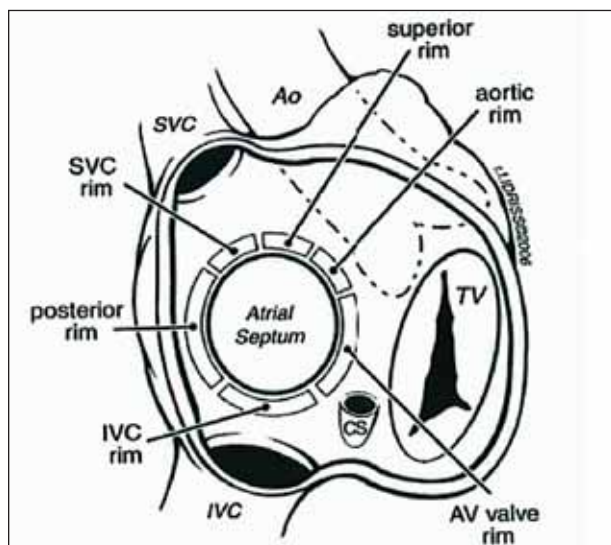


Figure 2. Classification of atrial septal rims. Reprinted with permission from Amin Z. Catheter Cardiovasc Interv 2006;68:778–787.¹

tum; rather, it is a defect in the roof of the coronary sinus that leads to communication between left and right atrium through the coronary sinus. Again, ideally this defect is not suited for device closure because of the risk of occluding the coronary sinus.

The subsequent discussion will focus on secundum ASD closure, as these are the only defects (barring PFO) that are amenable to device closure.

INDICATIONS FOR ASD CLOSURE

The indications for closure of secundum ASD have been clearly outlined in the 2008 American College of Cardiology/American Heart Association guidelines that were published in the *Journal of the American College of Cardiology* (Table 1).²

The indications for closure in the pediatric and the adult population are essentially the same. In pediatric patients, however, primary attention is directed to symptomatology of recurrent respiratory tract infection and failure to thrive. In adults, respiratory symptoms such as shortness of breath tend to occur after the age of 40 years.

The indications for ASD closure are based on the type of defect and the devices available to treat the defect. At the current time, there are two devices that have been approved for device closure by the US Food and Drug Administration. The Amplatzer septal occluder (St. Jude Medical, Inc., St. Paul, MN) can close defects up to 40 mm, and the Helex septal occluder (Gore & Associates, Flagstaff, AZ) can close defects up to 17 mm in diameter.

It should be noted that having knowledge of the indications for device closure is not sufficient to close an ASD.

CONTRAINDICATIONS TO ASD CLOSURE

- Aortic rim absence or severe deficiency confirmed in multiple TEE views. Absence of rims documented in multiple views of 30°, 40°, 50°+.
- IVC rim absence or severe deficiency (Figure 3).
- Pulmonary vascular resistance > 15 Woods units is an absolute contraindication.
- Coronary sinus rim absence with evidence of coronary sinus impingement by the device in the catheterization laboratory.
- Mitral valve impingement by the device with evidence of new-onset or increasing mitral insufficiency. Try a smaller device, if feasible.
- Development of AV block after device deployment.

Although criteria for closure are met on one level, there may be concurrent data that preclude closure of such defects. Naturally, if the defect is larger than 40 mm, it cannot be closed with a device because there is no device available that can close defects of such size. Similarly, if a patient has a concomitant cardiac lesion that requires surgery, the ASD defect can best be closed at the time of surgery. ASD closure is contraindicated in patients with irreversible pulmonary hypertension. ASD in such patients acts as a “pop-off” mechanism, and closure can be detrimental when the right heart cannot be decompressed during times of pulmonary hypertensive crisis. We recommend that these patients undergo cardiac catheterization for calculation of pulmonary vascular resistance.

If the pulmonary vascular resistance (PVR) is < 7 Woods units, then the defect can be closed in the same setting. Pulmonary vascular obstructive disease is rare before 30 years of age and is more common in women. One may consider using a fenestrated device if there are concerns for elevated pulmonary artery pressures because the fenestration can act as a pop-off when right ventricular pressures are high.³ There are some data showing that this may be efficacious in the short term.⁴ Some patients may require antipulmonary hypertensive therapy and oxygen at night for a few months after closure. If the PVR is > 7 Woods units, it is best not to close the ASD. There are data available that suggest that closure may be performed in patients with PVR as high as 10 Woods units because symptoms of pulmonary hypertension regress after closure.⁵

We believe that ASD closure should be withheld if PVR is > 10 Woods units. We recommend that the patient be started on antipulmonary hypertensive medical therapy, with the help of a pulmonologist, for at least 6 months. After this time, the patient should undergo recatheterization to assess PVR and the degree of left-to-right shunt. If

TABLE 1. INDICATIONS FOR ASD CLOSURE FROM THE AMERICAN COLLEGE OF CARDIOLOGY/AMERICAN HEART ASSOCIATION GUIDELINES

Indications for Closure of ASD	Indication Class
- Right atrial and right ventricular enlargement by echocardiography with or without symptoms. - ASD minimum diameter should be > 5 mm and < 40 mm on echocardiography. - Adequate rims of tissue (> 5 mm) from the defect to surrounding structures such as the coronary sinus, SVC, IVC, and AV valves, as well as the pulmonary veins.	Class I
Presence of an ASD with documented or verified paradoxical embolization and/or documented orthodeoxia-platypnea.	Class IIa
Net left-to-right shunting, pulmonary artery pressures less than two-thirds systemic levels, pulmonary vascular resistance less than two-thirds systemic vascular resistance, when either is responsive to pulmonary vasodilators, or test occlusion of the defect is successful.	Class IIb

criteria are met, then the defect can be closed in the same setting. In general, ASD closure is recommended in all symptomatic and asymptomatic patients with PVR < 10 Woods units. However, it is absolutely contraindicated in patients with PVR of 15 Woods unit or more. Patients with PVR between 10 and 15 should have aggressive antipulmonary hypertensive treatment and evaluation before exploring ASD closure.

Patients with evidence of left ventricular dysfunction, whether diastolic or systolic, represent a group that is at increased risk. These patients with ASD are generally older than 60 years and have a history of congestive cardiac failure. The left ventricle is less compliant than the right ventricle in these patients. The ASD tends to act as a pop-off for the left ventricle (as opposed to the right ventricle in patients with pulmonary hypertension), leading to compensatory fluid retention. Closure of the ASD may therefore result in acute left heart failure and pulmonary congestion. During the cardiac catheterization procedure, evaluation of left atrial pressures or pulmonary capillary wedge pressures after temporarily occluding the defect is very helpful.

A significant increase in left atrial pressure and a drop in cardiac output is a clear indication that the patient will require aggressive diuresis and anti-heart failure medications. After ASD closure, it is also recommended to leave a catheter in the pulmonary artery to measure pulmonary artery pressures overnight in these patients for optimal pressure measurement. Sometimes, it is best to optimize these patients with anti-heart failure medications and diuretics before device closure. These patients have been found to do very well at subsequent device closure. The *Contraindications to ASD Closure* sidebar summarizes what we believe to be the major contraindications to device placement in secundum ASD.

EVALUATION FOR ASD CLOSURE

The first ASD closure via transcatheter approach was performed in 1976.⁶ After a hiatus of several years, the closure process restarted in the late 1980s and has significantly progressed during the last 12 years.

A physical examination of a patient with ASD usually reveals subtle findings, and hence the diagnosis may be missed. Echocardiographic evaluation can confirm the diagnosis. Echocardiography is not only important for the diagnosis but is crucial in determining suitability for device closure. In addition, it is the primary modality on which the interventionist depends during the closure procedure. The determination can be made whether a particular ASD is suitable for transcatheter closure—not just from a typological perspective but also for size determination and the adequacy of rims for device placement. For the Amplatzer device, the rims should be 5 mm or larger (excluding the aortic rim), as suggested by the manufacturer in the instructions-for-use pamphlet. If 5 mm is considered to be an adequate rim size, then aortic rim deficiency will be common because more than 40% of patients with ASD have an aortic rim that is < 5 mm.⁷ Therefore, aortic rim deficiency is not a generalized contraindication to device closure. The aortic rim, however, is the most important rim when it comes to device-related complications such as erosion.⁸ Aortic rim deficiency in multiple transesophageal echocardiography (TEE) views should be considered a contraindication to device closure.

The Amplatzer septal occluder is a self-centering device, and its size is determined by its waist. The left disc is 6 mm larger than the waist for devices up to 10 mm, 7 mm larger for devices up to 32 mm, and 8 mm larger for devices up to 40 mm. The right atrial disc is 4 mm larger than the waist for devices up to 10 mm and 5 mm larger for all other sizes.

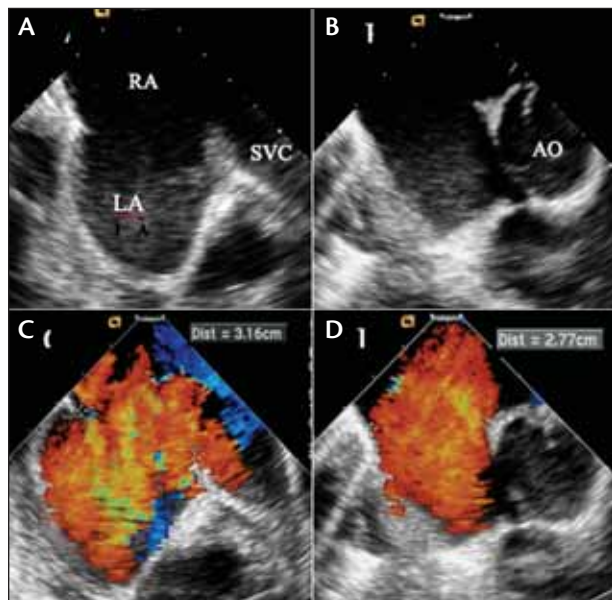


Figure 3. Intracardiac echocardiogram showing nearly absent IVC rim in a patient with a large ASD. Caval (A) and short-axis (B) aortic views without color. Caval (C) and short-axis (D) aortic views with color.

Because the right atrial disc of the Amplatzer septal occluder device is 5 mm larger than the waist, it was thought that atrial septal rims that are 5 mm in length should be adequate. However, there is no scientific study supporting 5-mm rim adequacy.

If one were to use the Helex device, there are no known criteria for atrial rim deficiency. The Helex is a non-self-centering device. The nominal diameter of the device has to be twice the size of the balloon-stretched diameter of the ASD.

It should be determined whether there is a single defect or whether the atrial septum is fenestrated. In cases of multiple defects, it is important to assess the septum separating the defects because the distance between the defects determines whether the patient will require more than one device. Transthoracic echocardiography in the pediatric age group is a useful tool prior to performing cardiac catheterization. The true delineation of the anatomy of the atrial septum, its relationship to nearby structures, and pulmonary

venous drainage delineation becomes increasingly difficult in adults who generally have poor acoustic windows. TEE has been used to successfully guide transcatheter closure of secundum ASD and PFO.^{9,10} Intracardiac echocardiography (ICE) can provide very similar information as TEE. It has replaced the use of TEE during ASD closure in some centers and is thought to be superior to TEE by some.¹¹ However, at this time, TEE remains the gold standard for ASD closure.

The drawbacks of ICE are the requirement for skilled expertise, difficult learning curve, placement of an 8- to 11-F venous line, the wide curve of the ICE catheter (which is more suitable for adults), the inability to obtain a four-chamber view (the ICE catheter sits in one of the four chambers), and the added cost incurred by using the disposable ICE catheters. The advantage of ICE is the ability to clearly delineate IVC and superior rims.

Correct sizing of the device is crucial. It is strongly recommended to measure the defect in three views if using TEE and two views if using ICE (a four-chamber view is not obtainable by ICE). The ASD should be measured in four-chamber, short-axis, and bicaval views with TEE as outlined in Figures 4 and 5. With the use of ICE (Figure 6), short-axis aortic and bicaval views are similar to the TEE views. A third view by ICE is called the *atrial view*, which shows the superior rim (the rim between the aortic and the SVC rims) can be seen while rotating the probe from bicaval to short-axis view. Every effort should be made to ensure that there is no obstruction to surrounding structures such as AV valves, the right upper pulmonary vein, and coronary sinus after placement of the device.

Once the patient is in the cardiac catheterization laboratory, a complete right heart catheterization should be performed on all patients. An arterial line is not typically needed. The catheter can be advanced into the left ventricle through the ASD for saturations and systemic pressures. Pulmonary vascular resistance is calculated if the pulmonary artery pressures are high. If the patient has pulmonary hypertension, right heart catheterization is performed on room air and with consecutive administration of 100% oxygen, which may be followed by the addition of nitric oxide. Some institutions use adenosine to determine reversibility of increased pulmonary vascular resistance.¹²



Figure 4. Use of TEE for defect evaluation and device closure. ASD in short-axis aortic view (A). ASD in four-chamber view (B). ASD with color flow in bicaval view (C). Short-axis aortic view after Amplatzer device placement (D). Bicaval view after Amplatzer device placement (E).

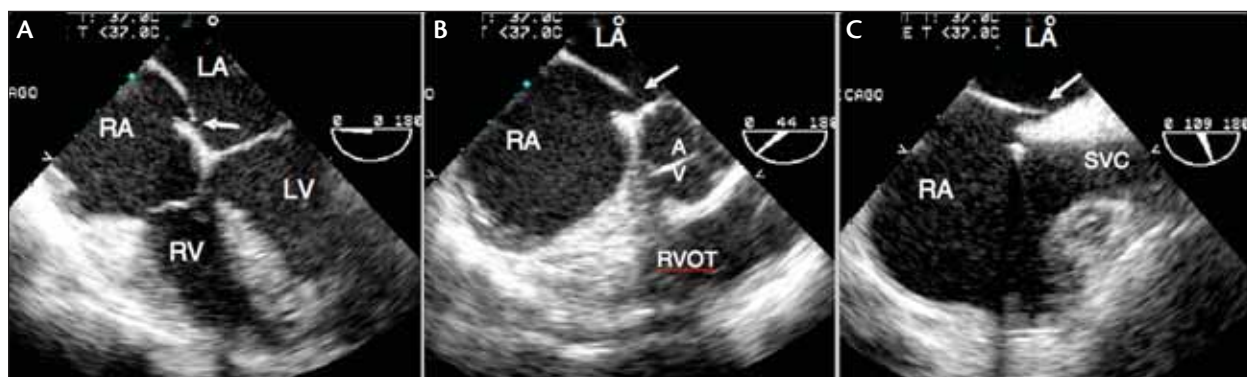


Figure 5. TEE standard views for evaluation of atrial septum. This patient has a PFO. Four-chamber view (A). Short-axis aortic view (B). Bicaval view (C). The white arrow points toward the PFO type opening.

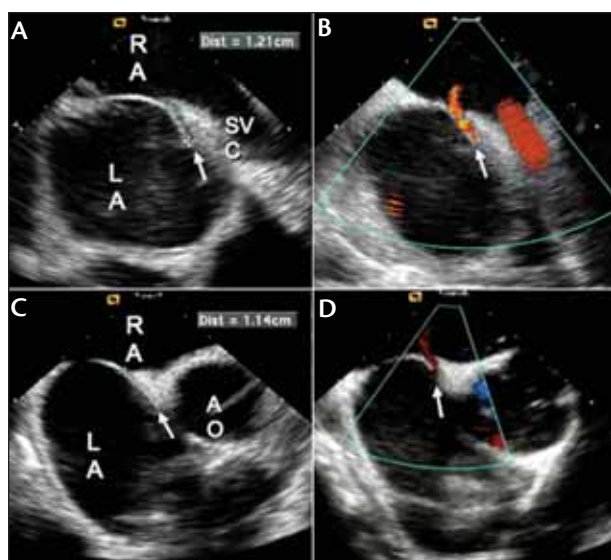


Figure 6. ICE standard view for evaluation of atrial septum. This patient has a tunnel type PFO. Caval view with and without color (A,B). Short-axis view with and without color (C,D). RA, right atrium; LA, left atrium. White arrow points toward the PFO opening. The measurement in A is the length of the PFO tunnel.

CONCLUSION

Device closure is one the most common procedures performed in cardiac catheterization laboratories. The morbidity and mortality rates associated with this procedure should be as low as possible, because technically, it is a simple procedure. However, challenges remain in attempts to decrease morbidity and mortality rates to an absolute minimum. We strongly believe that the risks of device closure can be brought down to a minimum with detailed and complete evaluation of the defects and by ruling out defects that should not be closed. This can be achieved with detailed evaluation, anticipation of hemodynamic consequences if

the defects are closed, an improved understanding of the available devices and their limitations, and with echocardiographic expertise of the interventionist. ■

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