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Vascular plugs – A key companion to Interventionists – *'Just Plug it'*

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ABSTRACT

Vascular plugs are ideally suited to close extra-cardiac, high flowing vascular communications. The family of vascular plugs has expanded. Vascular plugs in general have a lower profile and the newer variants can be delivered even through a diagnostic catheter. These features make them versatile and easy to use. The Amplatzer vascular plugs are also used for closing intracardiac defects including coronary arterio-venous fistula and paravalvular leakage in an off-label fashion. In this review, the features of currently available vascular plugs are reviewed along with tips and tricks of using them in the cardiac catheterization laboratory.

1. Introduction

Closure of abnormal natural or artificial vascular communications is frequently performed in the catheterization laboratory. Commonly, 2 types of materials are used for closure of vascular communications, which include materials for embolization like coils, gel foam or particles and the various septal/duct occluders. Embolization materials like coils are relatively inexpensive, have a low profile and are easy to deliver; but the release of these materials cannot be secure and the rates of embolism is higher. The occluder devices are expensive, need a relatively larger sheath for delivery and are difficult to deliver in tortuous structures due to their bulkier profiles. However, the duct/septal occluders can be released in a controlled fashion. The vascular plugs have features of both embolic materials and occluder devices. They have a relatively lower profile and can be released in a controlled fashion. Almost all the published literature with the vascular plugs is with Amplatzer vascular plugs (AVP) [St. Jude Medical, Inc.; Minnesota, USA].[1–5] AVP have evolved over years and are available in four different forms now – AVP I–AVP IV. All these forms of AVPs have been used for the embolization of medium to large vascular communications. Recently, Cera™ series of plugs from Lifetech [Lifetech Scientific Corp., China] became available.[6] Cardiac plugs for the closure of left atrial appendage and microplugs are the latest additions[7,8] to the series of vascular plugs. In this article, the various forms of plugs and technical aspects of their use in cardiac catheterization laboratory are reviewed.

2. Types of vascular plugs

AVP are established embolic devices manufactured by St. Jude Medical [St. Jude Medical, Inc.; St. Paul, Minnesota, USA]. The

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initial AVP was approved by the US FDA (Food and Drug Administration) in May 2004, for peripheral vascular embolizations. The indication for AVP and their usage have expanded significantly. The AVP II was introduced in 2007. All these plugs are self-expanding devices made of nitinol wire mesh which can be cylinderlized into a sheath. Upon release they assume the pre-specified shape due to the property of thermal memory. The differences among the series of AVPs are presented in Table 1 and Fig. 1. AVP I has single lobe and AVP II has 3 lobes, whereas AVP III and IV are bilobed. AVP I and IV are single layered, and AVP II and III are multilayered.[1,3] All these devices are complimentary additions and are not a replacement of earlier version. Each of them has a unique feature that is useful in a specific clinical situation.

The initial AVP, (also known as AVP I), made of finely braided Nitinol wire, had a single-layer mesh and a single-lobe design. It has a high radial force and is ideal for structures with short landing zone. However, choosing the appropriate length and diameter of the device is very critical as there are no rims on either side. AVP requires a longer time for complete occlusion. The AVP II is designed to improve the occlusive properties and has a finer and more densely woven nitinol braided in two or 3 layers. It has a central lobe and 2 discs on each side. The multi-layered, multi-segmented design reduces the time to occlusion and offers full cross-sectional vessel coverage. Thus, AVP II has lower migration and recanalization chances. The multi-layered mesh lobes create six occlusive planes, which enable faster vessel occlusion.[1,3]

AVP III is designed for embolization of structures with a very high flow. AVP III has an oblong cross-sectional shape made of multiple Nitinol mesh layers and has extended rims. It has the fastest occlusion properties. Device rims extending beyond device body enables full wall apposition and enhances stability in high-flow vessels. AVP III fits elliptical shaped vascular structures. AVP IV has the best profile among all the AVPs. In fact AVP IV can be delivered through a 0.038 compatible diagnostic catheter (5F diagnostic catheters). This eliminates the need for catheter exchange. Flexible mesh and the floppy distal section of the delivery wire make AVP IV attain a very low-profile, which improves the reach to distal vasculature and across tortuous and angulated structures. The multi-layered, double-lobed design also enables rapid embolization. However, AVP IV is only available up to a size of 8 mm.[3]

Cera™ is a new brand of plugs manufactured by Lifetech [Lifetech Scientific Corp., China]. The manufacturers claim that the Titanium Nitride (TiN) coating prevents thrombosis and improves endothelialization. It has a single lobe and has PTFE material for faster occlusion. Initial clinical data on other forms of this device is published recently.[6]

2.1. *Amplatzer cardiac plug*

The Amplatzer cardiac plug-2 (ACP 2) is a self-expanding device specifically designed for left atrial appendage (LAA) closure. ACP 2 has a distal lobe along with a proximal disc connected by a short waist. The ACP 2 is deployed through a septal puncture using a transfemoral route.[7]

2.2. *Micro plugs*

The micro-plugs are latest addition to the plug family, which can be delivered through a micro catheter. These micro plugs are available in 3 mm and 5 mm sizes that enables super-selective embolization of distal vessels.[8]

3. Indications for vascular plugs

Indications for the use of vascular plugs have expanded and it is said that there are no contraindications.[1] However, their use is approved for extra-cardiac vascular structures only in some countries. Most of the existing literature regarding vascular plugs is with the AVP family and pertains to its use in peripheral vascular malformations. Excellent reviews are available that summarizes the use of AVP in closing peripheral vascular structures ranging from arterial malformations, aneurysms, Arterio-Venous (AV) malformations, for venous occlusion including portal vein embolization, and even endoleak associated with EAVR. AVP have been used to occlude arteries including internal iliac, carotid, splenic, renal and gastroduodenal artery embolizations. They are also useful to close the various man-made shunts including AV fistula for hemodialysis, and transjugular intrahepatic portosystemic shunt (TIPS) occlusion.[1,9]

The ease of use, lower profile and precise deliverability make it ideally suited to close congenital malformations in even smaller children. Recently, a few case series have described the use of AVPs in various congenital malformations.[3,10,11] Shwartz's et al, initially described the use of AVP I and II in congenital heart disease, mostly in patients with PDA

Table 1 – Device characteristics of various generations of vascular plug family.

	AVP I	AVP II	AVP III	AVP 4	Amplatzer cardiac plug (ACP 2)[a]	Cera™
Structural details	Single lobe	3 lobes plug – one central and 2 peripheral	Oblong plug with extended rims	Two lobes (lower profile)	Distal lobe with proximal disc with a waist	Single lobe
Available diametric sizes (mm)	4–16	3–22	Long axis, 4–14	4–8	16–34	4–24
Length of plug (mm)	7–8	6–18	Short axis, 2–5	10–13.5	13–18	7–14
Guide catheter (Fr)	5–8	5–9	6–9	5F diagnostic	12–14	4–9

Modified from Wang W, et al 2012.[1]

[a] Only useful for left atrial appendage (LAA) occlusion.