Closure of Atrial Septal Defect and Patent Foramen Ovale, the Simple Way

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ABSTRACT
Catheter based closure of atrial septal defects was first described in 1974 but has only been used widely since the nineties. In 1992 the focus turned to closure of the patent foramen ovale which today is the most common atrial shunt closure. While the majority of centers advocate use of transesophageal or intracardiac echocardiographic guidance during implantation, fluoroscopy guided implantation is feasible, faster, cheaper, and more patient-friendly. Closure of a patent foramen ovale with an Amplatz occluder (currently the preferred device) may take as little as 10 minutes with the possibility to return to full physical activity a couple of hours later. Complications are exceedingly rare (<1%). They include (about in the order of frequency) inguinal access problems, thrombus on the device, device embolization, cardiac perforation, erosion of the atrial wall by the device, or infection of the device. So far there are no reports of late complications although atrial fibrillation is one to be looked out for.

INTRODUCTION
A patent foramen ovale (PFO) is present in all babies at birth and about 30% of teenagers. The prevalence decreases to about 20% in octogenarians [1]. While a PFO is not considered a congenital heart defect, the atrial septal defect (ASD) is. Its most common form, the ASD II (secundum, located in or around the fossa ovalis and not involving atrial inflow structures or heart valves) constitutes the most common congenital heart defect together with the ventricular septal defect (VSD). It is present in about 0.1% of people and ranges from minute to huge (e.g., 4 cm). It may be multiple (Swiss cheese variety). An ASD secundum may lead to significant volume overload, resulting in enlargement of all heart chambers, save the left ventricle. Atrial fibrillation is its most common and feared complication occurring typically after the age of 40 years and being the number one reason (before heart failure) for mortality. Surgical closure of an ASD in adults failed to reduce the incidence of atrial fibrillation over the subsequent 30 years [2].

The first report of successful closure of an atrial septal defect dates back to 1974 [3] preceding coronary angioplasty by more than 3 years. The introduction of the Rashkind atrial septal occluder in the eighties rekindled the interest in interatrial shunt closure that had lain dormant for 10 years, but catheter based ASD closure became commonplace only in the nineties with the introduction of self-centering devices, particularly the Amplatz occluder (Figure 1). In 1992 a first report on PFO closure to prevent paradoxical stroke launched a new era [4]. While ASD closure will remain a fairly rare procedure, PFO closure has the potential to become the most...
common procedure in interventional cardiology. Already, it accounts for about 10% of the interventional activity in some pioneering centers.

INDICATIONS

The smaller the ASD, the easier is catheter based closure with the PFO as the extreme example. Hence, it can be argued that all ASDs should be closed. The large ones because of their hemodynamic importance, the small ones and the PFOs because of their potential for paradoxical embolism and acknowledging their lack of intricacy for closing.

TECHNIQUE OF CLOSURE INTERATRIAL SHUNTS WITHOUT ECHOCARDIOGRAPHIC GUIDANCE

A transesophageal echocardiography is the best base for the indication of closure of any interatrial shunt. With the Amplatzer ASD occluder (Figure 2) it is not necessary to measure the rims. The device will conform to virtually any anatomy, provided the defect is not too large (>40 mm) and an adequately sized device is selected. It is recommended to perform a stretched defect measurement with a sizing balloon (compliant latex balloon with sizing markers) (Figure 2). There is a small risk of enlarging the ASD by tearing a possibly very thin portion of the septum primum with the measuring balloon. However, this may avoid undersizing of the device, which could be unstable if implanted commensurate to an echocardiographically measured ASD without paying attention to the stability of the surrounding rim in the region of the septum primum. If the measuring balloon shows a clear waist and remains in stable position straddling the defect, an Amplatzer septal occluder about 20% larger than the measured diameter should be selected. If the balloon cannot be stabilized in the ASD, this indicates instability of part of the septal wall and mandates oversizing of the device compared with the balloon measurement by 30%-50%.

Oversizing of the device has been advised against by a report analyzing the potential causes of the dreaded, albeit rare, device erosion due to friction of the device against the external atrial wall in contact with the pulsating aorta [5]. A contrary theory is that a somewhat oversized Amplatzer occluder will have rounder edges at least during the initial phase (Figure 2 C) and therefore should be less erosion-prone. During follow-up even generously sized Amplatzer occluders will flatten down (Figure 3).
If the intervention was based on a state-of-the-art transesophageal echocardiography, it is unlikely to miss additional ASDs by not using echocardiography during the intervention. Figure 4 demonstrates the case of a 27-year-old woman who wound up with 4 devices after 3 additional ASDs had been missed during closure of a presumed single ASD (report of a pre-intervention transesophageal echocardiogram) at the first intervention. During the second intervention, two ASDs were closed using transesophageal echocardiography. During follow-up, it turned out that an additional sizable ASD had been missed which was closed in a final third intervention, again without echocardiographic guidance. The septum was completely closed at follow-up.

The technique for PFO closure is analogous but even more simple. Figure 5 explains some salient features. Of the large variety of devices available for that purpose (Figure 6), only 3 have collected significant clinical experience (Amplatzer PFO occluders, PFOStar/TransSeptal devices, and the CardioSeal/StarFlex devices).

The key feature for correctly placing an Amplatzer PFO occluder (or any occluder for that matter) without echocardiographic guidance is an ideal angiographic projection combined with injection of contrast medium (performed by hand through the introducer sheath) where pertinent (Figure 7). If the device fails to straddle the septum secundum (negative Pacman sign), this will not necessary lead to embolization for the reasons explained in figure 8 but it will increase the risk.

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The advantages and disadvantages of using echocardiographic guidance for atrial shunt closure are summarized in Table 1. While a number of centers have already abandoned echocardiography during PFO closure for the simplicity of this procedure and its high number of cases mandating a frugal approach, echocardiographic guidance is still deemed mandatory for ASD closure in general. My experience with ASD closures with and without echocardiographic assistance proves that judicious and intelligent exploitation of fluoroscopy obviates the need for simultaneous echocardiography during any Amplatzer device implantation. Other devices are more cumbersome to implant but still do not mandate echocardiography either.

Hence, fluoroscopically guided closure of PFOs and ASDs is not only feasible but safe and equally effective as echocardiographically guided techniques. It affords considerable economical and comfort advantages. Table 2 recapitulates the important steps of the technique.

Interventional cardiologists embarking on interatrial shunt closure should start with the PFO using the 35 mm Amplatzer PFO Occluder for the initial cases. This is by far the easiest-to-use device with a good record of permanent occlusion. Once they feel comfortable with PFO closures using the standard device, they can proceed to ASD closures using the same technique.

FIGURE 6. Currently available devices for PFO closure in order of their user-friendliness and performance. A. Amplatzer PFO Occluder device, available in 5 sizes all with a thin, flexible and extendible neck: 25 mm (right disk 25 mm, left disk 18 mm, standard device); 35 mm (right disk 35 mm, left disk 22 mm); 18 mm (both disks 18 mm); Cribriform 25 mm (both disks 25 mm); Cribriform 35 mm (both disks 35 mm), (AGA, Minneapolis, Minnesota, U.S.A.), B. Solysafe (Carag, Baar, Switzerland), C. TransSeptal device (Cardia Inc. Burnsville, Minneapolis, U.S.A.), D. Premere device (VeloCimed, Maple Grove, Minneapolis, U.S.A.), E. StarFlex device (formerly CardioSeal) (NMT Medical, Boston, Massachusetts, U.S.A.), F. Helex Septal Occluder device (Gore Newark, Delaware, U.S.A.), G. Sideris Buttoned Occluder device (Sideris, Athens, Greece).
TABLE 1. Advantages and disadvantages of echocardiographical guidance during percutaneous interatrial shunt closure

<table>
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<tr>
<th>Advantages</th>
<th>Disadvantages</th>
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<tr>
<td>- Smaller risk of misplacement or suboptimal placement</td>
<td>- Need for general anesthesia (perhaps even intubation) or at least deep sedation</td>
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<tr>
<td>- Smaller risk of missing additional shunts</td>
<td>- Risk of aspiration with esophageal intubation in supine position</td>
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<td>- Immediate information about residual shunt</td>
<td>- Increased cost for additional manpower or use of intracardiac (disposable) echocardiographic equipment</td>
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<td>- No need for contrast medium injections</td>
<td>- Significantly prolonged procedure time and laboratory occupation</td>
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<td>- Shared responsibility between interventional cardiologist and echocardiographer</td>
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TABLE 2. Technique of percutaneous interatrial shunt closure with Amplatzer devices

- Outpatient procedure
- No echocardiographic guidance
- Local anesthesia at right groin
- Access through right femoral vein
- 0.035 inch (exchange) wire
- Multipurpose catheter to pass defect unless wire crosses spontaneously
- Balloon gauging (18 mm or 24 mm in small children, 34 mm in adults)
- 6-12 French sheath according to occluder size (9 French for PFO)
- Right atrial contrast medium injections (by hand, left anterior oblique and cranial view)
- Antibiotics (1 - 3 doses)
- Unrestricted physical activity after a few hours
- Acetylsalicylic acid 100 mg for 5 months
- Clopidogrel 75 mg for 1 month
- Prophylaxis against endocarditis (for 3 - 6 months)
- TEE at about 6 months (1 month after stopping platelet inhibitors)

device (25 mm Amplatzer Occluder) they can then move on to ASD closures, starting first with small defects (20 mm or smaller). Closure of larger defects (20 mm to 40 mm) should be reserved for subspecialized accomplished interventional cardiologists and percutaneous closure of even larger defects is currently not possible and may never be.
REFERENCES


