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Case Report

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Anastomosis and Endovascular Treatment of Iatrogenic Vertebral Artery Injury

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Conflict of Interest
The authors have no financial conflicts of interest.

ABSTRACT

Iatrogenic vertebral artery injury (VAI) that occurs during cervical spine surgery can cause life-threatening complications, such as arteriovenous fistulas, catastrophic bleeding, neurological impairment, cerebral ischemia, and death. We report a case of dominant VAI during surgery and the treatment of a 60-year-old man diagnosed with a C1-2-3 metastatic spine tumor from urothelial carcinoma. Active bleeding occurred during tumor resection using pituitary forceps, immediately followed by gauze packing and manual compression. Post further resection, we found that the vertebral artery (VA) was completely severed. After temporary clamping on both sides of the damaged VA, an artificial graft anastomosis was performed. After verifying that the flow was intact using Doppler Sonography, Occiput-C1-4-5-6 posterolateral fusion was performed. Angiography was performed immediately after surgery. We found a thrombus occluding the left VA, and performed mechanical thrombectomy and stent insertion. The final angiography showed good VA flow with no emboli. In this case, VA anastomosis and endovascular treatment were performed within a relatively short period of time post VAI, and the patient was able to recover without any neurological deficits.

Keywords: Vertebral artery; Metastasis; Surgical anastomosis; Endovascular procedure

INTRODUCTION

Vertebral artery injury (VAI) during cervical spine surgery is a rare complication, but it can result in catastrophic bleeding, cerebellar or brain stem infarction, permanent neurologic impairment, and even death.[10)]

Regarding the anterior and posterior approaches in cervical spine surgery, the risk of VAI occurrence is present in all phases of surgery, including exposure, decompression and instrumentation.[8)] The reported rates of VAI associated with anterior cervical surgery are 0.2% to 0.5%,[8,10)] and those associated with posterior C1-C2 transarticular fixation for atlantoaxial instability are 0% to 8.2%.[8,10,11)]

To prevent VAI, preoperative imaging studies should be carefully reviewed. On preoperative computed tomography (CT) angiography, the position of the vertebral artery (VA) and its relation to bony and surrounding structures should be noted.[7)] Surgeons in some hospitals also introduce computer-assisted navigation systems to reduce the possibility of VAI related to posterior screw insertion. These recent improvements in cervical spine surgery might have affected the incidence of iatrogenic VAI.[10)]

One review article suggests that the management of VAI should be considered in the following order: 1) performing tamponade with a hemostatic agents, 2) direct repair, and 3) postoperative endovascular procedures to prevent delayed complications.[12)] However, there is still a controversial aspect of the management and outcome of patients with iatrogenic VAI, and follow-up management data and research on the need for additional examinations are lacking.

Here, we present an extremely rare case of iatrogenic VAI during cervical spine surgery that was successfully treated with end-to-end anastomosis and endovascular stent insertion.

CASE REPORT

A 60-year-old male patient visited the hospital with severe posterior neck pain and a tingling sensation in both hands, which began two months earlier. His neurological exam was without deficit. Cervical spine magnetic resonance imaging demonstrated an 8-cm enhanced mass with internal necrotic changes involving the posterior neck muscle at the C2-3 level (**FIGURE 1**). Additionally, abdominal chest enhanced CT and positron emission tomography-computed tomography (PET-CT) were performed to determine the tumor origin. He was diagnosed with urothelial carcinoma with multiple metastasis.

On cervical spine CT and CT angiography, which was conducted to determine the VA pathway and check the range of the mass, a metastatic tumor compressed the spinal cord and encased the left VA. An osteolytic lesion was found at the C2 and C3 levels (**FIGURE 2**). The left VA was shown to be dominant and deviated toward the lateral side rather than taking the normal VA pathway. Therefore, palliative surgery was decided to reduce pain related to

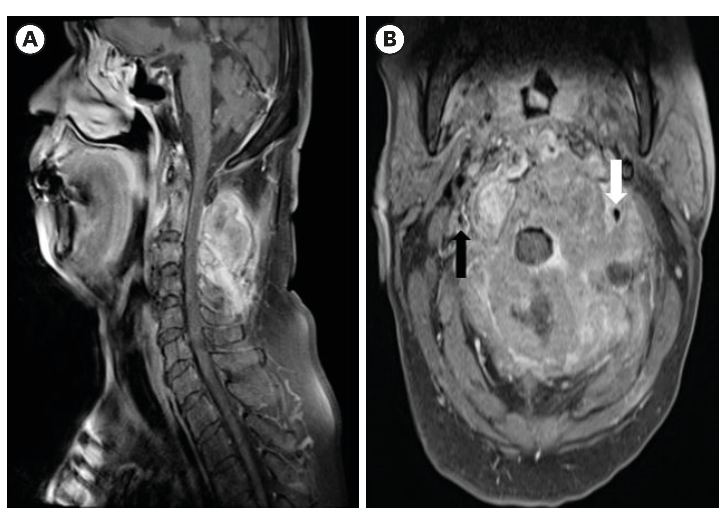

FIGURE 1. Pre op T1-weighted enhanced magnetic resonance imaging. (A) Enhanced mass involving C1-2 posterior elements extending into the posterior neck muscles on T1-weighted enhanced magnetic resonance imaging. (B) The left vertebral artery slightly deviated toward lateral side and was encased by a tumor (white arrow), normal right vertebral artery (black arrow).

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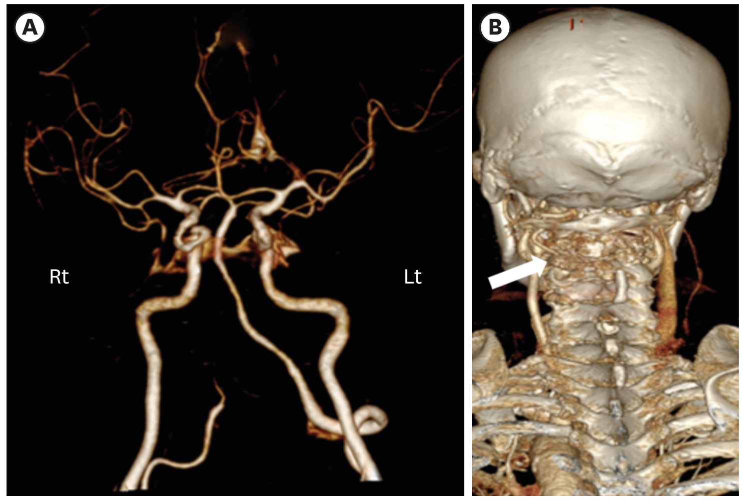

FIGURE 2. Preoperative Computed tomography angiography. (A) Computed tomography angiography showing left vertebral artery dominance. (B) A preoperative 3-dimensional reconstruction image of a computed tomographic scan of the cervical spine revealed a C2-3 osteolytic lesion (arrow).

instability of the osteolytic lesion, reduce cancer-related pain and prevent neurologic deficits by decompression of the spinal cord. Surgery was planned for subtotal resection of the tumor and stabilization through occipital-cervical fusion.

The operation was performed with the posterior approach. The tumor was found to be approximately 7.91 × 5.24 cm in size and pinkish, located at the C2-3 level, and involved the muscle, C2 left lamina and pedicle (**FIGURE 3A**). The dissection plane was relatively well maintained, tumor decompression was performed, and the tumor around the VA was also removed. Immediately, the remnant mass around the VA was removed using pituitary forceps, and arterial bleeding occurred in the cranial direction extending approximately 1 cm beyond the mass removal location. We tried to control bleeding from the injured vessel with bipolar coagulation, a compressive packed absorbable gelatin sponge, and hemostatic agents, such as oxidized regenerated cellulose. However, we were not able to achieve

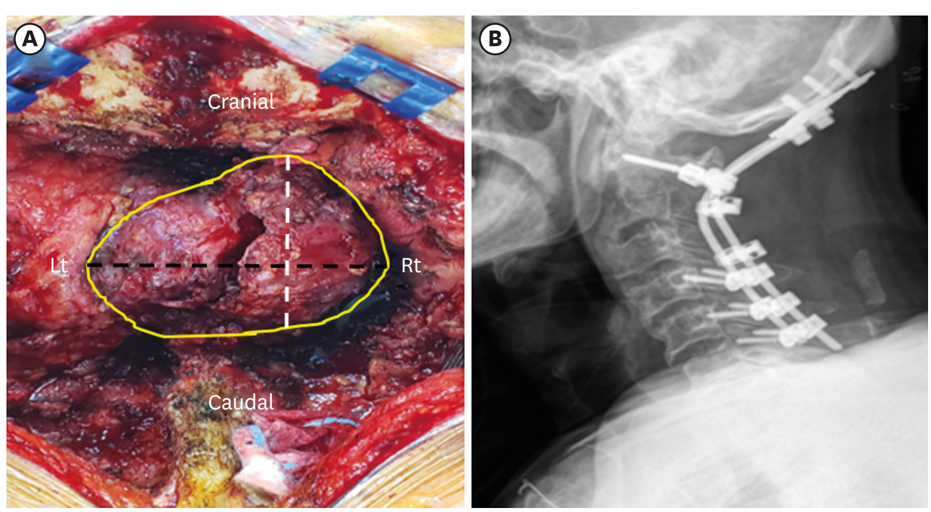

FIGURE 3. (A) Gross image of the exposed tumor. The tumor was found to be approximately 7.91 (black dotted line) × 5.24 cm (white dotted line) in size, to have an irregular margin (yellow line), to be pinkish, to be located at the C2-3 level and to involve the C2 lamina. (B) Postoperative cervical spine X-ray.

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successful control of bleeding. We used hemoclips around the site where bleeding occurred, and we exposed the proximal and distal parts of the injured VA by dissection. A direct primary repair was attempted. Afterward, the blood flow was checked using Doppler sonography, but the blood flow of the injury site was not detected. After cutting off some of the distal and proximal parts of the injured VA, anastomosis was performed using an artificial vessel graft (Impra_Carboflo short tapered 40A64C, 4–6 mm × 40 cm, CR BARD Inc., Murray Hill, NJ, USA). Constant blood flow around the injured VA was confirmed using Doppler sonography. As previously planned, the patient underwent occipito-C1-4-5-6 fusion for stabilization (**FIGURE 3B**). We completed the operation 2 hours after the VAI had occurred. The systolic blood pressure was maintained above 120 mmHg during surgery.

After surgery, the patient was transferred to the angiography room for further evaluation, and transfemoral cerebral angiography was performed (**FIGURE 4**). Angiogram showed occlusion of the left VA at the proximal part of the anastomosis. After mechanical thrombectomy, the left VA was recanalized. The right VA was nondominant, but some of the blood flow with the contralateral side and the right side was maintained. After 30 minutes, angiogram showed a gradual narrowing of the left VA, and a stent (LVIS & LVIS JR cerebral stent, 3.5 ×

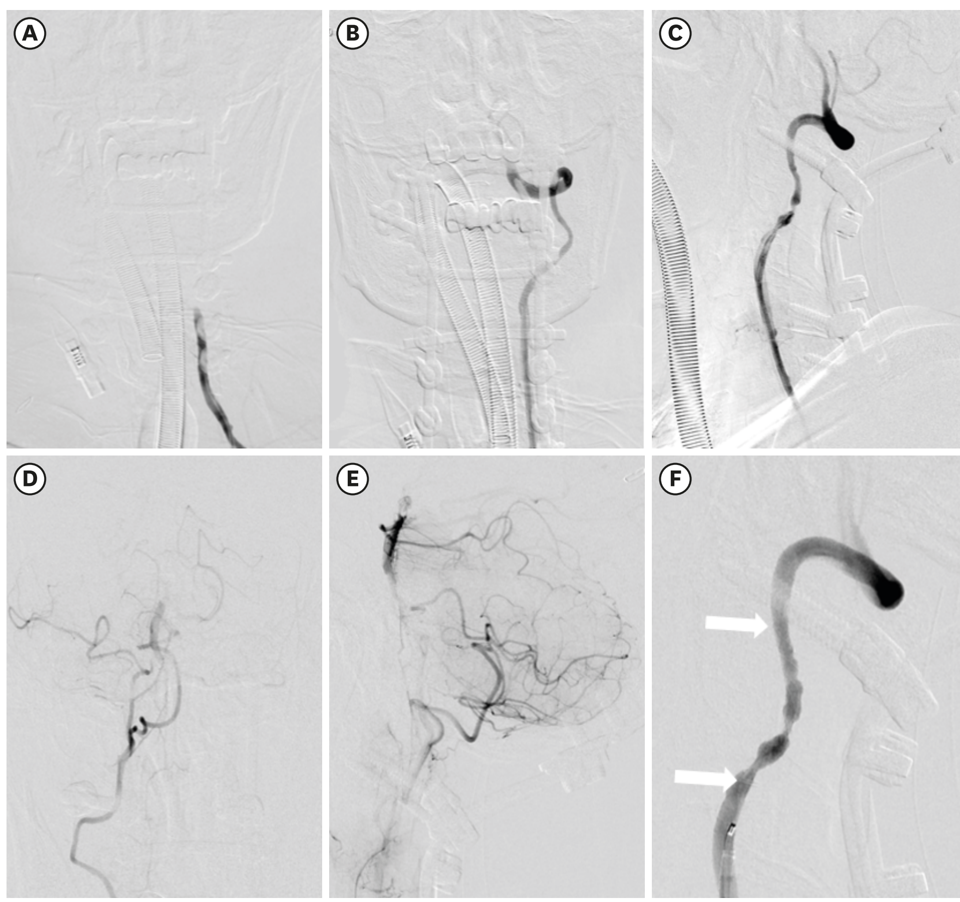

FIGURE 4. Post operative transfemoral cerabral angiography. (A) AP view of the left VA. Occlusion of the left VA at the proximal part of the anastomosis. (B) AP view of the post-thrombectomy left VA. The recanalized left VA. (C) Lateral view of the post-thrombectomy left VA. Narrowed left VA at the anastomosis site. (D) AP view of the right VA. No significant stenosis and good flow of the right VA with some of the collateral circulation. (E) Lateral view of the right VA. Good flow of the right VA. (F) Lateral view of a postdeployed endovascular stent on the left VA. The narrowed left VA with maintained blood flow. The arrows mark the proximal and distal parts of the stent.
AP: anterior posterior, VA: vertebral artery.

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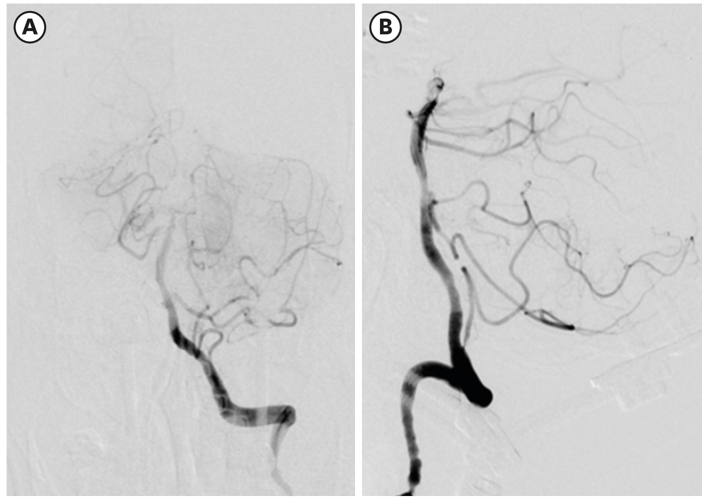

FIGURE 5. Final angiography. Anteroposterior view (A) and lateral view (B) of the left VA. Angiogram showing good flow of the left VA and collateral circulation maintenance of the blood flow of the contralateral side.
VA: vertebral artery.

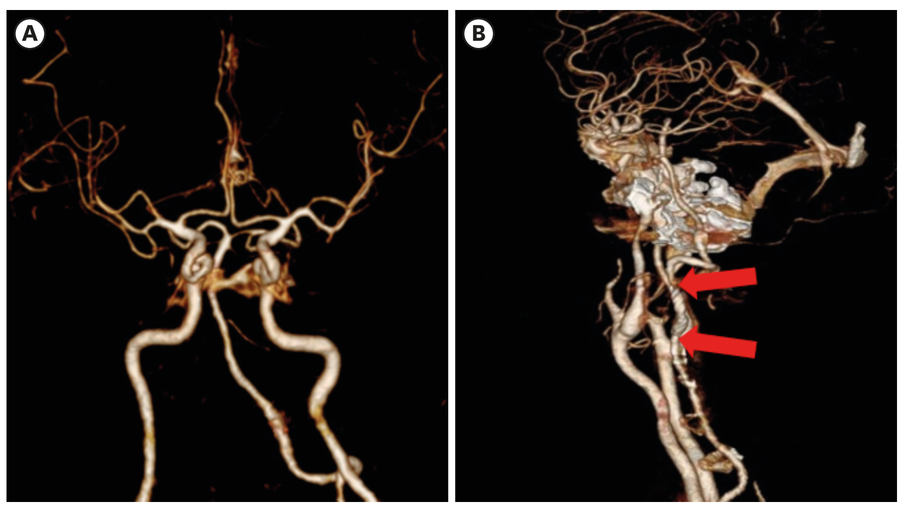

FIGURE 6. Seven-day postoperative computed tomography angiography. (A) Anterior posterior view. Demonstrating good flow of the posterior circulation, including the vertebro-basilar artery. (B) Lateral view. Red arrows are proximal and distal part of stent.

28 mm, MicroVention Inc., Aliso Viejo, CA, USA) was inserted into the anastomosis vessel to maintain the vessel's internal diameter. The patient was transferred to the intensive care unit after demonstrating that there was no narrowing of the left VA on the final angiogram (**FIGURE 5**). CT angiography was performed to evaluate the VA on the seventh day after surgery (**FIGURE 6**). No vascular abnormalities were identified in the posterior circulation with the left VA. The patient recovered without neurologic symptoms.

DISCUSSION

Iatrogenic VAI during cervical spine surgery is a rare but fatal complication with the potential to cause catastrophic bleeding, neurologic deficit, and death. The complications of VAI are arteriovenous fistulas, delayed hemorrhage, pseudoaneurysm, thrombosis with embolism, cerebral ischemia, stroke, and death. Vascular complications can occur at any time after surgery.[13] When the vessel is completely occluded, it immediately becomes postoperatively ischemic and can be partially occluded by emboli later.[12,13] Studies on outcomes after VAI reported brain ischemia and death rates that varied from 0% to 33%. These reports explained that many factors affected the final outcomes, including arterial dominance, the degree of injury to the vessel, management strategies and timing, and individual variation in tolerance to ischemia.[1,14-16]

The Cervical Spine Research Society published the results of a VAI questionnaire provided to its members. An overall surgery VAI incidence of 0.07% (111/163,324) was reported among the members. The VAI proportion that occurred during the variable stage of cervical spine surgery accounted for 44% of cases (49 of 111 VAIs). The instrumentation and approach phases accounted for 36% (40/111) and 11.7% (13/111) of cases, respectively. In addition, in 32.4% of cases, the VAI occurred during posterior upper cervical (C1-2) instrumentation.[8] Although the recently popular C1-2 lateral mass posterior screw fixation method can achieve successful results for axial instability,[2,4,5,9] VAI during C2 pedicle screw insertion can occur due to variations in the size and angle of the pedicle and position of the transverse foramen.[3,17]

Anatomical abnormalities in the VA are usually congenital or related to individual degeneration and pathological conditions. An abnormal VA pathway due to a tortuous course and anomalies can increase the risk of VAI. In addition to abnormal VA pathways, coarse drilling, the loss of landmarks, and misplacement or displacement of instruments are factors that can increase the risk of VAI.[6] Preoperative evaluation of the vascular anatomy may be necessary for safer surgical treatment, and MR angiography or CT angiography is very helpful for examining VA abnormalities. Technological developments such as computer-assisted navigation systems as well as preoperative examinations and the efforts of surgeons affect the incidence of iatrogenic VAI.[10]

Unexpected VAI can be encountered at any time despite the efforts of neurosurgeons. When VAI occurs, red bleeding, which is brighter than bone bleeding, can occur suddenly. Although there is no clearly defined protocol for VAI management, many agree on the basic principles of vertebrobasilar ischemia prevention, bleeding control, and the prevention of cerebral embolic complications. Regarding basic principles, appropriate fluid resuscitation is needed first to increase perfusion pressure to reduce the risk of posterior circulation ischemia.[13]

When VAI occurs, direct tamponade is effective for bleeding control using hemostatic agents such as absorbable gelatin sponges and oxidized cellulose. However, even if effective hemostasis is achieved, it can lead to complications such as delayed hemorrhage and fistula formation. Alternatively, direct repair of a damaged VA can be attempted. Direct repair can preserve the normal blood flow and reduce the risk of ischemic complications.[7] As in our case, if the damage is severe and the margin is irregular, the surgeon can try end-to-end anastomosis after cutting off some of the proximal and distal parts of the injured VA. Additionally, permanent occlusion can be attempted through VA ligation, but complications such as cerebellar infarction, cranial nerve paresis, and hemiplegia can occur. Therefore, VA ligation can be performed when contralateral VA patency is maintained and sufficient posterior circulation is identified when angiography is available in the operating room. The vessel must be ligated both proximally and distally, as delayed embolic or hemorrhagic complications and fistula formation can occur when only proximal ligation is performed.[5,13] For these reasons, if intraoperative angiography is possible, it can be very helpful for intraoperative decision-making. However, if intraoperative angiography is not possible, it can

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be performed immediately after surgery to detect vascular complications, confirm adequate collateral circulation to the brain, and determine the patency of the surgically repaired vessel. When vascular complications appear on angiography after surgery, attempting endovascular treatments such as immediate coil embolization, stent-assisted coil embolization, stent-grafts, or covered stents might help reduce neurologic deficiency in patients.

CONCLUSION

VAI is very rare, but it can cause very serious complications that can lead to death. To prevent VAI, it is most important to establish an accurate surgical plan by performing CT angiography and magnetic resonance imaging before surgery to check the route of the artery.

In our case, VA anastomosis and endovascular treatment were performed within a relatively short period of time after VAI occurred, and the patient was able to recover without any neurological deficits. When VAI occurs, we suggest trying tamponade with hemostatic agents and direct primary repair or anastomosis of the injured VA. Finally, immediate angiography should be performed after surgery to verify vascular complications.

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