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Management of Asymptomatic Vertebral Artery Injury Caused by a Cervical Pedicle Screw Malposition: Two Case Reports

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Abstract

Iatrogenic vertebral artery (VA) injury in cervical fusion is an extremely rare complication but can lead to serious sequelae. We present two successful cases of internal trapping for preventing delayed-onset ischemic stroke after iatrogenic VA stenosis caused by a cervical pedicle screw. A 34-year-old female underwent posterior cervical fusion for C4/C5 dislocation fracture. No neurological deficits were observed after the operation. However, the postoperative images revealed that the left C5 pedicle screw perforated the transverse foramen, and the left VA was suspected to be occluded at the screw insertion site. Before revision surgery, we tried to embolize the injured VA with coils. A microcatheter could be navigated from the ipsilateral VA to the distal of the screw, and internal trapping was performed with coils. Another case is that of a 50-year-old male with cervical spondylosis, who underwent posterior decompression and cervical fusion. The neurological symptoms did not deteriorate after the operation. However, the postoperative computed tomography images revealed the perforation of the right C3 transverse foramen by the pedicle screw. In right vertebral angiography, about 70% stenosis was observed at the screw insertion site. Although revision surgery was not planned due to good stability, we embolized the right VA after balloon occlusion test, to prevent the delayed-onset thromboembolic complications. Both the patients recovered without any neurological deficits. Iatrogenic VA injuries, even if asymptomatic immediately after surgery, can lead to serious sequelae in case of delayed-onset ischemic stroke. Therefore, careful attention should be paid when the screw perforates the transverse foramen.

Keywords: consensus, spinal diseases, stroke, thromboembolism

Introduction

Iatrogenic vertebral artery (VA) injury in cervical fusion is an extremely rare complication. However, it can cause massive bleeding or delayed-onset thromboembolic complications, which can lead to serious sequelae and death.[1–5] The indications for endovascular treatments of iatrogenic VA injury in cervical fusion include intraoperative bleeding, delayed-onset thromboembolism from the injured site, pseudoaneurysm, and arteriovenous fistula. Owing to the rarity of asymptomatic iatrogenic VA injury in cervical fusion, which may lead to delayed-onset ischemic stroke, no management consensus has been reached. Here we report two successful cases of internal trapping for preventing delayed-onset thromboembolic complications after asymptomatic VA injury caused by a cervical pedicle screw malposition.

Case Report

Case 1

A 34-year-old female presented to the emergency department with a traffic injury. Computed tomography (CT) revealed a C4/C5 dislocation fracture (Fig. 1a). CT angiography revealed no apparent damage

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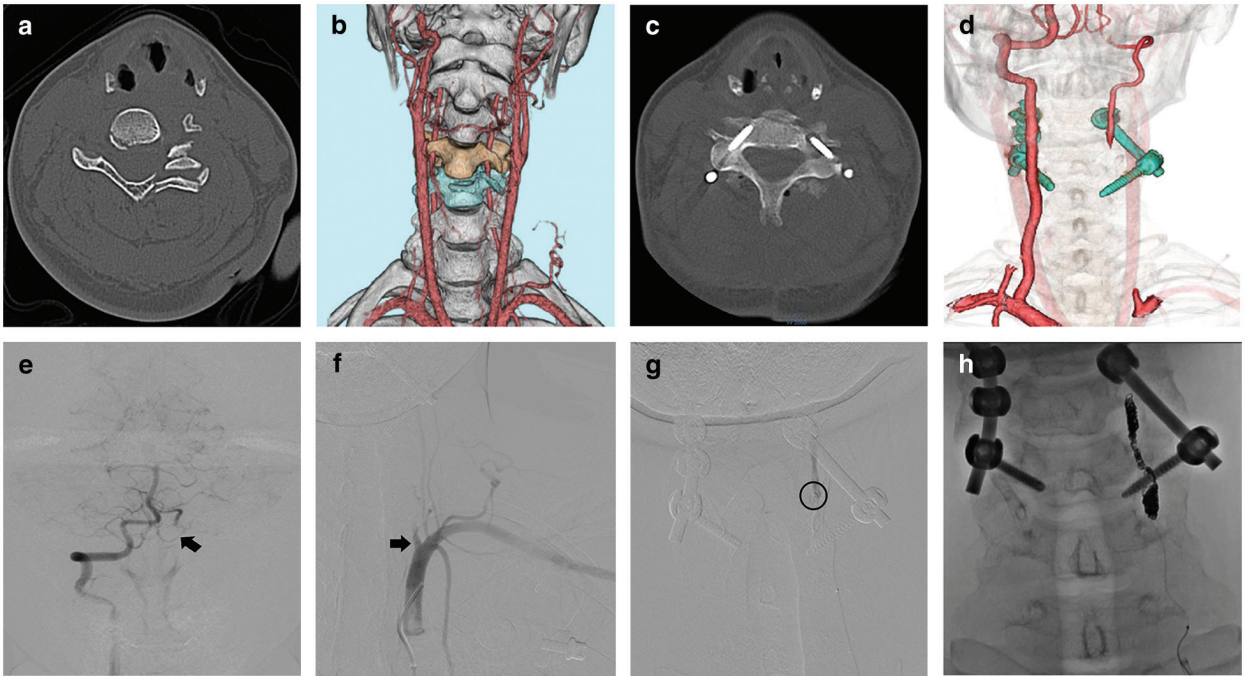

Fig. 1 (a) CT scan of the cervical spine showing a dislocation fracture at the C4–C5 level. (b) Preoperative CT angiogram showing no bilateral VA injuries. (c) Postoperative CT scan showing a left C4 pedicle screw perforating the transverse foramen. (d) Postoperative CT angiogram showing no visualization of the left VA from the origin to the distal side of the screw. (e) Right VA angiogram showing the left posterior inferior cerebellar artery retrogradely (arrow). (f) Left subclavian artery angiogram showing the left VA suspected to be occluded at the origin (arrow). (g) The microcatheter could be navigated distal to the screw through the ipsilateral approach without much resistance. Circle, position of the microcatheter tip. (h) Coil embolization. CT: computed tomography, VA: vertebral artery.

to the bilateral VAs and similar diameters on both sides (Fig. 1b). After 1 week, posterior cervical fusion with C3 bilateral lateral mass screws, C4 right lateral mass screws, and C5 bilateral pedicle screws was performed. No arterial bleeding was observed during screw insertion, and no new neurological deficits were observed after the operation. However, the CT scan on the third day after the operation revealed that the left C5 pedicle screw had perforated the transverse foramen (Fig. 1c). CT angiography did not visualize the VA from the origin to the distal side of the screw (Fig. 1d). Although the dislocation reduction position was good, the stability was poor because the screw did not reach the cortical bone on the ventral side. Removal and replacement of the pedicle screw with a lateral mass screw were planned. Before reoperation, coil embolization was performed to prevent bleeding during the screw removal and thromboembolic complications during resumption of antegrade blood flow after screw removal.

Endovascular treatment

Right vertebral angiography visualized the left posterior inferior cerebellar artery retrogradely (Fig. 1e). Left subclavian angiography revealed only the origin of the left VA (Fig. 1f). A 6-Fr Slim Guide guiding catheter (Medikit Co. Ltd., Tokyo, Japan) was placed in the origin of the left VA, and an Excelsior SL-10 microcatheter (Stryker, Kalamazoo, MI, USA) could be guided to the cranial side of the screw by pushing without much resistance (Fig. 1g). The left VA was embolized with coils from the cranial side to the caudal side of the stenosed site (Fig. 1h). After the embolization, the neurological findings did not worsen, and MRI revealed no acute infarction.

Reoperation

The left C5 pedicle screw was removed, and a left C6 lateral mass screw was added for posterior fusion from C3 to C6. Bleeding was easily controlled during the screw removal, and the total amount of intraoperative bleeding was 50 ml. No ischemic stroke occurred after the screw removal. After rehabilitation, the patient recovered without any neurological deficits. At the 18-month follow-up, she has not experienced any ischemic stroke, and CT angiography showed the persistence of the left VA occlusion.

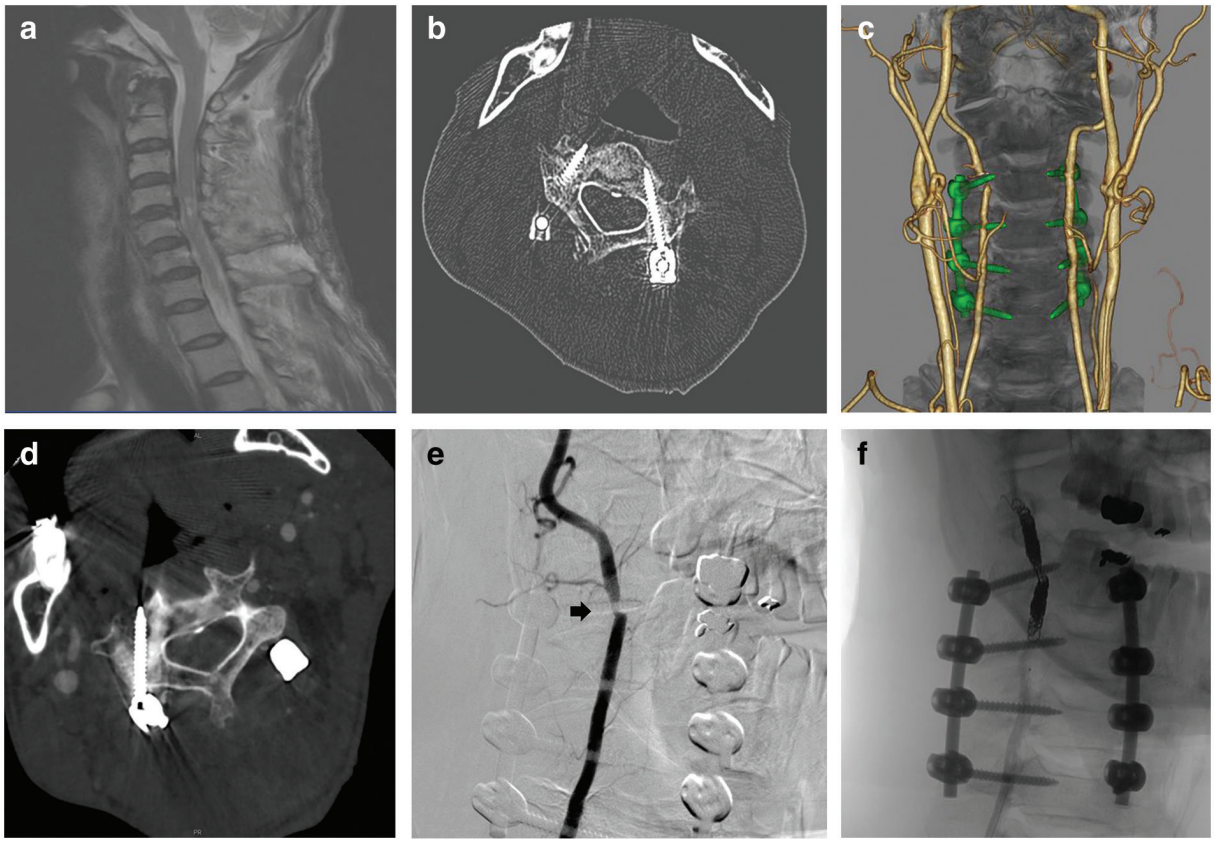

Fig. 2 (a) Magnetic resonance image of the cervical spine showing cervical spondylosis. Posterior fusion was performed. (b) Postoperative CT scan showing the right C3 pedicle screw perforating the transverse foramen. (c) Postoperative CT angiogram showing a right VA stenosis at the screw insertion site. The left VA was larger in diameter than the right VA. (d) It was difficult to judge from axial image of CT angiogram whether the screw had caused intima damage. (e) Right VA angiogram showing a 70% stenosis at the screw insertion site (arrow). (f) Coil embolization. CT: computed tomography, VA: vertebral artery.

Case 2

A 50-year-old male with cervical spondylosis underwent posterior decompression and interbody fusion from C3 to C6 (Fig. 2a). No arterial bleeding was observed during the operation, and no deterioration of neurological symptoms was observed after the operation. However, postoperative CT revealed a perforation of the right C3 transverse foramen by a pedicle screw (Fig. 2b). On CT angiography, the stenosis of right VA was at the C3 pedicle screw insertion site (Fig. 2c). It was difficult to judge from CT angiography whether the screw had caused intima damage (Fig. 2d). Although the stability was good because the screw tip reached the ventral cortical bone, internal trapping was performed to prevent delayed-onset thromboembolic complications.

Endovascular treatment

Right vertebral angiography revealed that the antegrade blood flow was maintained, but 70% stenosis was observed at the C3 pedicle screw insertion site (Fig. 2e). A 6-Fr Optimo balloon-guiding catheter (Tokai Medical Products, Aichi, Japan) was placed in the right VA, and a Headway 17 microcatheter (MicroVention; TERUMO, Tustin, CA, USA) was navigated to the distal side of the screw by using a CHIKAI 14 micro guidewire (Asahi Intecc, Aichi, Japan). After a balloon occlusion test, the right VA was embolized with coils from the cranial side to the caudal side of the stenosed site (Fig. 2f). After embolization, the neurological findings did not worsen, and the MRI revealed no acute infarction. He recovered without any new neurological deficits. At the 14-month follow-up, he has not experienced any ischemic stroke.

Discussion

The pedicle screw is widely used because of its excellent stability. However, if the trajectory deviates

laterally, it may violate the transverse foramen and injure the VA. Anatomical studies of cervical pedicle indicate a safety margin of only 4 mm.[6] Moreover, in patients with cervical trauma or instability, the insertion of pedicle screws would become more complicated. Although the navigation system has advanced, cervical pedicle screw malposition has still a certain number of complications.[7] On the other hand, the VA occupies 27.4% (C3) to 35.7% (C6) of the transverse foramen.[8] Therefore, even if the screw perforates the transverse foramen, the frequency of VA injury is low. The overall incidence of iatrogenic VA injury in the cervical spine surgery ranges from 0.07% to 1.4%,[1–3] and only 12.7–25.6% of iatrogenic VA injuries develop cerebellar or stem infarction.[3–5] This relatively low incidence rate of ischemic stroke after iatrogenic VA injury may be due to the abundant collateral vessels in the posterior circulation,[5] such as segmental arteries, deep cervical and ascending cervical arteries, and contralateral VA. Therefore, most ischemic stroke cases after iatrogenic VA injury are considered artery-to-artery embolisms, not hemodynamic mechanisms. All three reported cases of ischemic stroke after iatrogenic VA injury had delayed onset, which suggests an artery-to-artery embolism.[9–11]

Antiplatelet therapy may potentially prevent the ischemic stroke after iatrogenic VA injury. However, it is unclear how long antiplatelet therapy should be continued in this situation. Additionally, a case of repeated ischemic stroke despite maximal antiplatelet therapy has been reported.[10] Although the type of high-risk iatrogenic VA injury, i.e., more likely to cause ischemic stroke, is unclear, several factors must be considered for indicating prophylactic intervention. First, if thromboembolism has already occurred or a thrombus has formed at the injured site, interventions for further embolism prevention should be considered. Second, stenosis severity may be associated with thrombus formation. An in vitro study confirmed the association of platelet adhesion rate and stenosis severity.[12] Although the pathology of intracranial atherosclerotic lesions is different from that of VA stenosis caused by the screw, artery-to-artery embolism was reported to be more likely to occur with a higher stenosis rate.[13] As another mechanism, the indentations of the VA by the screw may cause disturbance of the blood flow dynamics in the web-like structure of the carotid artery.[10,14] The blood flow stasis distal to the VA indentations may result in thrombus formation.[10,14] Moreover, strong compression by the screw is likely to damage the intima, which can cause a thrombus formation, as reported in cases of traumatic carotid artery dissection.[15] Alternatively, the penetration of the pedicle screw into the vessel lumen may provide a thrombogenic surface. Titanium, the raw material of the pedicle screw, has been shown to be thrombogenic when in contact with blood.[16] Third, screw removal confers a high risk because the thrombus formation at the injured site causes a distal embolus when the anterograde blood flow resumes after screw removal. Yang et al. reported a case of VA injury during screw removal in which cerebral infarction developed on the next day.[17] Furthermore, in blunt cervical injury, it is known that postoperative recanalization of the injured VA sometimes occurs and can result in thromboembolic infarction. In recent years, the efficacy of proximal VA embolization before direct reposition surgery of traumatic cervical fracture with VA occlusion has been reported.[18,19] Revision surgery for iatrogenic VA injury is considered to be similar situation. If the screw perforating the transverse foramen must be removed, after assessing the degree of VA injury, embolization before screw removal should be considered to prevent not only embolism but also bleeding.

In case 1, severe stenosis and screw removal were considered risk factors of ischemic stroke. The blood flow had a to-and-flow state due to severe stenosis caused by the pedicle screw. Therefore, the risk of thrombus formation at the injured site and distal embolus after screw removal was high. In case 2, severe stenosis was the risk factor. As the antegrade flow was maintained, conservative monitoring was considered an option. However, as there was a concern about the risk of thrombus formation because of flow stasis, and the possibility of intima damage could not be ruled out, internal trapping was performed given the risk of delayed-onset ischemic stroke, which leads to serious sequalae. However, in cases the stenosis is not severe and the intima damage or dissection is not suspected, prophylactic embolization is not considered necessary.

Finally, artery dominance and tolerance of ischemia should be considered. A case report described a recurring ischemic stroke after iatrogenic VA injury treated with a pipeline embolization device (PED).[10] In cases without ischemic tolerance, a PED may be a reconstructive treatment option.

Conclusion

We experienced two successful cases of internal trapping for preventing delayed-onset ischemic stroke after iatrogenic VA injury caused by a pedicle screw malposition. Iatrogenic VA injuries, even if asymptomatic immediately after surgery, can lead to serious sequelae when delayed-onset ischemic

stroke occurs. Careful attention should be paid when the pedicle screw perforates the transverse foramen.

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Author Contribution

All authors contributed to the study conception and design. Data collection was performed by Takafumi Otsuka and Masahiro Nishihori. The first draft of the manuscript was written by Takafumi Otsuka, and Takashi Izumi commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Conflicts of Interest Disclosure

The authors declare that they have no conflicts of interest.

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