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Case Report

Interventional Distal Embolization before Corrective Cervical Spinal Surgery for Posttraumatic Vertebral Artery Occlusion: A Case Report and Review of the Literature

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Objective: A traumatic vertebral artery (VA) injury may result in serious cerebral infarction in the vertebrobasilar area. However, the approach to its diagnosis and the optimal treatment have not yet been established. We present a patient with traumatic occlusion of a unilateral VA due to the multiple cervical spine fractures who required decompression and fixation, in whom the injured VA was coil embolized distal to the occlusion prior to the cervical spine surgery.

Case Presentation: A 47-year-old woman was injured in a car accident and, presented with C6-C7 superior articular process fractures and C2-C3 ossification of the posterior longitudinal ligament (OPLL) with sensory hypoesthesia and motor palsy of the left upper limb. MRA showed left VA occlusion and patent contralateral VA. DSA showed left VA occlusion from the origin to C5/6 and its antegrade flow by collateral orthodromic circulation from the muscular branches. To prevent vertebrobasilar infarction due to migration of the thrombus from the occluded VA which was recanalized by surgical fixation, distal coil embolization of the injured VA by navigating a microcatheter through the contralateral VA across the vertebrobasilar junction was performed. Neither ischemic events nor new neurologic symptoms occurred during follow-up.

Conclusion: Preoperative coil embolization to a traumatic VA occlusion can be one of the therapeutic choices to prevent thromboembolic stroke after cervical spine surgery. When the proximal segment of the VA was injured and VA occluded from origin, this treatment strategy is feasible, safe, and effective.

Keywords ▶ traumatic vertebral artery occlusion, endovascular embolization, spinal surgery

Introduction

A vertebral artery (VA) injury associated with blunt cervical spine trauma is not as rare as the past.[1)] When traumatic VA injuries cause ischemic stroke of the cerebellum, brain stem, or posterior cerebral artery region, severe neurological sequelae and mortality can occur.[1)] Thus, in the case of VA-related trauma, early diagnosis by CT, MRI, and DSA is needed. Treatment with an antiplatelet agent and the anticoagulant is recommended to prevent thrombogenesis in the injury artery and distal embolization.[2,3)] Some cases reported fatal thromboembolic infarction of the vertebrobasilar area after cervical spinal correction.[4,5)] Therefore, the efficacy of proximal occlusion of the injured VA by endovascular treatment before surgical repair for the cervical spinal fracture has been reported.[6–8)] However, proximal embolization of the injured VA cannot be performed with a lower cervical spine fracture and the VA occluded from the origin at the subclavian artery. We present herein a case of distal coil embolization of the injured VA to prevent migration of the thrombus from the injured VA after surgical fixation.

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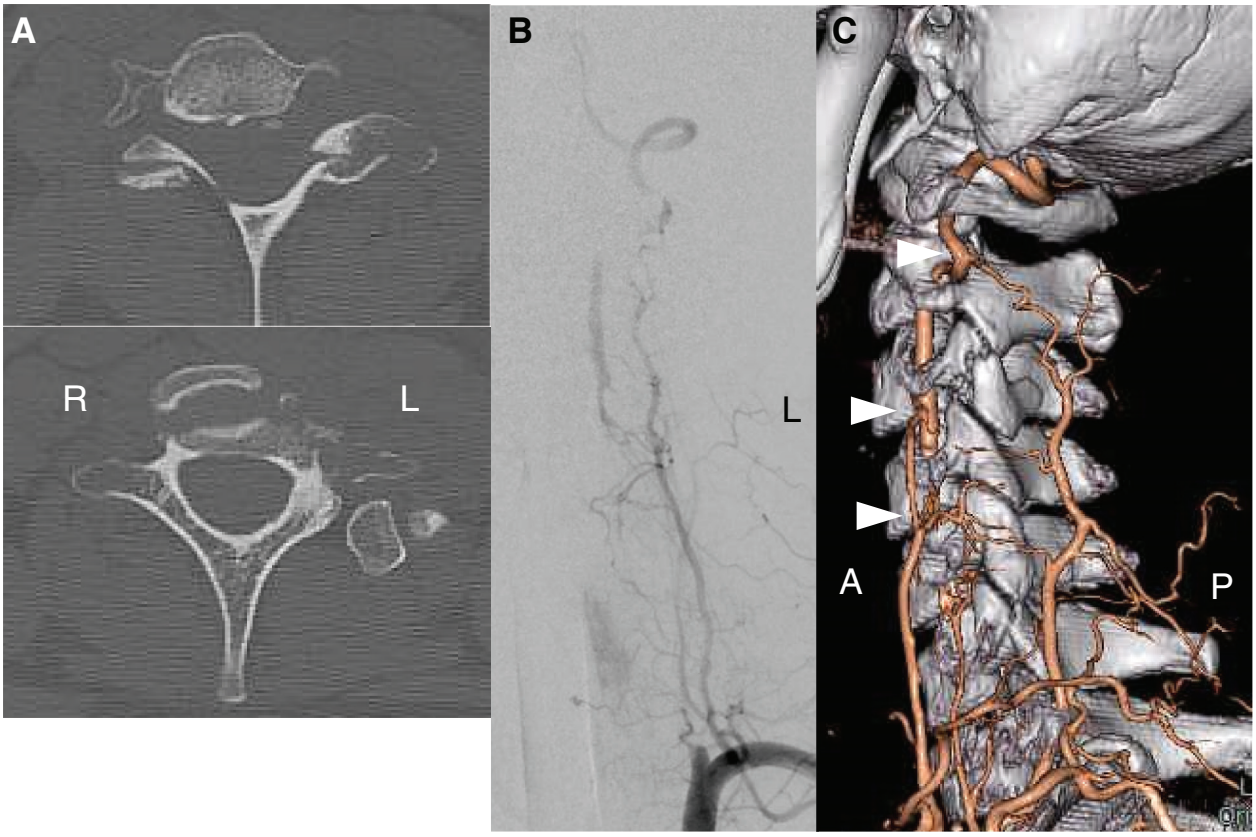

Fig. 1 **(A)** Axial CT of C6 and C7 level image. This CT images show superior articular process fractures of left C6 and C7. **(B)** DSA image of the anterior–posterior view from the left subclavian artery and **(C)** 3D fusion image of DSA of the left subclavian artery and CT. These images show left VA occlusion from the origin to the C5 level and antegrade flow of V3 and V4 by collateral circulation. White arrowheads indicate the inflow of collateral circulation from the muscular branches at C1/2, C3/4, and C4/5. VA: vertebral artery

Case Presentation

A 47-year-old woman was driving in a light car and was overturned in a collision with another car. Though her consciousness remained lucid, she complained of immediate loss of power in her left upper extremity. Her neck was fixed, and she was transferred to the local hospital where cervical spine trauma was suspected. Because of the unavailability of spine specialists, she was transferred to our institution 5 hours after injury.

Clinical assessment in our hospital found a Glasgow Coma Scale of 15, but sensory hypoesthesia and motor palsy (manual muscle testing [MMT] 2-3) of the left elbow, hand, and fingers. CT showed a C7 vertebral body fracture, superior articular process fractures of left C6 and C7, and C2-3 ossification of the posterior longitudinal ligament (OPLL) **(Fig. 1A)**. MRI demonstrated no acute ischemic lesions in the vertebrobasilar area, but MRA and CTA showed occlusion of the left VA. DSA showed left VA occlusion from the origin to the C5 level and antegrade flow of V3 and V4 by collateral orthodromic circulation from the muscular branches at C1/2, C3/4, and C4/5 **(Fig. 1B** and **1C)**. The right VA was patent and flowed into the basilar artery (BA) **(Fig. 2A)**. For the multiple fractures of the cervical spine, cervical decompression and fixation were necessary. However, when the cervical spine is decompressed, and the occluded left VA is recanalized, there is a risk that the thrombus from the injured VA will migrate to the distal part of the VA and BA. Furthermore, it was difficult to embolize on the proximal part of obstruction because the damaged VA occluded from the region of origin. Therefore, distal coil embolization of the injured left VA by navigating a microcatheter through the right VA across the vertebrobasilar junction was performed to prevent migration of the thrombus formed post-surgical fixation 3 days after injury. No preoperative antiplatelet agents were administered. First, a 5-Fr guide catheter Launcher (Medtronic Interventional Vascular, Danvers, MA, USA) was inserted into the right femoral artery and advanced until the tip reached the right VA and a 4-Fr JB2 catheter (Medikit, Tokyo, Japan)

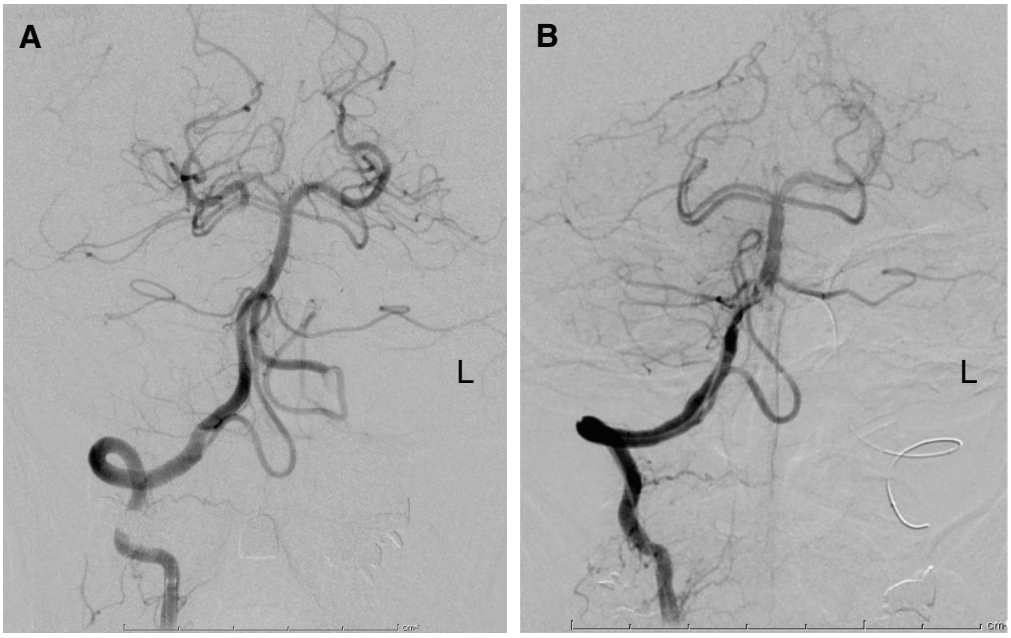

Fig. 2 **(A)** DSA of the anterior–posterior view from the right VA shows retrograde flow down the left VA and PICA. **(B)** A microcatheter is passed from the right VA to the vertebrobasilar junction, and retrograde microcatheterization of the left VA is performed. Microcatheter insertion is displacing the blood vessels in the VA union. PICA: posterior inferior cerebellar artery; VA: vertebral artery

was inserted into the left femoral artery and placed in the left subclavian artery for diagnosis. Heparin was administered prior to placement of the guiding catheter. DSA images showed the same findings on admission and no changes in the left VA occlusion. An Excelsior SL-10 microcatheter (Stryker, Kalamazoo, MI, USA) was navigated over a CHIKAI 0.36-mm (0.014 inch) and CHIKAI10 0.26-mm (0.010 inch) microwire (Asahi Intec, Aichi, Japan) via the right VA into the vertebrobasilar junction, and microcatheterization at the left VA (V2) of the C5 level was performed **(Fig. 2B)**. A total of four hydrogel coils (HydroSoft 3D; Micro Vention, Aliso Viejo, CA, USA) were placed at the C4-5 level to stabilize the coil mesh **(Fig. 3A)**. No procedural complications were encountered. The final post-embolization DSA demonstrated that the right VA was patent, and collateral circulation from muscular branches at C1/2 and C3/4 remained and flowed into V3 and V4 of the left VA and the left posterior inferior cerebellar artery (PICA) **(Fig. 3B)**. Three days after the procedure, posterior fusion with decompression was performed for multiple fractures and OPLL of the cervical spine by spine surgeons in our hospital. There was no migration of the coil mass on the postoperative X-ray examination **(Fig. 4)**, and MRI showed that the left VA remained occluded. Neither ischemic events nor new neurologic symptoms occurred during follow-up.

Discussion

Traumatic VA occlusion is an increasingly recognized complication of traumatic cervical spine injury, with an incidence of approximately 10%, and it is a risk factor for vertebrobasilar ischemia through mechanisms of hemodynamic failure and thromboembolism.[1] When stroke of the vertebrobasilar area occurs, the mortality rate is from 75% to 80%.[1] Biffl et al.[2] reported a cerebrovascular injury scale for the internal carotid arteries and VAs: grade 1, arteriographic appearance of irregularity of the vessel wall, dissection, or intraluminal hematoma with <25% luminal stenosis; grade 2, intraluminal thrombus, raised intimal flap visualized, dissection, or intraluminal hematoma with ≥25% luminal narrowing; grade 3, pseudoaneurysm; grade 4, vessel occlusion; and grade 5, vessel transection.[2] They reported a high frequency of grades 1, 2, and 4.[2] Anti-thrombotic therapy such as aspirin or heparin is recommended for grade 1 and 2 patients.[3] On the other hand, Scott et al. classified VA injury into low grade (grades 1 and 2) and high grade (grades 3 and 4) by analyzing the Biffl cerebrovascular injury scale.[9,10] They reported that the incidence of posttraumatic ischemia in low-grade cases was as low as 1.7%, and they found no correlation between the stroke rate and the use of antiplatelet or anticoagulant therapy.[9] Thus, administration of anti-thrombotic drugs to

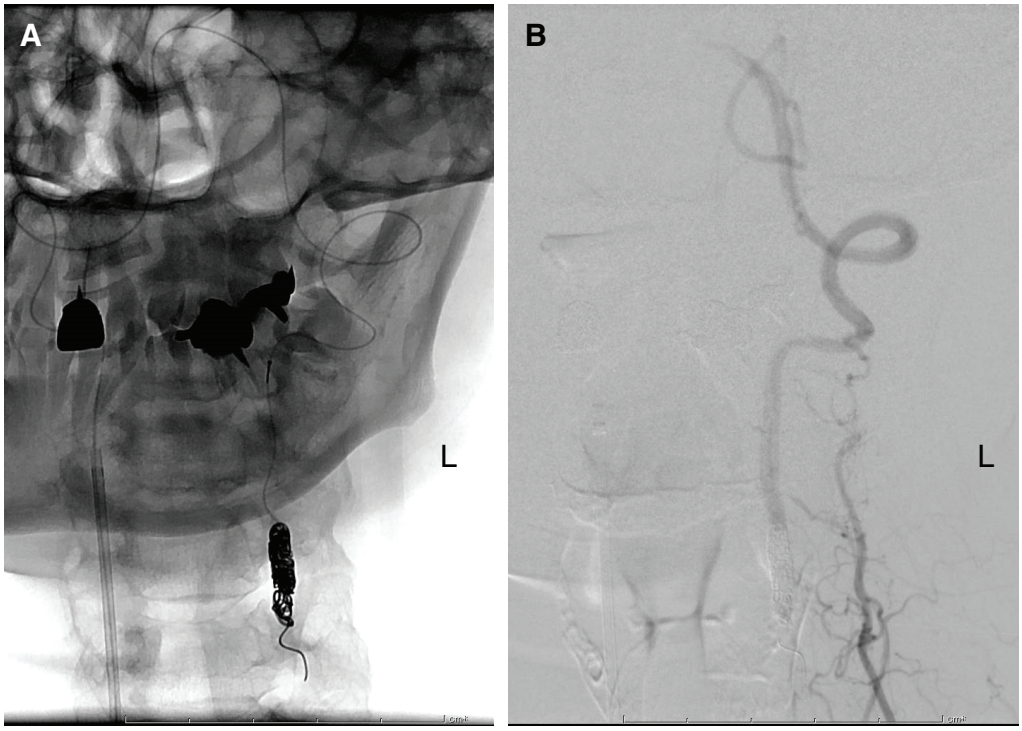

Fig. 3 **(A)** Cerebral angiography image after completion of coil embolization. The coil can be seen in the left VA from the C4-C5 level. **(B)** DSA of the anterior–posterior view from the left subclavian artery shows anterograde flow of the left VA by collateral circulation from the muscular branches at C1/2 and C3/4. VA: vertebral artery

low-grade cases is controversial. In the present case, we presumed the possibility of traumatic dissection at the left VA, but MRI showed no infarction in the vertebrobasilar area, and the follow-up DSA image demonstrated no progression of occlusion at the left VA. Therefore, we diagnosed VA occlusion which was caused by compression due to multiple cervical spine fractures. We did not administer antiplatelet or anticoagulant therapy before the endovascular treatment. But, Scott et al.[9] reported that the pathology of the VA injury was indistinguishable from dissection, pseudoaneurysm, and occlusion.

Posttraumatic recanalization was observed in 35% of the grade 4 cases.[9,10] However, the impact of cervical spine manipulation for treatment of cervical spine fractures on stroke is unknown. A retrospective study showed that corrective cervical spine surgery reduced the risk of ischemic stroke by stabilizing the spine, thereby reducing motion across the occluded segment of the VA and preventing thrombus embolization.[1] But, in some cases, new thromboembolic infarction of the vertebrobasilar area due to recanalization of the VA occlusion occurred after cervical spinal correction, and BA occlusion was frequently fatal.[4,5] Therefore, several case reports and reviews reported endovascular treatment for patients with VA injury.[6–8] One study reported that endovascular treatment increased costs and the potential risk for stroke, and it did not appear to provide additional benefit.[11] These studies included dissection, pseudoaneurysm, and occlusion, and they did not distinguish among methods of endovascular treatment such as stenting and coiling. In a retrospective study, preoperative embolization of an occluded VA significantly reduced postoperative infarction in a specific cohort of patients who needed surgical reduction or fixation of the cervical spine.[12] This study showed that 5 of the 19 VA occlusion patients who required cervical spinal reduction developed radiologically confirmed thromboembolic stroke after cervical surgery, and none of these five patients had undergone preoperative VA embolization. Considering the frequency and the fatality of thromboembolic infarction due to VA recanalization after cervical spinal surgery, proximal coil embolization of an occluded VA is a safer and more effective procedure than stenting or coiling for VA dissections and pseudoaneurysms. It is difficult to determine whether the pathological condition of VA occlusion is dissection, occlusion, or pseudoaneurysm, so we judged approaching to the lesion with suction device has an extremely high risk of bleeding.

No cases have been reported in which coils were placed distal to the level of occlusion. We consider that distal coil

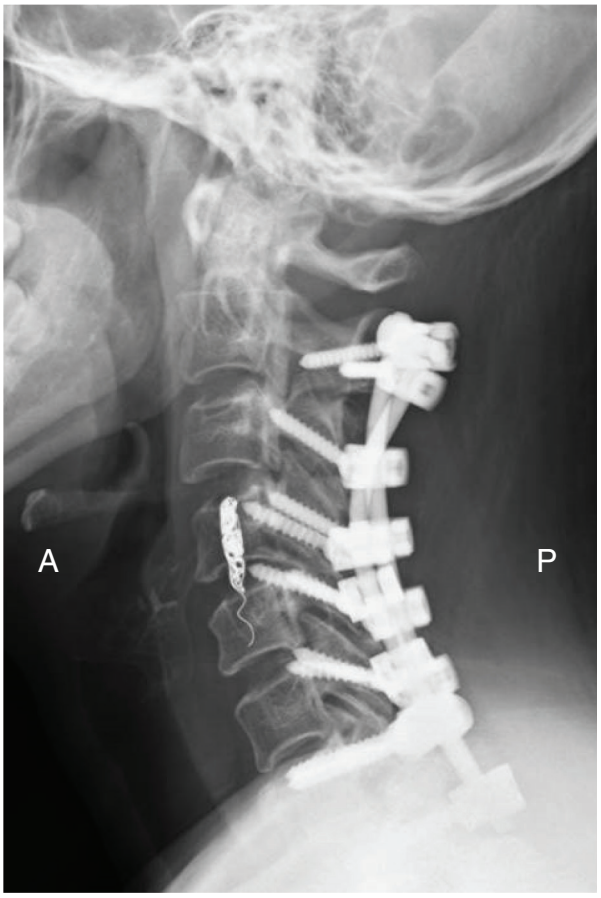

Fig. 4 Postoperative radiography of the cervical spine shows good fixation by bilateral pedicle screws on both sides at C2-Th1 and the fixed coil mass at C4-5 level.

embolization is as effective as proximal embolization to prevent thromboembolic infarction after spinal surgery, and it reduces the risk of vertebrobasilar infarction due to antegrade catheterization and coiling during endovascular treatment. This procedure is possible with or without aberrant origin, if injured VA is occluded from the origin. However, retrograde microcatheterization is sometimes more difficult. In the present case, because DSA from the right VA showed a steep angle of VA union, retrograde microcatheter insertion displaced the vessel, like a bilateral VA. This procedure was performed under local anesthesia while checking for neurological symptoms. By confirming good flow of the anterior spinal artery and BA after microcatheterization to the contralateral VA and no depiction of small vessels such as some radiculomeningeal arteries before embolization, no procedural complications were occurred. We consider that there is a risk that displacement of blood vessels in the VA union may cause perforator injury, so proximal embolization should be performed if possible from the viewpoint of safety and simplicity. But, in the present case, the patency at the origin of the VA is slight, so guidance of a microwire and microcatheter into the thrombus distal to the patent segment may migrate the thrombus to the periphery. There is no way to protect embolization of the thrombus into the vertebrobasilar area. Distal coil embolization increases costs and risks of intraoperative stroke, but the benefits of preventing a fatal stroke outweigh its disadvantages if the VA is occluded from the origin and proximal embolization is difficult. I believed that pathophysiology of the traumatic VA injury is different, but interventional embolization should be given as an alternative treatment of VA occlusion to prevent possible fatal stroke after cervical spine surgery.

Balloon test occlusion (BTO) is a method of predicting ischemia in the vertebrobasilar area after permanent unilateral VA embolization. In a previous report, BTO was found to be essential to determine the adequacy of collateral circulation from the contralateral VA or PICA in patients with a hypoplastic contralateral VA.[13] However, Sorteberg et al.[14] reported that spinal medullary branches are too small angiographically, and BTO cannot reliably exclude the risk of occlusion of a spinal medullary branch. On the other hand, Zoarski et al.[15] reported that endovascular occlusion of the cervical segment of 1VA can be safely performed without antecedent BTO. A total of 59 patients underwent VA occlusion without antecedent BTO, and none of them developed the postprocedural infarction. As long as both VAs are patent and converge at the vertebrobasilar junction, there is anatomical potential for retrograde filling of the distal intracranial VA to the level of the PICA origin, and there is no vascular supply to the spinal cord arising from the target segment of the affected vessel. In the present case, BTO by exchanging the balloon catheter after placing the microcatheter in the contralateral VA was planned, but it was not performed because microcatheterization caused displacement of the VA union, and insertion of the balloon catheter was expected to exacerbate it. We retrogradely embolized the injured VA near the occlusion point, preserving collateral orthodromic circulation from the muscular branches as much as possible. Posttraumatic cervical spine surgery should be performed as soon as possible after diagnosis for recovery of neurological function. Indo et al.[12] reported that patients had undergone cervical spine surgery within 24 hours after proximal embolization for VA occlusion. The present case also had to undergo spine surgery as soon as possible after embolization. Therefore, we

devised to guide the microcatheter retrogradely to the just distal end of injured VA and attempted to make a large coil mass to prevent the coil moving. But the distance between the microcatheter and the guiding catheter was increased since the microcatheter had to be guided just distal position of the VA lesion. Therefore, we had difficulty operating the microcatheter and could not make a dense coil mass mixed of large and small coils. We used hydrogel coils to stabilize the coil mass and prevent recanalization of VA after the cervical spine surgery. And we recommend an X-ray image to see whether the coil mass is moving and MRI to evaluate for infarction and recanalization.

Conclusion

A case of traumatic VA occlusion with multiple fractures of the cervical spine that required spinal decompression and fixation was presented. Preoperative coil embolization to a traumatic VA occlusion can be one of the therapeutic choices to prevent thromboembolic stroke after cervical spine surgery. This treatment strategy to embolize the distal segment of the injured VA is feasible, safe, and effective when the proximal segment of the VA is injured and the VA is occluded from its origin.

Disclosure Statement

None of the authors have any commercial or financial involvement in connection with this study that represent or appear to represent any conflicts of interest.

References

1) Foreman PM, Griessenauer CJ, Michelle C, et al: Corrective spinal surgery may be protective against stroke in patients with blunt traumatic vertebral artery occlusion. *Neurosurg Spine* 2015; 5: 665–670.
2) Biffl WL, Moore EE, Elliott JP, et al: The devastating potential of blunt vertebral arterial injuries . *Ann Surg* 2000; 231: 672–681.
3) Bromberg WJ, Collier BC, Diebel LN, et al: Blunt cerebrovascular injury practice management guidelines: the Eastern Association for the Surgery of Trauma. *J Trauma* 2010; 68: 471–477.
4) Nakao Y, Terai H: Embolic brain infarction related to posttraumatic occlusion of vertebral artery resulting from cervical spine injury: a case report. *J Med Case Rep* 2014; 8: 344.
5) Tumialán LM, Theodore N: Basilar artery thrombosis after reduction of cervical spondyloptosis: a cautionary report. *J Neurosurg Spine* 2012; 16: 492–496.
6) Herrera DA, Vargas SA, Dublin AB: Endovascular treatment of traumatic injuries of the vertebral artery. *AJNR Am J Neuroradiol* 2008; 29: 1585–1589.
7) Stein DM, Boswell S, Sliker CW, et al: Blunt cerebrovascular injuries: does treatment always matter? *J Trauma* 2009; 66: 132–143; discussion 143–144.
8) Isaji T, Ohshima T, Nakura T, et al: Efficacy of endovascular proximal occlusion before direct reposition surgery of blunt cervical fracture with unilateral vertebral injury. *NMC Case Rep J* 2019; 6: 131–134.
9) Scott WW, Sharp S, Figueroa SA, et al: Clinical and radiological outcomes following traumatic Grade 1 and 2 vertebral artery injuries: a 10-year retrospective analysis from a Level 1 trauma center. *J Neurosurg* 2014; 121: 450–456.
10) Scott WW, Sharp S, Figueroa SA, et al: Clinical and radiographic outcomes following traumatic Grade 3 and 4 carotid artery injuries: a 10-year retrospective analysis from a Level 1 trauma center. The Parkland Carotid and Vertebral Artery Injury Survey. *J Neurosurg* 2015; 122: 610–615.
11) Burlew CC, Biffl WL, Moore EE, et al: Endovascular stenting is rarely necessary for the management of blunt cerebrovascular injuries. *J Am Coll Surg* 2014; 218: 1012–1017.
12) Indo M, Oya S, Shojima M, et al: Prevention of thromboembolic infarction after surgery for traumatic cervical fracture with vertebral artery occlusion by preoperative endovascular coil embolization. *World Neurosurg* 2019; 129: 838–844.
13) Luo CB, Chang CY, Teng MM, et al: Endovascular treatment of ruptured vertebral dissecting aneurysms with electrodetachable coils. *J Chin Med Assoc* 2005; 68: 578–584.
14) Sorteberg A, Bakke SJ, Boysen M, et al: Angiographic balloon test occlusion and therapeutic sacrifice of major arteries to the brain. *Neurosurgery* 2008; 63: 651–660; discussion 660–661.
15) 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: 856–861.