Int J Biol Med Res.2021 ;12(2):7293-7300

Contents lists available at BioMedSciDirect Publications

International Journal of Biological & Medical Research

Journal homepage: www.biomedscidirect.com

Original article

MULTI-CASE REVIEW OF VARIOUS APPLICATIONS OF VASCULAR PLUGS IN EMBOLIZATION OF HIGH FLOW VASCULAR LESIONS

A. Gursale[a], V. Ukirde[a]*, A. Bansal[a], R. Hira[a]

OPD 39, Department of Vascular Interventional Radiology, LTMG Hospital, Sion, Mumbai 400 022, India

ARTICLE INFO

Keywords:
AVM – arteriovenous malformation;
AVP – Amplatzer vascular Plug;
embolisation

ABSTRACT

Introduction: The Amplatzer Vascular Plug (AVP) was created for peripheral embolization as a modification of the family of Amplatzer septal occluders used in the treatment of congenital heart malformations. The device has evolved over the years and multiple versions have been launched into the market. Immediate and accurate occlusion of high flow vascular malformations as well as their arterial feeders by usage sophisticated, advanced track able devices like such Avascular plug have added another tool to the armamentarium of the Interventional Radiologist. Vascular plugs are ideally suited to close extra-cardiac, high flowing vascular communications. Aims and Objectives: To study applications of vascular plugs in embolization of high flow vascular lesions. Materials and methods: Imaging proven cases of high flow vascular malformation were selected after written and informed consent. A patients were treated successfully with vascular plug after angiographic evaluation. Results: Ten embolization were performed of which 7 (70%) elective and 3 (30%) were done on emergency basis. Of these 7 cases 3 cases (42%) needed vascular plug and augmented with another embolic agents which includes coils in 1 case (16.6%)] and sterol in 2 cases (33.3%)]. Of the emergency 3 cases 2 (66.6%) needed plug with and adjunct embolic agent like gel foam in one case and coil in other. Conclusion: Successful embolization was performed in all cases. This includes pulmonary AVM, Dialysis fistula closure, Abernathy syndrome & portal hypertension. The vascular plug is a very useful embolization agent that allows the operator to treat a variety of high flow conditions including very challenging vascular lesions, such as high-flows AVF and vessels with short landing zones. There is good control on the device with minimal risk of distal embolization or migration. Becoming familiar with the different versions of the device within the AVP family and the utility of combining the AVP with other embolization therapies is very important.

Introduction

The Amplatzer Vascular Plug (AVP) was created for peripheral embolization as a modification of the family of Amplatzer septal occluders used in the treatment of congenital heart malformations. The device has evolved over the years and multiple versions have been launched into the market. Immediate and accurate occlusion of high flow vascular malformations as well as their arterial feeders by usage sophisticated, advanced track able devices like such Avascular plug have added another tool to the armamentarium of the Interventional Radiologist.

The purpose of this article is to review current clinical applications of the AVP in the field of interventional radiology

Vascular plugs are ideally suited to close extra-cardiac, high flowing vascular communications.

* Corresponding Author : **druvrays@gmail.com**

II] REVIEW OF LITERATURE:

The Amplatzer Vascular Plug (AVP; St. Jude Medical, St. Paul, MN) is a disk made of a mesh of braided nitinol. The disk is attached to a 155-cm-long, PTFE-coated delivery wire with a stainless-steel micro screw, which allows the operator to release the plug into the final position by rotating the cable in a counter clockwise fashion using a supplied torque device. [1, 2]

There are 4 types of vascular plugs [Table 1A and 1B]. The first generation has a single-lobe design for rapid occlusion in short vessel landing zones. [3]

The second generation is multilayered, created for enhanced conformability to the variable vessel landing zones. The fourth generation has recently been approved by the FDA and can be deployed through a microcatheter [4, 5]

The resistance to blood flowcreated by the nitinol mesh facilitates fibrin coverage during the clotting process. Thrombogenicity is increased by adding more braid layers or having more wire struts with smaller openings; the increased cross-sectional area coverage accelerates thrombus formation and embolization after plug placement. [6]

III] AIMS AND OBJECTIVES:

To study the various uses of vascular plugs in the field of interventional radiology with its vascular and non-vascular applications

IV] MATERIAL AND METHODS:

Patients referred to the department of Interventional radiology with high flow vascular malformations/lesions on an emergency or elective basis were evaluated on Ultrasound, CT or DSA and were treated under fluoroscopy and ultrasound guidance with informed consent.

V] OBSERVATIONS & RESULTS:

A total of10 cases [Table 2] were referred to the Department of Vascular and Interventional Radiology in a span of 20 months which were evaluated and posted for closure using vascular plug.

Of these 2 were pediatric age group and rest were adults. One case was done on emergency basis and rest 9 were elective. Selected follow up on most cases was available.

However on follow-up, most cases had significant reduction in the complaint and most of them had no repeat episodes of the complications, however due to secondary comorbidities, few patients had to go for repeat interventions.

Of the 10 cases which presented to our institution the following specialties were involved in this study, the various specialties involved as a referral basis for such cases included:

Gastro-Med (n = 5); Nephrology (n = 3); Cardio-vascular Surgery (n = 1) and Otorhinolaryngology (n = 1).

Of the limited cases presented to us 4 cases needed the use of vascular plug alone as the embolic agent while rest of the 6 cases needed vascular plug along with an adjunct embolic agent which were s terol in 3 cases and coils in 2 case. Repeat Intervention was required in only 1 case.

Potential Challenges of Using the AVP:

1. Device advancement:

Braided sheaths are more commonly used these include Flexor Check – Flo Introducers (Cook Medical) and Destination sheaths (Terumo Medical). Non braided variety have high chances of kinking and can result in complications. Newly advanced sheaths with metallic spirals such as the Super Arrow – Flex sheaths can cause increased resistant while advancing the plug and should not be used. [7]

A braided diagnostic catheter with 0.035" or 0.038" inner lumen system should be used along with these sheaths as delivery catheters [8]

For the larger 7- and 8-mm AVP IVs, the use of a 5F. Guiding catheter with a 0.056" inner lumen could be very helpful. The continuous injection of normal saline through the sheath or flushing port of the AVP IV can ease the advancement of the device by reducing the friction of the plug against the catheter wall. [8, 9]

2. Persistent patency:

Incomplete embolization could be related to a vessel that never occludes or to a vessel that was occluded initially and then later recanalizes. [9] Incomplete embolization is caused due to the presence of a side branch that originates near the proximal end of the plug [10]

3. Vessel recanalization:

A vessel that was initially occluded can later recanalize, it can have serious consequences. [11, 12]. This can be due to supply from new collaterals due to hyper vascularity of the lesion.

4. Plug detachment:

The configuration of the AVP requires a relatively straight segment of target vessel with a fairly constant diameter. With angulated branching points, jamming of the screw thread has resulted in early detachment. [13]

5. Contrast injection:

With the AVP IV, especially with the 7 and 8 mm sizes, it is very difficult to inject contrast through the proximal hemostatic valve due to the tight seal. [13] In such cases precise positioning has to be done prior introduction of the plug in the guiding catheter

6. Reconfiguration:

Reconfiguration of the AVP was reported by Sheridan et al, where the device, due to its natural tendency to achieve its nominal diameter, resulted in shorter and wider devices in follow-up imaging.[14]

7. Device migration

Can be caused by a) placing an undersized plug; b) Very short landing zones; c) Surgical manipulation of vessel in which plug is deployed [15]

Clinical Applications

1. Vascular Uses

A. ARTERIAL:

i. Pulmonary Arteriovenous Malformations Embolization

ii. Splenic Artery Embolization

iii. Embolization of Bleeders/ Injuries in Aorto-iliac segments

iv. Arteriovenous Fistulas Embolization

v. Radio embolizationfor hepato-cellular carcinoma

B. VENOUS AND MESENTERIC

i. Portal and Mesenteric Venous Circulation

ii. Gastric Varices and Vascular plug-Assisted Retrograde Trans venous Obliteration

iii. Preoperative Portal Vein Embolization

iv. Gonadal Vein Embolization

v. Solid-Organ Percutaneous Access Closure

vi. Dialysis Fistulas Complications

vii. Emergency Embolization and Neurovascular Applications

2. Nonvascular Uses:

A. GENITOURINARY APPLICATIONS

1. VASCULAR USES:

A) ARTERIAL USES:

i. PULMONARY ARTERIO-VENOUS MALFORMATIONS:

Advantages include:

a. No risk of distal embolization causing stroke

b. Very distal occlusion of the feeding vessels at the venous sac thus preventing any persistent perfusion of the venous sac by collaterals

c. Mean occlusion time of simple AVM's is approx. 3 min

d. Recanalization rate is less as compared to coils [16, 17 , 18, 19]

Disadvantages of other embolic agents in such cases include:

Coils:

a. Needs multiple soft detachable coils

b. Lesser control over detachment

PVA particles:

a. Distal embolization and stroke[18, 19]

ii. SPLENIC ARTERY EMBOLIZATION:

Advantages:

a. Better placement in long landing zones

b. Less chances of distal migration or infarction [20]

c. Less radiation dose and average procedural time [20]

Disadvantages of other embolic agents:

a. Coils have a risk of distal migration (30%)

iii. EMBOLIZATION OF BLEEDERS/ INJURIES IN THE AORTO-ILIAC SEGMENTS :

Advantages of vascular plugs in this segment

a. Prevention of endoleaks type 2by occlusion of internal iliac, inferior mesenteric artery and accessory renal arteries prior EVAR. [22,23,24]

b. Very proximal occlusion is possible with a single device without causing ischemia [21]

iv. ARTERIO-VENOUS FISTULA EMBOLIZATION

Advantages include:

a. Less risk of distal embolic particle migration [25,26]

b. Treatment of arterio-venous fistulas with a short neck “stuffing technique”

c. After the plug is deployed to the midpoint, the sheath isadvanced over the AVP, causing the proximal tip of the AVP(still in the guiding sheath) to invaginate into the devicealready deployed distal half before final release [27]

v. RADIOEMBOLIZATION:

a. Embolization of any potential gastro-intestinal branch [GDA] to prevent accidental migration of radioactive particles. This can be accomplished by vascular plug which is quite proximal. In such conditions the appropriate vascular plug type used is type 4, with a 4 Fr delivery catheter device. This plug is used because of its better tracking ability. [28]

B) VENOUS AND MESENTERIC USES:

i. PORTAL AND MESENTERIC VENOUS CIRCULATION:

a. Placing a vascular plug proximally with keeping a micro-catheter distally for injection of sclerosant will prevent leaking of the sclerosant to non-targeted normal branches. [30]

II. GASTRIC VARICES AND VASCULAR PLUG ASSISTED RETROGRADE TRANS VENOUS OBLITERATION

a. The main complication of Balloon assisted retrograde trans venous obliteration (BRTO)is non targeted embolization due to balloon deflation or migration, a vascular plug was found to be more effective in such cases.[32]

iii. PREOPERATIVE PORTAL VEIN EMBOLIZATION

a. Less time consuming

b. Placement of plug 1 cm distal to the portal vein bifurcation with cyanoacrylate glu-embolization of the distal portal branches [33, 34]

iv. SOLID ORGAN PERCUTANEOUS ACCESS CLOSURE

a. In certain cases where there is a necessity to get a percutaneous access via a solid organ like liver, spleen or kidney which has a high vascular flow and supply, there have been few instances like where the percutaneous access had to be modified with a larger luminal diameter sheath in cases like TIPSS closure, Percutaneous Splenic approach trans venous obliteration of lienorenal collaterals, Trans hepatic thromboaspiration of Porto-venous thrombus etc. In such cases while removing the sheath to prevent the complication of access site bleeding a vascular plug can be used during removal of sheath. [35]

v. GONADAL VEIN EMBOLIZATION

a. To prevent reflux of the sclerosant which is injected through a micro-catheter and plug is deployed proximally. [36]

vi. EMERGENCY AND NEUROVASCULAR APPLICATIONS

a. Rapid embolization and no distal embolization with necrosis

b. Cases like accidental intracranial vessel injuries , large intracranial andextra cranial AVM can be treated with Parent vessel occlusions andocclusion of the venous pouch in AVM's

2) NON-VASCULAR USES:

A) GENITO-URINARY APPLICATIONS:

a. The ureteral closure rates combining coils withgelatin sponge or tissue adhesive have been mixed, with success rates of 50 to 100%. [37, 38]

b. Modifications to the use of the AVPinclude adding latex layers by placing a surgical glove finger over the plug and using the plug as a scaffold fortraditional coil- and tissue-adhesive application. The successrates for these combined techniques range from 80 to100%.[37 , 38]

XI) Tables and Figures:

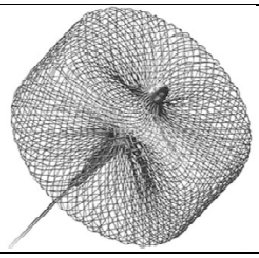
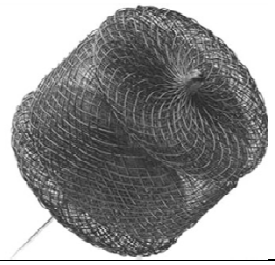
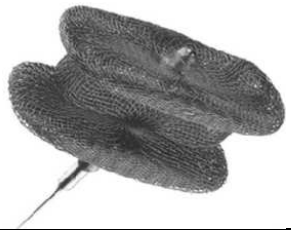
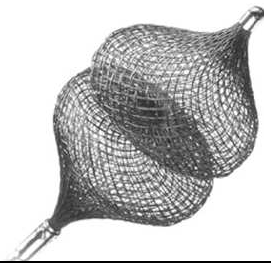
Version	Details	Advantages
AVP I 	Single layered disc Short landing zone with precision 4mm to 16 mm and needs 4F - 6F sheath	Easy placement
AVP II 	Braided multilayer nitinol Faster and variable landing zones From 2mm - 22mm Sheaths : 4F – 7F	Longer segment deployment Better apposition in short landing zones
AVP III 	Faster occlusion in challenging high flow situations Size : 4mm – 14 mm Sheath : 4F – 7F	Tortuous anatomy
AVP IV 	Better track ability in tortuous anatomy Size : 4 mm to 8mm	For 3 - 6 mm diameter vessels

Table 1A. Schematic representations of types of Amplatzer vascular plugs [Source: Ref. 38]

	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

Table 1B. Types of Amplatzer vascular plugs

SR no	*Diagnosis*	*Presenting complaints*	*Need for plug insertion*	*Access taken for plug insertion*	*Type of vascular plug*	*Additional embolising agent*	*Post procedure complications if present*	*3 months Follow Up*
1	pulmonary sequestration	recurrent pneumonia	pre-operative for lobectomy	arterial access	type 1	nil	massive bleeding in peri-operative period due to inadvertent injury to aorta	No further complaints of hemoptysis
2	left brachio-cephalic A-V fistula with cardiac failure	congestive cardiac failure	to block fistula and reduce hyper dynamic circulation	venous access	type 2	nil	improvement of CCF	Thrombosed fistula on USG On 2D Echo mild improvement on Ejection fraction
3	A-V fistula (brachio-cephalic) with distal digital vessels ischemia	fingers blackening with tingling	to block fistula I/v/o steal phenomenon	venous access	type 2	nil	improvement of digital ischemia	
4	Abernathy syndrome with recurrent rectal bleed	rectal bleeding intermittent	to block the Porto-venous fistulous communication	venous access as well as portal access	type 2	foaming sclerosant	mild improvement in rectal symptoms initially but no significant improvement on later f/u	Repeat of intermittent rectal bleeding No intervention done.
5	portal hypertension with recurrent GI bleeding due to varices	recurrent hematemesis and malenae	to block the engorged paraumbilical vein	percutaneous venous access and a long sheath from hepatic vein through TIPSS stent for control	type 2	gel foam	bleeding from percutaneous paraumbilical veins due to distension	Thrombosed paraumbilical vein on USG , Persistent ascites No fresh complaints
6	parent vessel occlusion of ICA I/v/o peri operative injury during JNA removal	sudden hypotension	to prevent perivascular leak	arterial access	type 2	detachable coils	nil	Lost to follow up
7	Splenic artery pseudoaneursym with HB drop for coiling with plug insertion	Persistent GI bleed with Hb drop	Large aneurysm with tortuous artery post coiling due to persistent filling of aneurysm	Arterial access	Type 2	Pushable coils	nil	CECT revealed Thrombosed aneurysm with Splenic infarcts. Persistent low Hb due to hypersplenism No hematemesis
8	Massive hematemesis due to gastro-esophageal varices in portal hypertension	Massive Hb drop with blood aspirate in the NG tube	To prevent sclerosant migration in the renal vein	Venous access	Type 2	Gel foam	nil	Lost to follow up
9	Massive gastric bleeding noted during gastroscopy during second attempt made for glu injection for varices	Hb repeatedly dropped with malenae episodes	To prevent sclerosant migration in left gastric and non targetedembolization	Venous access	Type 2	Gel foam	nil	
10	Massive retroperitoneal bleed with Hb drop in a case of incidental left Renal hyper vasculartumor with Injury to left lumbar region	Hb drop with patient unstable to be taken to operation table	To prevent additional bleeding and make patient vitally stable	Arterial access	Type 1	Coils	Nil	Patient lost to follow-up

Table 2. Clinical Cases presenting to the department of Radiology at LTMGH, Sion

CASE 1[Fig 1]:

20Y/F, with C/O hemoptysis since 5-6 yrs., each episode 30-40 ml Contrast CT showed a lung opacity with arterial supply directly from the aorta S/O Pulmonary Sequestration

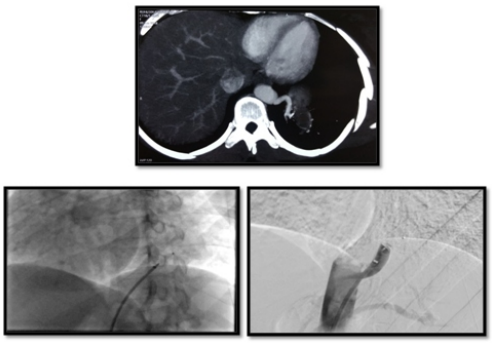


Fig 1. Pulmonary sequestration (top); vascular plug deployment (bottom left); post vascular plug deployment (bottom right)

CASE 2 [Fig 2]:

A 3.5 Yr/M with complaints of intermittent rectal bleeding;

Contrast CT shows: Prominent dilated vein at the confluence of portal and splenic v; a dilated IMV (10mm) with a dilated superior rectal vein and internal iliac vein.

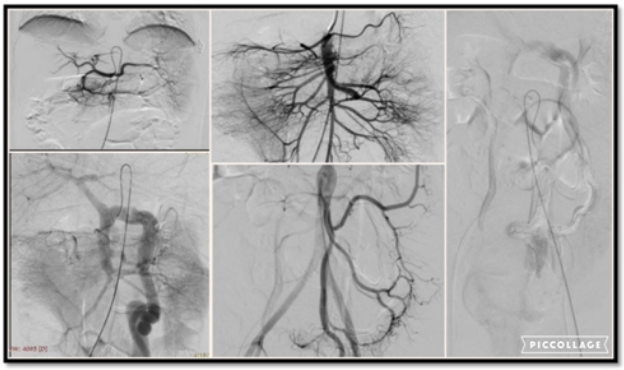


Fig 2. Demonstrating closure of the porto-systemic shunt by AVP and treatment of the dilated venous channels by injection of sclerosant. Post –procedure early and delayed images of the SMA were documented which revealed no-collateral filling.

CASE 3 [Fig 3]:

15Y / M with right nasal block due to JNAF was referred for pre-operative embolization however during excision developed bleeding due to inadvertent ICA injury. Parent vessel occlusion was done with vascular plug and coils.

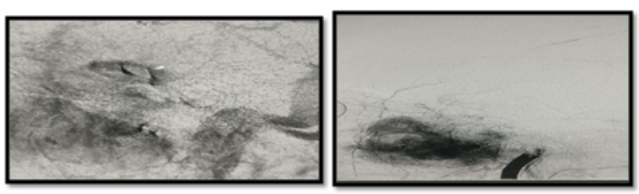


Fig. 3. Shows leak of contrast in the pituitary fossa in cerebral angiogram (left); post plug deployment in the ICA with absence of blush and collateral filling from contralateral ICA (right)

CASE 4 [Fig 4]:

20 Y/M, K/C/O CKD on thrice a week dialysis now Came with c/c of high output cardiac failure

Closure of the A-V fistula by vascular plug with dialysis through permacath

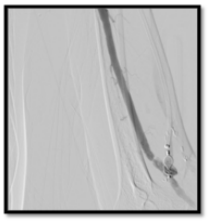


Fig. 4. Closure of venous side of brachiocephalic fistula using AVP for a patient presenting with high output cardiac failure.

CASE 5 [Fig 5]:

A case of renal transplant on immunosuppression with left brachio-cephalic fistula causing significant distal arterial steal phenomenon and digital ischemia. Patient was referred for fistula closure.

Fig 5. Fistulogram showing steal with no distal flow (top left); Compression of venous segment demonstrating forward distal arterial flow (top right); Insertion of vascular plug in fistula (bottom left); Arteriogram showing good distal flow post plug deployment (bottom right)

CASE 6 [Fig 6]:

45Y/M patient with liver cirrhosis presenting with portal hypertension and large periportal and perigastric collaterals. TIPSS shunt created to reduce portal hypertension along with vascular plug insertion for the paraumbilical collateral.

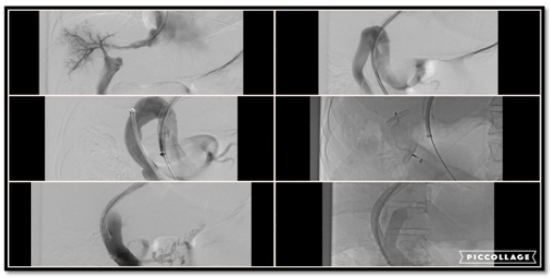


Fig 6. Portogram via transjugular approach (top left); Portogram with catheter in main portal vein (top right); Catheter in paraumbilical vein (middle row left); Vascular plug in paraumbilical vein (middle row right); Portogram post plug insertion with no retrograde flow (bottom left); TIPSS stent insertion (bottom right)

CASE 7 [Fig 7]:

44 Y/F, came with complaints of persistent GI bleed with Hb drop , CT angiogram revealed a large 5 x 6 cm pseudoaneurysm arising from mid splenic artery.

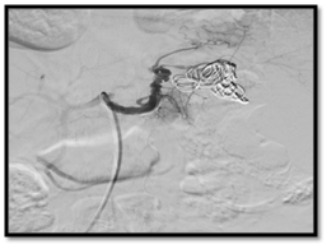


Fig 7. Plug deployment in the splenic artery with complete occlusion of distal circulation and pseudoaneurysm

CASE 8 [Fig 8]:

K/C/O Renal cell carcinoma with persistent bleeding came to emergency with hemoperitoneum. Patient was vitally unstable and was not fit for surgery.

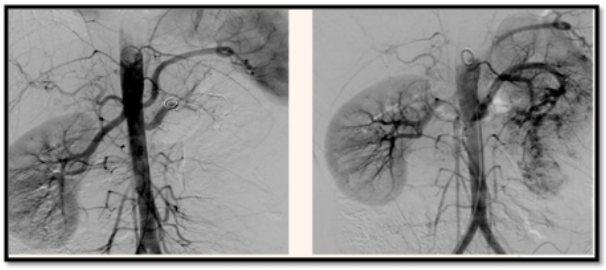


Fig 8. Vascular Tumour seen on angiogram (right). Hence plan was made to occlude the entire left renal artery by using a vascular plug. Post plug insertion angiogram showed no flow in the left renal artery (left). Patient was immediately operated and stable post-operative.

VIII) CONCLUSION:

Amplatzer vascular plugs are versatile occlusion devices which can be used in a wide spectrum of clinical scenarios with very high technical success rate and fewer complications and procedural time.

These embolic agents have higher success rates in treatment of high flow vascular malformations and lesions as compared to other embolic agents used alone and are helpful in primary as well as adjunct treatment in such cases.

IX] ACKNOWLEDGMENT:

Dr. Anagha Joshi, Prof & HOD, Department of Radiology, LTMG Hospital for her constant support and guidance.

References

1-6. Lopera JE. The Amplatzer Vascular Plug: Review of Evolution and Current Applications. Semin Intervent Radiol. 2015;32(4):356-369. doi:10.1055/s-0035-1564810

7. Wang W, Li H, Tam MD, Zhou D, Wang DX, Spain J. The amplatzer vascular plug: a review of the device and its clinical applications. Cardiovasc Intervent Radiol. 2012;35(4):725-740. doi:10.1007/s00270-012-0387-z

8. Zhu, Xiaoli & Tam, Matthew & Pierce, Gregory & Mclennan, Gordon & Sands, Mark & Lieber, Michael & Wang, Weiping. (2011). Utility of the Amplatzer Vascular Plug in Splenic Artery Embolization: A Comparison Study with Conventional Coil Technique. Cardiovascular and interventional radiology. 34. 522-31. 10.1007/s00270-010-9957-0.

9. Rimon, Uri et al. "Amplatzer Vascular Plug: expanding the applications spectrum." Cardiovascular and interventional radiology vol. 31 Suppl 2 (2008): S84-7. doi:10.1007/s00270-007-9042-5

10. White, H A, and S J Travis. "The Amplatzer vascular plug." Cardiovascular and interventional radiology vol. 31, 2 (2008): 448-9. doi:10.1007/s00270-007-9259-3

11. Dorenberg, Eric J et al. "Recurrent rupture of a hypogastric aneurysm caused by spontaneous recanalization of an Amplatzer vascular plug." Journal of vascular and interventional radiology: JVIR vol. 17, 6 (2006): 1037-41. doi:10.1097/01.RVI.0000222821.56922.03

12. Lopera, Jorge E. "The Amplatzer Vascular Plug: Review of Evolution and Current Applications." Seminars in interventional radiology vol. 32, 4 (2015): 356-69. doi:10.1055/s-0035-1564810

13. Pech M, Mohnike K, Wieners G, et al. Advantages and disadvantages of the Amplatzer Vascular Plug IV in visceral embolization: report of 50 placements. Cardiovasc Intervent Radiol. 2011;34(5):1069-1073. doi:10.1007/s00270-011-0150-x

14. Sheridan, Bennett et al. "Reconfiguration of the Amplatzer Vascular Plug II 5 months after occlusion of venovenous collateral in a bidirectional cavopulmonary circulation." Catheterization and cardiovascular interventions: official journal of the Society for Cardiac Angiography & Interventions vol. 75, 6 (2010): 857-60. doi:10.1002/ccd.22459

15. Maleux G, Rega F, Heye S, Troost E, Budts W. Asymptomatic migration of a first-generation AMPLATZER vascular plug into the abdominal aorta: conservative management may be an option. J Vasc Interv Radiol. 2011;22(4):569-570. doi:10.1016/j.jvir.2010.11.033

16. Hart JL, Aldin Z, Braude P, Shovlin CL, Jackson J. Embolization of pulmonary arteriovenous malformations using the Amplatzer vascular plug: successful treatment of 69 consecutive patients. Eur Radiol. 2010;20(11):2663-2670. doi:10.1007/s00330-010-1851-2

17. Abdel Aal AK, Hamed MF, Biosca RF, Saddekni S, Raghuram K. Occlusion time for Amplatzer vascular plug in the management of pulmonary arteriovenous malformations. AJR Am J Roentgenol. 2009;192(3):793-799. doi:10.2214/AJR.08.1534

18. Trerotola SO, Pyeritz RE. Does use of coils in addition to amplatzer vascular plugs prevent recanalization?. AJR Am J Roentgenol. 2010;195(3):766-771. doi:10.2214/AJR.09.3953

19. Rabellino M, Serra M, Peralta O, et al. Early experience with the AMPLATZER vascular plug IV for the occlusion of pulmonary arteriovenous malformations. J Vasc Interv Radiol. 2014;25(9):1333-1337. doi:10.1016/j.jvir.2014.05.016

20. Zhu X, Tam MD, Pierce G, et al. Utility of the Amplatzer Vascular Plug in splenic artery embolization: a comparison study with conventional coil technique. Cardiovasc Intervent Radiol. 2011;34(3):522-531. doi:10.1007/s00270-010-9957-0

21. Vogl TJ, Pegios W, Balzer JO, Lobo M, Neuhaus P. Arterielles steal-syndrom bei patienten nach lebertransplantation: transarterielle embolization von A. lienalis oder A. gastroduodenalis [Arterial steal syndrome in patients after liver transplantation: transarterial embolization of the splenic and gastroduodenal arteries]. Rofo. 2001 Oct;173(10):908-13. German. doi: 10.1055/s-2001-17592. PMID: 11588678.

22. Kouvelos GN, Koutsoumpelis A, Peroulis M, Matsagkas M. In endovascular aneurysm repair cases, when should you consider internal iliac artery embolization when extending a stent into the external iliac artery?. Interact Cardiovasc Thorac Surg. 2014;18(6):821-824. doi:10.1093/icvts/ivu042

23. Wong S, Greenberg RK, Brown CR, Mastracci TM, Bena J, Eagleton MJ. Endovascular repair of aortoiliac aneurysmal disease with the helical iliac bifurcation device and the bifurcated-bifurcated iliac bifurcation device. J Vasc Surg. 2013;58(4):861-869. doi:10.1016/j.jvs.2013.02.033

24. Fernández-Alonso L, Fernández-Alonso S, Grijalba FU, et al. Endovascular treatment of abdominal aortic aneurysms involving iliac bifurcation: role of iliac branch graft device in prevention of buttock claudication. Ann Vasc Surg. 2013;27(7):851-855. doi:10.1016/j.avsg.2012.08.012

25. Chun JY, Mailli L, Abbasi MA, et al. Embolization of the internal iliac artery before EVAR: is it effective? Is it safe? Which technique should be used?. Cardiovasc Intervent Radiol. 2014;37(2):329-336. doi:10.1007/s00270-013-0659-2

26. Wang W, Li H, Tam MD, Zhou D, Wang DX, Spain J. The amplatzer vascular plug: a review of the device and its clinical applications. Cardiovasc Intervent Radiol. 2012;35(4):725-740. doi:10.1007/s00270-012-0387-z

27. Ward, Thomas J., Michael L. Marin, and Robert A. Lookstein. "Embolization of a Giant Arterioportal Fistula Requiring Multiple Amplatzer Vascular Plugs." Journal of Vascular Surgery 62, no. 6 (December 1, 2015): 1636–39. https://doi.org/10.1016/j.jvs.2014.04.031.

28. Bulla K, Hubich S, Pech M, Löwenthal D, Ricke J, Dudeck O. Superiority of proximal embolization of the gastroduodenal artery with the Amplatzer vascular plug 4 before yttrium-90 radioembolization: a retrospective comparison with coils in 134 patients. Cardiovasc Intervent Radiol. 2014;37(2):396-404. doi:10.1007/s00270-013-0684-1

29. Dudeck O, Bulla K, Wieners G, et al. Embolization of the gastroduodenal artery before selective internal radiotherapy: a prospectively randomized trial comparing standard pushable coils with fibered interlock detachable coils. Cardiovasc Intervent Radiol. 2011;34(1):74-80. doi:10.1007/s00270-010-9845-7

30. Paz-Fumagalli R, Crain MR, Mewissen MW, Varma RR. Fatal hemodynamic consequences of therapeutic closure of a transjugular intrahepatic portosystemic shunt. J Vasc Interv Radiol. 1994;5(6):831-834. doi:10.1016/s1051-0443(94)71616-x

31. Gwon DI, Ko GY, Yoon HK, et al. Gastric varices and hepatic encephalopathy: treatment with vascular plug and gelatin sponge-assisted retrograde transvenous obliteration--a primary report. Radiology. 2013;268(1):281-287. doi:10.1148/radiol.13122102

32. Ringe KI, Weidemann J, Rosenthal H, et al. Transhepatic preoperative portal vein embolization using the Amplatzer Vascular Plug: report of four cases. Cardiovasc Intervent Radiol. 2007;30(6):1245-1247. doi:10.1007/s00270-007-9158-7

33. Bent CL, Low D, Matson MB, Renfrew I, Fotheringham T. Portal vein embolization using a nitinol plug (Amplatzer vascular plug) in combination with histoacryl glue and iodinized oil: adequate hypertrophy with a reduced risk of nontarget embolization. Cardiovasc Intervent Radiol. 2009;32(3):471-477. doi:10.1007/s00270-009-9515-9

34. Grosse U, Brechtel K, Ketelsen D, et al. Portal vein recanalization and embolization of the transsplenic puncture tract using an Amplatzer® vascular plug: a case report. BMC Res Notes. 2015;8:193. Published 2015 May 8. doi:10.1186/s13104-015-1138-4

35. Bittles MA, Hoffer EK. Gonadal vein embolization: treatment of varicocele and pelvic congestion syndrome. Semin Intervent Radiol. 2008;25(3):261-270. doi:10.1055/s-0028-1085927

36. Farrell TA, Wallace M, Hicks ME. Long-term results of transrenal ureteral occlusion with use of Gianturco coils and gelatin sponge pledgets. J Vasc Interv Radiol. 1997;8(3):449-452. doi:10.1016/s1051-0443(97)70587-6

37. Schild HH, Günther R, Thelen M. Transrenal ureteral occlusion: results and problems. J Vasc Interv Radiol. 1994;5(2):321-325. doi:10.1016/s1051-0443(94)71494-9

38. Ramakrishnan, Sivasubramanian. (2015). Vascular plugs - A key companion to Interventionists - 'Just Plug it'. Indian heart journal. 67. 399-405. 10.1016/j.ihj.2015.07.001