

Efficacy of Endovascular Proximal Occlusion before Direct Reposition Surgery of Blunt Cervical Fracture with Unilateral Vertebral Injury

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Cerebral infarction related to traumatic vertebral artery (VA) injuries is not common. However, if VA injuries cause ischemic and/or hemorrhage stroke, these subsequent problems can result in severe residual impairment and mortality. Herein, we present five patients with cervical vertebra fractures due to blunt cervical trauma who underwent preoperative endovascular therapy. Between June 2010 and April 2018 in our hospital, five patients with traumatic occlusion of a unilateral VA underwent coil embolization to prevent post-surgical stroke due to reperfusion in the VA. Because of cervical instability or subluxation, all of the patients received endovascular therapy before surgery for their cervical fracture. None of the patients presented with stroke after presurgical embolization and direct surgery. When stagnated blood, including thrombi, in the occluded VA is released during cervical surgery, brain embolism may occur. Therefore, early cerebrovascular vessel assessment and presurgical endovascular treatment must be considered to prevent stroke after direct surgery.

Keywords: vertebral artery injury, endovascular therapy

Introduction

Cerebral infarction related to traumatic vertebral artery (VA) injuries is uncommon. In the literature, the incidence rate of VA injuries due to blunt trauma upon admission ranges from 0.4% to 0.71%.^{1,2} However, if VA injuries cause ischemic and/or hemorrhage stroke, such as cerebellar, brain stem, or cerebral infarction on the posterior cerebral artery region, severe residual impairment and mortality can occur.

Some authors have reported the incidence of VA-related problems, such as VA injury, VA-related stroke, and mortality; diagnosis, such as by computed tomography (CT), magnetic resonance imaging, and digital subtraction angiography (DSA); and treatment, such as by administration of anticoagulant and antiplatelet agents for VA injury. The management of

asymptomatic VA injury and the efficacy of endovascular therapy before cervical fixation for a cervical fracture have not been evaluated. Herein, we present five patients with cervical vertebra fracture due to blunt cervical trauma who underwent preoperative endovascular therapy. To the best of our knowledge, this is the first report on the evaluation of the efficacy of presurgical endovascular embolization for unilateral VA injury.

Case Report

We conducted a retrospective analysis of patients between June 2010 and April 2018 in our hospital. A total of five patients with traumatic occlusion of a unilateral VA had undergone coil embolization to prevent intra- and post-surgical stroke due to the reperfusion in the VA. We assessed the five patients aged 26–64 years, of which three were men and two were women. Table 1 lists all of the patients who presented with cervical bone injuries and fracture types. The causes of injuries were traffic accident for two patients, falling down the stairs for one patient, and work accident for two patients (one fell from a height of 9 m, and the other was hit by a steel wire rope).

The American Spinal Injury Association (ASIA) grade was used to assess the severities of the spinal cord injuries.^{3,4} A 58-year-old woman (case no. 3) had complete impairment (ASIA grade A: no motor or sensory function in the lowest sacral segment). She was presented with complete paralysis below the C4 region. Three patients (case nos. 1, 2, and 4) had incomplete impairment (ASIA grade C: less than one-half of the key muscles below the neurological spinal level have grade 3 or better strength; and ASIA grade D: at least one-half of the key muscles below the neurological spinal level). A 64-year-old woman (case no. 5) did not present with sensory and motor dysfunction (ASIA grade A).

Because of cervical instability or subluxation, all of the patients received endovascular therapy before surgery for cervical fracture. Both endovascular and direct operative indications were discussed by our experts. Informed consent to present their cases was obtained from the patients and/or their next of kin.

Representative Case

We chose case no. 5 as a representative case. This 64-year-old woman had a C2 hangman's fracture due to falling down on a 10-step stair (Fig. 1). Magnetic resonance angiography and CT angiography showed left VA injury at a part of the fracture (Fig. 2). She was admitted to the orthopedic department of our hospital. Fitting with a cervical collar was the

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Table 1 Five cases of cervical vertebra fracture by blunt cervical trauma

	Age/Sex	Bone injury type	Clinical neurological findings	Artery injury	ASIA grade
1	26/M	C2 Fx through the FT C6 and C7 laminae Fx	Motor and sensory disturbances in the bilateral C7 region	Right VA	C
2	31/M	C4–C6 Fx through the FT	Motor and sensory disturbances in the right C5 and 6 regions	Right VA	D
3	58/M	C3/4 subluxation	Complete paralysis below the C4	Right VA	A
4	45/F	C5 Fx through the FT C5/6 subluxation	Sensory disturbance in the C5 region	Right VA	D
5	64/F	C2 hangman's Fx	None	Left VA	E

ASIA grade: American Spinal Injury Association grade,⁴⁾ Fx: fracture, FT: foramen transverse, VA: vertebral artery.

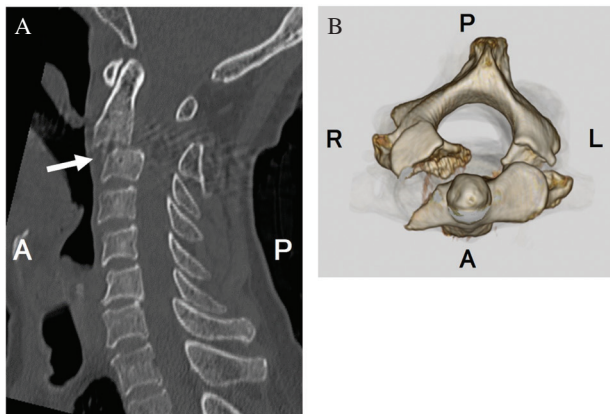


Fig. 1 (A) Sagittal computed tomography (CT) image. (B) Three-dimensional CT image. These CT images show C2 hangman-type fractures.



Fig. 2 (A) Magnetic resonance angiography (MRA) image. (B) CT angiography (CTA) image. These images show that the flow of the left vertebral artery is poor.

only medical management performed before endovascular therapy. Antiplatelet drug and heparin were not provided. On post-injury day 1, the orthopedic surgeon planned to

perform C2 screw fixation. The injured left VA was already nearly occluded at the distal portion, but she had no ischemic symptoms. Therefore, after discussion, we decided that coil embolization of the left proximal VA with recanalization after cervical reduction should be performed under local anesthesia to prevent thromboembolic ischemic stroke.

Digital subtraction angiography showed an occlusion at the left VA at the lower edge level of the C2 vertebral body (Fig. 3). Under local anesthesia, a 6-Fr long sheath was inserted into the right femoral artery. A 6-Fr guiding catheter was advanced into the left VA. A Headway 17 microcatheter (Terumo, Tokyo, Japan) was navigated by using a Chikai 14 micro-guidewire (Asahi Intecc Co., Ltd, Seto, Aichi, Japan) at the dead end of the left VA. Complete occlusion was achieved by using 11 detachable platinum coils. The blood supply to the left cerebellum was maintained via the right VA. No endovascular therapy-related complication was observed. On the day after the coil embolization, we performed direct cervical fixation. She did not present with any postoperative neurological deficits and was then discharged.

Discussion

In the literature, the incidence rate of VA injuries due to blunt trauma ranges from 0.4% to 0.71%.^{1,2)} Moreover, the rate of stroke-related VA injury reportedly has ranged from 0% to 14%.^{1,2,5)} Miller et al.¹⁾ reported that approximately 2.6% of patients with VA injury who received heparin and antiplatelet therapy presented with stroke, whereas approximately 54% of untreated patients developed stroke. In addition, the incidence of mortality-related stroke with VA injury reportedly has ranged from 4% to 13%.^{1,5,6)}

Vertebral artery injury is associated with some conditions involving the vessels: pseudoaneurysm, endothelial injury, and dissection. These injuries can cause an intra-arterial hematoma, subsequent hemodynamic ischemic stroke, and artery-to-artery distal embolization. Some patients with VA injury are asymptomatic upon admission. Therefore, screening for vascular injury is necessary in the early phase. Then, the inner-lining dissection or possible endoluminal injury must be identified, and anticoagulant and/or antiplatelet drug therapy is recommended.^{1,7)} These anticoagulant treatments might decrease subsequent catastrophic stroke events.

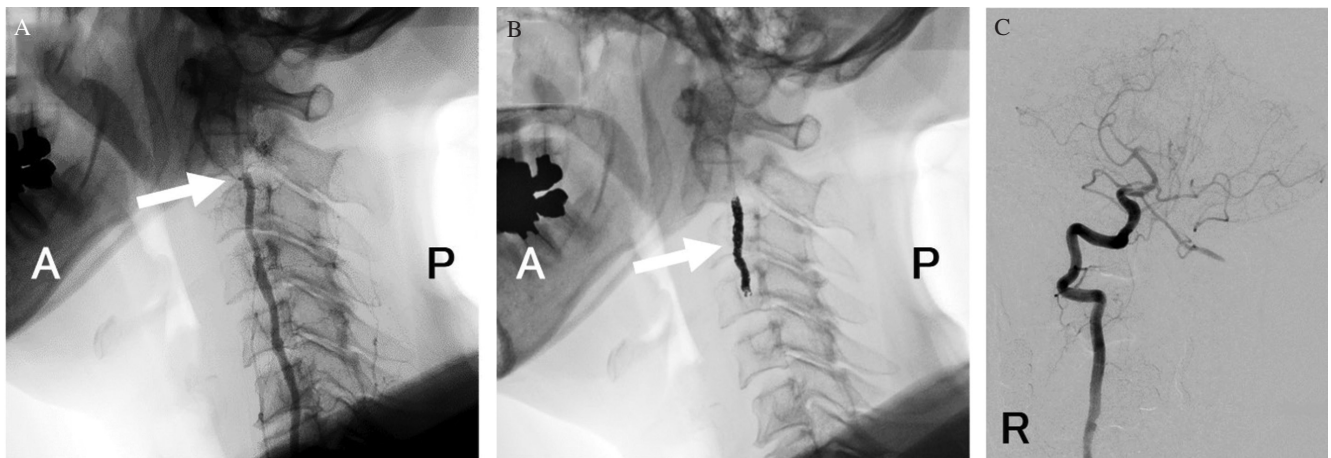


Fig. 3 (A) Digital subtraction angiography (DSA) lateral view of the left vertebral artery (VA) is shown. The left VA flow is occluded at the C3 level. (B) After completion of coil embolization. The coil can be seen in the left VA from the C2–C4 level. (C) A DSA anterior–posterior view of the right VA is shown. Blood flow from the right VA is the end at left VA at upper end of atlas. DSA shows occlusion of the left VA at the bottom edge of the C2 level.

Some authors have shown that VA injury has a significantly higher incidence than that of other types of cervical fractures in patients with fracture of the foramen transverse (case nos. 1, 2, and 4), subluxation (case nos. 3 and 4), or upper cervical fracture (case no. 5).^{2,7,8)} Furthermore, the rate of VA injury is significantly higher in patients with complete motor paralysis (ASIA grades A and B) than in patients with intact neurological status (ASIA E).⁹⁾ In our case series, one patient presented with ASIA grade A. Therefore, screening tests are mandatory for patients with a cerebrovascular injury who present with a fracture of the foramen transverse, subluxation or upper cervical fracture, and complete motor paralysis.

Endovascular therapy before direct cervical surgery is indicated in cases of traumatic VA injury with instability or subluxation because recanalization can cause distal embolization when the surgeon performs a reduction of the cervical alignment. Chang reported infarction after cervical fusion with traumatic cervical instability.¹⁰⁾ When the stagnated blood, including thrombi, in the occluded VA is released during cervical direct surgery, brain embolism may suddenly occur. We cannot prevent embolism during direct surgery. The occurrence of unilateral VA endovascular occlusion has been widely accepted in patients with VA dissecting aneurysms. We believe that unilateral traumatic VA occlusion leads to permanent occlusion not only in patients with ischemia of the posterior circulation but also in patients who do not show severe neurological deficits due to ischemia of the posterior circulation. It is necessary to perform coil embolization of an additional parental artery occlusion with subsequent recanalization to prevent thromboembolic ischemic stroke due to recanalization after cervical reduction. In fact, Nakao et al.¹¹⁾ reported a case of a brain infarction due to recanalization of the occluded left VA following the open reduction of cervical spinal dislocation.

In addition, since the common sites of VA injury are in the upper cervical region, posterior inferior cerebellar arteries

(PICAs) are not likely to be involved in dissecting aneurysms, but when PICAs are involved, endovascular internal trapping is challenging. Moreover, because the target lesions have already occluded, a balloon-attached guiding catheter for temporary flow control is never required. The dual-catheter technique used in making an anchor coil also is not required. Therefore, the endovascular procedure is quite simple, as in our cases. We did not use intraprocedural systemic heparin. The endovascular surgical time lasted between 30 and 60 min.

To the best of our knowledge, this is the first case series to evaluate the efficacy of presurgical endovascular embolization for unilateral VA injury. However, some limitations should be considered. First, the number of cases was small, so our conclusions might not apply to all cases, and we did not assess long-term efficacy. Second, the endovascular surgeries can be performed within 1 h, and the direct cervical reduction must be performed as quickly as possible to save the injured spinal nerve. The costs of this complicated treatment and the requirement of highly organized medical staffs should also be considered.

Conclusion

We presented five cases of patients with VA injuries who received presurgical endovascular therapy. When the stagnated blood, including thrombi, in the occluded VA is released during cervical surgery, brain embolism may occur. Therefore, early cerebrovascular vessel assessment and presurgical endovascular treatment must be considered to prevent intra- and post-surgical stroke.

Conflicts of Interest Disclosure

None. All authors, who are members of the Japan Neurosurgical Society (JNS), have filled out the online self-reported COI disclosure statement forms through the website for JNS members.

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