Case Report

Access this article online

Quick Response Code:

Website: http://www.braincirculation.org

DOI: 10.4103/bc.bc_18_19

Therapeutic occlusion of the vertebral artery using a new penumbra occlusion device system and ruby coils (penumbra): A technical note

Jay P. Kinariwala[1], Gary B. Rajah[2], Rahul Vaidya[3], Sandra Narayanan[1,2]

Abstract:

There are several methods to achieve the therapeutic sacrifice of the vessel, coiling brings the most commonly used. Penumbra occlusion device (POD) system is a newer modality for therapeutic large vessel occlusion, and it is the Food and Drug Administration approved only for peripheral vessels. We report a case where therapeutic vertebral artery (VA) occlusion was achieved with the POD system and Ruby coils for the first time. A patient was diagnosed with a new malignant-appearing tumor of the cervical spine. A conventional angiogram showed multiple tiny arterial feeders from the VA beyond scope of coil/onyx embolization, so we performed a balloon occlusion test followed by therapeutic sacrifice of the VA. A successful VA occlusion was achieved with significant reduction in the tumor blush, followed by open resection of the tumor. The patient had favorable postoperative course and without any neurological symptoms attributed to the VA occlusion.

Keywords:

Cervical tumor, coil embolization, penumbra, penumbra occlusion device, ruby coils, vertebral artery sacrifice

Introduction

Therapeutic occlusion of a vessel is a preferred approach to the treatment of certain aneurysms,[1,2] arteriovenous malformations (AVMs),[3,4] arteriovenous fistulas (AVFs), and presurgical strategy to reduce blood flow to a tumor.[4] Many surgical and endovascular techniques and devices currently exist with proven efficacy and favorable safety profile. Open surgical ligation and endovascular embolization with either embolic agent[5] or coils[6] are among the most commonly practiced. Recently, Penumbra, Inc. has introduced a novel method of endovascular vessel occlusion. Penumbra occlusion device (POD) system comprises two components, POD® and POD® packing coil. Unlike conventional vascular plugs, POD is highly trackable, and vessel sacrifice solution is delivered through high-flow microcatheter. POD can be used for arterial and venous embolization in the arteries and veins in the peripheral vasculature. The POD uses proprietary technology to anchor in high-flow vessels. Proximal to the robust anchoring segment, the coil transitions into a soft packing segment, creating a dense occlusion at the point of deployment. POD packing coil is a soft, shapeless coil able to conform to a variety of vessel sizes. It packs densely behind a POD or Ruby® coil backstop and is available in various length options ranging from 15 to 60 cm. Although it has been approved by the Food and Drug Administration to treat intracranial aneurysms, neurovascular AVM and AVF,

Departments of [1]Neurology, [2]Neurosurgery and [3]Orthopedics, Wayne State University, Detroit, MI, USA

Address for correspondence:
Dr. Jay P. Kinariwala, 4201 St Antoine, University Health Center 8A, Detroit, MI 48201, USA.
E-mail: jaykinariwala@wayne.edu

Submission: 30-07-2019
Accepted: 15-10-2019
Published:18-02-2020

How to cite this article: Kinariwala JP, Rajah GB, Vaidya R, Narayanan S. Therapeutic occlusion of the vertebral artery using a new penumbra occlusion device system and ruby coils (penumbra): A technical note. Brain Circ 2020;6:52-6.

and peripheral vessel embolization, to our knowledge, POD has not been utilized in any cervical vessel occlusion procedure for cervical/spinal tumors.

Case Report

A patient with a known remote history of Hodgkin's lymphoma and giant cell tumor of the right ischium was diagnosed with a new malignant-appearing mass in the lung on computed tomography of the chest. Further investigations with magnetic resonance imaging-cervical spine revealed 1.5-cm enhancing soft-tissue lesion in the C4 vertebral body (VB), causing neural foraminal stenosis at the adjacent levels on the left with cord compression [Figure 1a and b]. Given progressive symptoms and solitary mass, a decision was made to perform surgical resection. Conventional angiogram revealed C4 VB avid tumor blush with contrast from the left, more than right vertebral injection [Figure 1c and d]. The arterial feeders were small caliber short pedicles directly extending from the vertebral artery (VA) which were beyond embolization capability.

Considering possible sacrifice of the left VA during the resection, a balloon test occlusion (BTO) was performed to assess collateral circulation from the contralateral VA [Figure 2a]. A 6-F femoral artery access was gained by a usual technique. At first, 6-F ENVOY® 95 cm guide catheter® (DuPuy Synthes) was placed with its tip in V2 segment of the left VA, below the C4 vertebra. A robust guide is needed as the POD system is a 020 coil system. Then, 5 mm × 15 mm HyperGlide® (Covidien) balloon catheter was wedged into the V2/3 segment, as the VA was initially large enough to accompany an inflated balloon in the V2 segment just distal to the C4 blush without full occlusion. Once full occlusion was achieved at V2/3 segment, noted by the absence of distal intracranial contrast opacification, the balloon catheter was kept inflated for the next 30 min, while maintaining systolic blood pressure <140 mmHg, and neurological examination was performed at every 3–5 min intervals to assess neurological deficits. We examined for orientation, comprehension, naming, repetition, calculation, pupillary reaction, gaze examination, visual field testing, facial weakness, hearing, vertiginous sensations, and hemibody weakness/numbness. Based on our observation, patients vulnerable to ischemia due to vertebral occlusion usually decompensate earlier in the procedure. No definitive neurological deficit was observed. Simultaneous injection from the contralateral VA was performed which demonstrated adequate reflux without any perfusion deficit. Hence, balloon occlusion test confirmed no neurological deficit if the left VA was needed to be sacrificed.

After completion of the BTO, the balloon was deflated and removed. A PX Slim 027 microcatheter® (Penumbra) was navigated past the C4 blush into the V2 segment over a Synchro 2 wire® (Stryker). A 4 mm × 300 mm POD (anchoring) was then deployed from the PX Slim microcatheter, starting with the microcatheter parked 1 cm proximal from the desired area of POD placement. The first POD was packed as tight as possible with forwarding microcatheter pressure during deployment after the anchoring loop. The first POD was nonocclusive

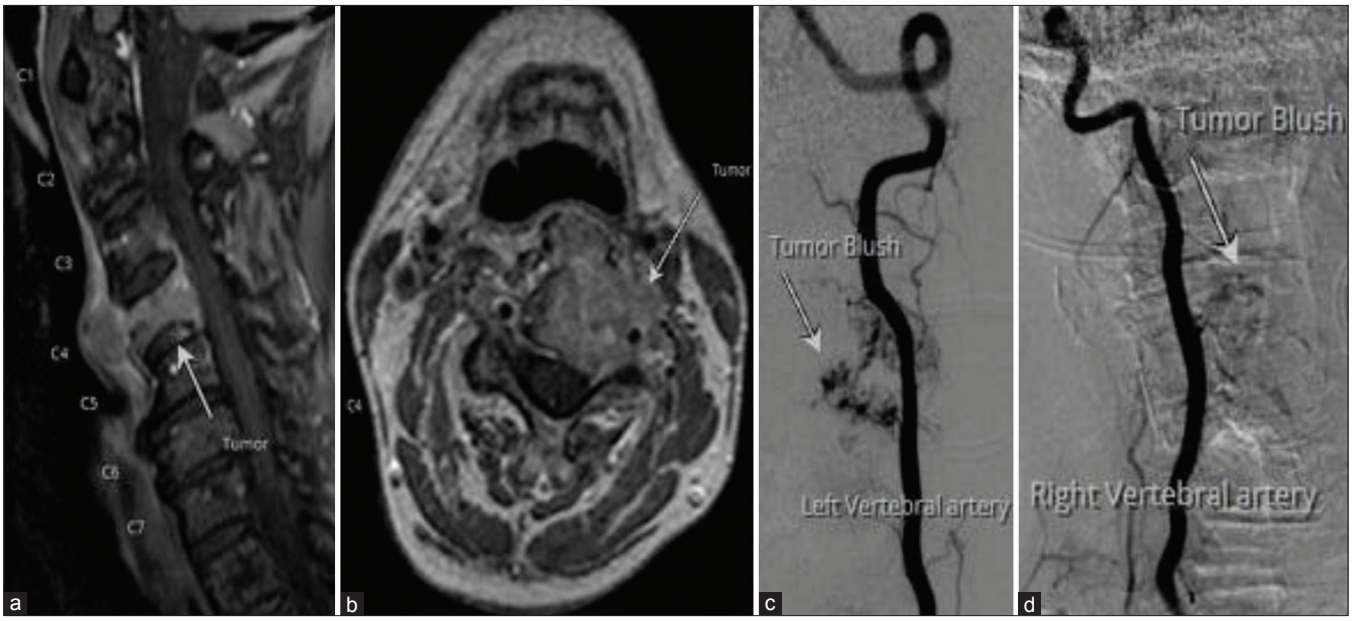

Figure 1: Initial pretreatment images. (a and b) Magnetic resonance imaging cervical spine with contrast sagittal and axial sections, showing C4 vertebral body tumor with neural foraminal stenosis and cord compression at C3–C4 and C4–C5 levels. (c and d) Diagnostic angiogram showing left and right vertebral injection with C4 vertebral body tumor blush more from the left than the right

distally [Figure 2b]. A 60 mm shapeless POD packing coil was then used with forwarding microcatheter pressure to ensure tight packing which was finally achieved by several attempts of resheating and redeployment in the stenotic portion of the VA. The second 30 cm POD packing coil was placed afterward followed by a 3 cm × 20 cm Ruby coil® (Penumbra) which was used to cap the last major tumor feeder [Figure 2c]. Total left VA occlusion was achieved demonstrated by the absence of C4 VB tumor blush, and the right VA injection demonstrated good filling of the posterior circulation without any perfusion deficit and stasis of the contrast in the V4 segment of the left VA [Figure 2d]. The patient was started on aspirin 81 mg to prevent stump emboli.

The following day, the patient was taken to the operating room for tumor resection which was achieved successfully. Total blood loss during the entire procedure was approximately only 300 cc which is significantly less than expected. The VB defect was reconstructed with polymethylmethacrylate followed by anterior plating [Figure 3a and b]. The patient recovered from anesthesia with the baseline neurological function and no immediate postoperative complication. The histology of the tumor revealed poorly differentiated carcinoma.

Discussion

Preoperative embolization of tumors to reduce vascularity and intraoperative blood loss has been known for a long time.[7] Over the period of time, with the advancement of technology, various techniques have been developed to achieve maximum embolization of the arterial feeders to the tumor as previously. Preoperative embolization has been established a safe procedure to perform in a retrospective study of 100 cases;[8] however, no large randomized control trial exists at this time. In retrospect analysis of the various methods used to sacrifice the artery, we found several articles emphasizing on different techniques [Table 1]. As illustrated in the table, coils were used most commonly (214 cases) followed by detachable balloons (64 cases), onyx (44 cases), ligation (23 cases), vascular plug (20 cases), and clipping (2 cases). We used a novel technique in this patient, which, to our knowledge, has never been used for this purpose. POD is a comprised POD and POD packing coils.[24]

Unlike conventional vascular plugs, POD is highly trackable, and vessel sacrifice is achieved through a high-flow microcatheter. POD can be used in arterial and venous embolizations. The POD uses proprietary

Table 1 : Overall trend of endovascular methods used for vessel sacrifice

First author	Vessel sacrificed	Endovascular method used	Cases
Carlson[9]	Vertebral	Vascular plug	12
Madaelil[10]	Vertebral (10) and PICA (2)	Coils	12
Ogungbemi[11]	Vertebral	Balloons	18
Munich[12]	Vertebral	Coil and Onyx	2
Zoarski[13]	Vertebral	Coils (55), balloons (4)	59
Robinov[14]	Vertebral	Coils and balloons	26
Hoshino[15]	Vertebral	Ligation	15
Drake[16]	Vertebral	Ligation	8
Barr[17]	Vertebral (11), ICA (6) and CCA (2)	Coils	19
Tanaka[18]	Vertebral	Balloon (2) and Clip (2)	4
Leibowitz[2]	Vertebral	Coils	13
Herrera[19]	Vertebral	Coils (2) and Balloon (16)	18
Chalouhi[20]	Vertebral (15) and ICA (26)	Coils and Onyx	41
Grigoryan[21]	Vertebral	Coils	2
Ong[22]	Vertebral (5) and ICA (3)	Vascular plug	8
Sorteberg[23]	Vertebral (7) and ICA (35)	Coils	42

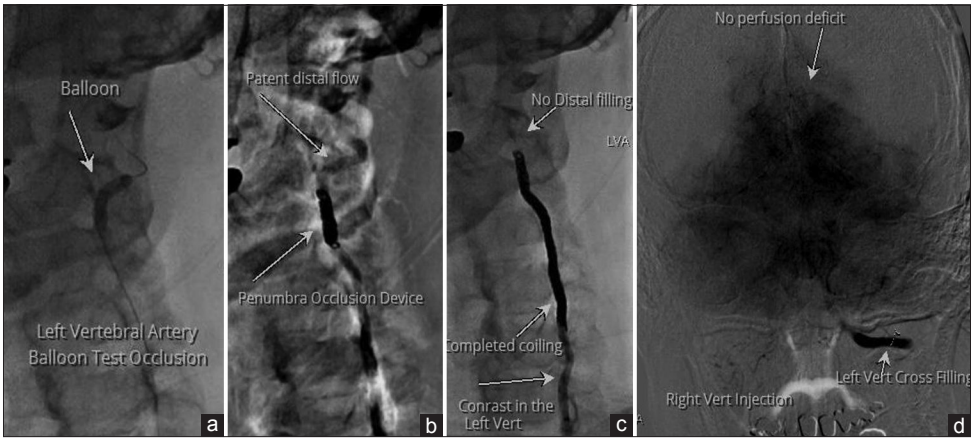

Figure 2: Treatment images. (a) Balloon test occlusion with the balloon inflated in the left vertebral artery. (b) Penumbra occlusion device coils deployed with the evidence of persistent distal contrast opacification. (c) Ruby coils deployed and complete occlusion of the left vertebral artery. (d) Right vertebral artery injection showing no perfusion deficit and left V4 segment cross filling

Table 2: Reported use of POD system in endovascular field

First author	Type of study	Vessels sacrificed	Number of cases	Complications
Jambon[25]	Pilot	Splenic artery	12	2 cases of abcess
Jambon[26]	Case series	Top of Form 16 splenic arteries 11 renal arteries 4 mesenteric arteries 3 arteriovenous fistulae 1 iliac artery 1 gonadal veinBottom of Form	37	1 case of post embolic syndrome and 1 case of splenic abscess
Petitpierre[29]	Case series	Splenic artery	4	None
Ashour[27]	Case series	Spinal epidural plexus	2	None
Spiotta[28]	Experimental case series in swine	Common carotid artery	8	None

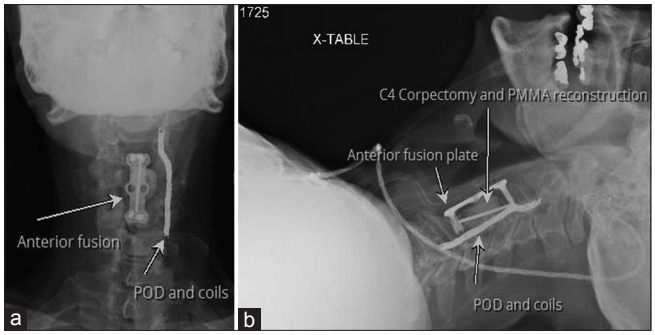

Figure 3: Postoperative images. (a and b) Anterior fusion plate and penumbra occlusion device coils in anteroposterior and lateral view

technology to anchor in high-flow vessels. Proximal to the robust anchoring segment, the coil transitions into a soft packing segment, creating a dense mechanical occlusion at a point of deployment, thus creating dense occlusion in a short segment. POD packing coil is a soft, shapeless coil able to conform to a variety of vessel sizes ranging 3.25–8 mm in diameter that packs densely behind a POD or Ruby coil backstop and provides total occlusion of the vessel.[25] Ruby coil is a large volume coil, available in two softness levels, which packs densely due to its softness, usually delivered through high-flow microcatheters.

Thus far, POD is only used in peripheral vessels, and no report, to date, exists of POD being used in humans to sacrifice cerebral vasculature. In a comprehensive literature search on PubMed, we found a total of five articles in which POD was utilized [Table 2]. Jambon *et al*.[25] reported a comparison between vascular plug and POD system which demonstrated shorter intervention duration, shorter fluoroscopy time, and 100% efficacy as compared to vascular plug and conventional coils. Another case series demonstrated similar results in 36 patients without any migration of the coils; however, two cases of abscess were reported due to the POD.[26] Spiotta *et al*. reported eight carotid artery sacrifices in swine using POD, demonstrating its shorter procedural duration, low cost, safety, and efficacy.[27] Finally, Ashour *et al*. reported two pediatric cases of lower vertebral–spinal AVFs treated successfully with POD without any complications.[28]

POD system is a newer and effective method of treating various intracranial pathologies. Here, we report a case of therapeutic VA sacrifice using the POD system successfully without any procedure-related complication with shorter procedural and fluoroscopy time and lower cost than other conventional methods, which makes its use even more promising.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

References

1. Roy D, Milot G, Raymond J. Endovascular treatment of unruptured aneurysms. Stroke 2001;32:1998-2004.
2. Leibowitz R, Do HM, Marcellus ML, Chang SD, Steinberg GK, Marks MP. Parent vessel occlusion for vertebrobasilar fusiform and dissecting aneurysms. AJNR Am J Neuroradiol 2003;24:902-7.
3. Gifford HS, Sepetka I, Deem M, Dieck M. Devices and Methods for Treating Vascular Malformations: US Patent 6375668; 2002.
4. Barton PP, Waneck RE, Karnel FJ, Ritschl P, Kramer J, Lechner GL. Embolization of bone metastases. J Vasc Interv Radiol 1996;7:81-8.
5. Panagiotopoulos V, Gizewski E, Asgari S, Regel J, Forsting M, Wanke I, *et al*. Embolization of intracranial arteriovenous malformations with ethylene-vinyl alcohol copolymer (Onyx). AJNR Am J Neuroradiol 2009;30:99-106.
6. Eckard DA, O'Boynick PL, McPherson CM, Eckard VR, Han P, Arnold P, *et al*. Coil occlusion of the parent artery for treatment of symptomatic peripheral intracranial aneurysms. AJNR Am J Neuroradiol 2000;21:137-42.
7. Broaddus WC, Grady MS, Delashaw JB Jr., Ferguson RD, Jane JA. Preoperative superselective arteriolar embolization: A new approach to enhance resectability of spinal tumors. Neurosurgery 1990;27:755-9.
8. Wilson MA, Cooke DL, Ghodke B, Mirza SK. Retrospective analysis of preoperative embolization of spinal tumors. AJNR Am J Neuroradiol 2010;31:656-60.
9. Carlson AP, Abbas M, Hall P, Taylor C. Use of a polytetrafluoroethylene-coated vascular plug for focal intracranial parent vessel sacrifice for fusiform aneurysm treatment. Oper Neurosurg (Hagerstown) 2017;13:596-602.

10. Madaelil TP, Wallace AN, Chatterjee AN, Zipfel GJ, Dacey RG Jr., Cross DT 3rd, *et al.* Endovascular parent vessel sacrifice in ruptured dissecting vertebral and posterior inferior cerebellar artery aneurysms: Clinical outcomes and review of the literature. J Neurointerv Surg 2016;8:796-801.
11. Ogungbemi A, Elwell V, Choi D, Robertson F. Permanent endovascular balloon occlusion of the vertebral artery as an adjunct to the surgical resection of selected cervical spine tumors: A single center experience. Interv Neuroradiol 2015;21:532-7.
12. Munich SA, Tan LA, Keigher KM, Chen M, Moftakhar R, Lopes DK, *et al.* The pipeline embolization device for the treatment of posterior circulation fusiform aneurysms: Lessons learned at a single institution. J Neurosurg 2014;121:1077-84.
13. Zoarski GH, Seth R. Safety of unilateral endovascular occlusion of the cervical segment of the vertebral artery without antecedent balloon test occlusion. AJNR Am J Neuroradiol 2014;35:856-61.
14. Rabinov JD, Hellinger FR, Morris PP, Ogilvy CS, Putman CM. Endovascular management of vertebrobasilar dissecting aneurysms. AJNR Am J Neuroradiol 2003;24:1421-8.
15. Hoshino Y, Kurokawa T, Nakamura K, Seichi A, Mamada T, Saita K, *et al.* A report on the safety of unilateral vertebral artery ligation during cervical spine surgery. Spine (Phila Pa 1976) 1996;21:1454-7.
16. Drake CG. Ligation of the vertebral (unilateral or bilateral) or basilar artery in the treatment of large intracranial aneurysms. J Neurosurg 1975;43:255-74.
17. Barr JD, Lemley TJ. Endovascular arterial occlusion accomplished using microcoils deployed with and without proximal flow arrest: Results in 19 patients. AJNR Am J Neuroradiol 1999;20:1452-6.
18. Tanaka K, Waga S, Kojima T, Kubo Y, Shimizu T, Niwa S, *et al.* Non-traumatic dissecting aneurysms of the intracranial vertebral artery. Report of six cases. Acta Neurochir (Wien) 1989;100:62-6.
19. Herrera DA, Vargas SA, Dublin AB. Endovascular treatment of traumatic injuries of the vertebral artery. AJNR Am J Neuroradiol 2008;29:1585-9.
20. Chalouhi N, Starke RM, Tjoumakaris SI, Jabbour PM, Gonzalez LF, Hasan D, *et al.* Carotid and vertebral artery sacrifice with a combination of onyx and coils: Technical note and case series. Neuroradiology 2013;55:993-8.
21. Grigoryan M, Cordina SM, Khatri R, Hassan AE, Rodriguez GJ. Vessel occlusion using a single long oversized coil in vertebral artery dissection: A technical note. J Neurointerv Surg 2013;5:e11.
22. Ong CK, Lam DV, Ong MT, Power MA, Parkinson RJ, Wenderoth JD, *et al.* Neuroapplication of amplatzer vascular plug for therapeutic sacrifice of major craniocerebral arteries: An initial clinical experience. Ann Acad Med Singapore 2009;38:763-8.
23. Sorteberg A, Bakke SJ, Boysen M, Sorteberg W. Angiographic balloon test occlusion and therapeutic sacrifice of major arteries to the brain. Neurosurgery 2008;63:651-60.
24. Penumbra, Inc. Website. Available from: http://www.penumbrainc.com/peripheral-device/pod-system. [Last accessed on 2018 Dec 12].
25. Jambon E, Hocquelet A, Petitpierre F, Le Bras Y, Marcelin C, Dubuisson V, *et al.* Proximal embolization of splenic artery in acute trauma: Comparison between penumbra occlusion device versus coils or amplatzer vascular plug. Diagn Interv Imaging 2018;99:801-8.
26. Jambon E, Petitpierre F, Brizzi V, Dubuisson V, Le Bras Y, Grenier N, *et al.* Proximal occlusion of medium-sized vessels with the penumbra occlusion device: A study of safety and efficacy. Cardiovasc Intervent Radiol 2017;40:210-5.
27. Spiotta AM, Turner RD, Chaudry MI, Turk AS, Hui FK, Schonholz C, *et al.* Carotid sacrifice with a single penumbra occlusion device: A feasibility study in a swine model. J Neurointerv Surg 2016;8:99-102.
28. Ashour R, Orbach DB. Lower vertebral-epidural spinal arteriovenous fistulas: A unique subtype of vertebrovertebral arteriovenous fistula, treatable with coil and penumbra occlusion device embolization. J Neurointerv Surg 2016;8:643-7.
29. Petitpierre F, Lasserre AS, Tricaud E, Le Bras Y, Dubuisson V, Grenier N, *et al.* Proximal embolization of the splenic artery with a penumbra occlusion device (POD): A novel occlusion technique for blunt splenic injuries. Cardiovasc Intervent Radiol 2016;39:309-12.