

Case Report

Posterior Atlantoaxial Screw-Rod Fixation in a Case of Aberrant Vertebral Artery Course Combined with Bilateral High-Riding Vertebral Artery

Young Seop Park, M.D., Dong Ho Kang, M.D., Kyung Bum Park, M.D., Soo Hyun Hwang, M.D.

Department of Neurosurgery, Gyeongsang National University School of Medicine, Jinju, Korea

We present a case of posterior atlantoaxial screw-rod fixation in a patient with an aberrant vertebral artery (VA) course combined with bilateral high-riding VA. An aberrant VA which courses below the posterior arch of the atlas (C1) that does not pass through the C1 transverse foramen and without an osseous anomaly is rare. However, it is important to consider an abnormal course of the VA both preoperatively and intraoperatively in order to avoid critical vascular injuries in procedures which require exposure or control of the VA, such as the far-lateral approach and spinal operations.

KEY WORDS : Atlanto-axial joint · Vertebral artery · Bone screws.

INTRODUCTION

An aberrant vertebral artery (VA) coursing below the posterior arch of C1 which does not pass through the C1 transverse foramen has rarely been reported in the literature (Table 1)^{1,4,5,7,12-14,16}. In the Sato et al.¹¹ and Tokuda et al.¹⁴ angiographic series, only 0.7% of the VAs coursed under the C1 posterior arch in patients without an osseous anomaly; whereas, the incidence of this VA anomaly went up to 19.7% in those with osseous anomalies such as the occipitalization of C1 or Klippel-Feil syndrome.

Here, we present a successfully treated case by posterior atlantoaxial screw-rod fixation of a patient with an aberrant VA course without osseous anomaly combined with bilateral high-riding VA carrying a risk of VA injury.

CASE REPORT

A 51-year-old woman presented with neck pain, shoulder

pain, and suboccipital pain (occipital neuralgia) after falling from a cultivate. She did not have any significant prior trauma history and was neurologically intact. Cervical plain radiographs including the dynamic view showed reducible atlantoaxial instability (Fig. 1). Magnetic resonance imaging (MRI) and computerized tomography (CT) scan demonstrated no craniocervical junction abnormality or osseous abnormality. Three-dimensional helical CT scanning revealed a dominant and aberrant VA course of the left VA. It coursed below the C1 posterior arch without passing through the C1 transverse foramen, piercing and entering the dura mater between the C1 and C2 lamina (Fig. 2). However, the course of the contralateral VA through the narrow space between the occipital bone and the C1 posterior arch was normal. CT scanning also revealed bilateral subluxated facets and bilateral high-riding VA (Fig. 3). In place of transarticular screw fixation (TSF), posterior atlantoaxial fixation using the polyaxial screw-rod system (PSRF) (Vertex; Sofamor/Daneck Inc, Memphis, TN, USA) was performed to reduce the risk of VA injury (Fig. 4).

Surgical procedure

With the patient in the prone position and neutral or slightly extended neck position, a vertical midline posterior cervical incision from 1 cm aboveinion to spinous process level of

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• Address for reprints : Dong Ho Kang, M.D.
Department of Neurosurgery, Gyeongsang National University School of
Medicine, 79 Gangnam-ro, Jinju 660-702, Korea
Tel : +82-55-750-8737, Fax : +82-55-759-0817
E-mail : ns4793@hanmail.net

Table 1. Summary of the reported cases of aberrant vertebral artery course

Author (year)	Case no.	Osseous anomaly	
Takahashi ¹³⁾ (1963)	1	None	Autopsy*
Abe et al. ¹⁾ (1968)	1	None	Autopsy*
Tokuda et al. ¹⁴⁾ (1985)	6	4 (invagination, block vertebrae, occipitalization, Chiari malformation)	
Vincentelli et al. ¹⁶⁾ (1991)	1	None	
Sharma et al. ¹²⁾ (1993)	1	Klippel-Feil syndrome	
Jian et al. ⁹⁾ (2003)	1	None	Cadaver dissection*
Hotta et al. ⁴⁾ (2005)	1	Chiari malformation, Occipitotantal Assimilation	

*The aberrant vertebral artery course was found at autopsy or cadaver dissection, respectively

C4 was made. The posterior elements of C1 and C2 down to the C2/3 facet joint and up to the caudal rim of the foramen magnum were exposed bilaterally with subperiosteal dissection. The medial and lateral border of the C1 lateral masses were exposed underneath the posterior arch. Massive venous bleeding around C2 root often occurs at this stage which could be effectively controlled by compression with haemostatic sponges and cottonoids.

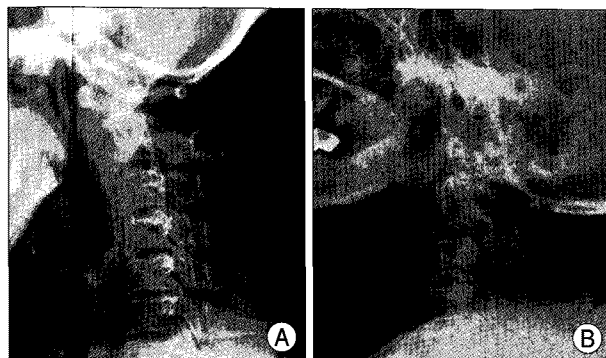


Fig. 1. Plain radiographs of the cervical spine (extension view) shows reducible atlantoaxial instability. A : Flexion. B : Extension.

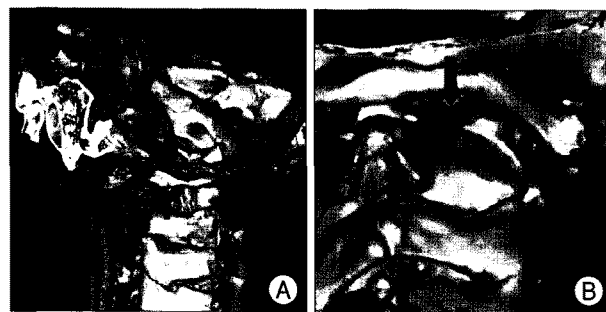


Fig. 2. A : Three-dimensional computed tomography with vertebral angiography shows a dominant and aberrant VA course of the left VA. It courses below the posterior arch of C1 without passing through the C1 transverse foramen, piercing and entering the dura mater between the C1 and C2 lamina (arrows). B : The course of the contralateral VA through the narrow space between the occipital bone and the posterior arch of C1 was normal (arrows).

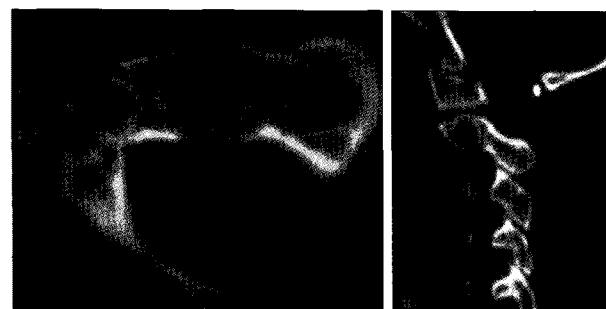


Fig. 3. The preoperative CT scanning reveals bilateral subluxated facets and bilateral high-riding VA with a narrow isthmus of a diameter less than 3 millimeters.

With fluoroscopic guide, the posterior arch drilling was carefully performed with high-speed drill at the midpoint of lateral mass of C1. After further hand drilling and tapering, polyaxial titanium screws with a diameter of 3.5-4.0 mm and length of 28-32 mm were inserted. The drill and screws were directed 10-20 degrees medially and cranially, aiming at the anterior tubercle under the fluoroscopic guidance.

The medial and lateral border of the C2 isthmus was exposed bilaterally. Our entry point of C2 screw was inferior lateral quadrant of the lateral mass. The drill and screws were directed about 20-30 degrees medially and 30-40 cranially. The trajectory and expected length of the C2 pars screws could be estimated on preoperative computed tomography. After placing all the screws, reduction of C1-2 instability could be achieved by pushing the C2 spinous process with thumb and pulling the C1 posterior arch with a clamp. Rods were loaded into the C1 and C2 screw heads on both sides and locked finally. Then bone grafting was performed with allo bone chip and/or auto bone. The postoperative course was uneventful except for mild occipital neuralgia.

DISCUSSION

Although posterior atlantoaxial fixation using the polyaxial screw-rod system can decrease the damage on VA, judging from the authors' experiences, it is thought that the position of the VA is still a limiting factor in a case of high-riding VA in which the bending point of the VA under the C2 superior articular facet is too medial, too posterior and/or too high, and the height and/or the width of the isthmus of the axis is narrowed²⁾. The only substantial difference amongst the various screw placement techniques is the ability to change the angle of the C2 pedicle screw without regard to the position of the C1 lateral mass as described by Resnick et al.¹⁰⁾.

In this case of atlantoaxial instability combined with bilateral high-riding VA, PSRF was performed to reduce the risk of VA injury through using an acute-angled C2 screw trajectory and short screws. The postoperative plain radiographs

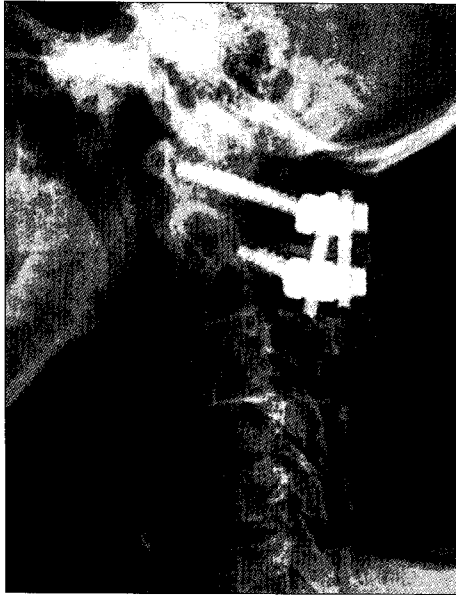


Fig. 4. The postoperative plain cervical radiographs shows the achievement of satisfactory reduction.

and CT scanning showed that satisfactory fusion and reduction were achieved; the C2 screws were inserted without violating the VA. Intraoperatively, we ascertained that an aberrant VA course did not interfere with the entry point of the C1 lateral mass and showed avulsion of the left C2 root.

The formation of the VA is a dynamic process of progressive anastomosis and development of the cervical segmental arteries^{6,8)}. In Padgett's stage 3-4 (embryo of 7-14 mm, 32-35 days), the primitive VA begins to develop from longitudinal anastomosis among the cervical segmental arteries, which have a metameric arrangement. The basilar artery is formed by anastomosis of the primitive neural arteries, and its blood supply comes from the posterior communicating arteries. In Padgett's stage 5 (embryo of 16-18 mm, 40 days), the origin of the VA shifts toward the ductus arteriosus, close to the origin of the subclavian artery, which appears at this stage. Several VA branches run among the rootlets of the IX, X, and XI cranial nerves. At this stage, the VA begins to control posterior circulation. In Padgett's stage 6 (embryo of 20-24 mm, 44 days), the cervical segmental arteries undergo involution to become the radicular arteries. The embryogenesis of several anomalous VA types could be explained with adequate understanding of the described embryogenesis. If the second segmental artery coursing along the C2 nerve root replaced the C1 segmental artery, this occurrence could result in the failure of the longitudinal anastomosis between the C1 and C2 segmental artery; the VA could have an aberrant course which would pass below the posterior arch of C1 without passing through the C1 transverse foramen, as illustrated in the present case. If the C2 segmental artery fails to regress, duplication of the VA may occur above and below

C1. Furthermore, segmentation of VA embryogenesis and rearrangement of the embryonic sclerotome could explain why an anomalous VA is usually associated with an osseous anomaly, such as occipitalization of the C1, Klippel-Feil syndrome, or absence of the C1 transverse foramen^{14,15)}.

An aberrant VA coursing below the posterior arch of C1 without passing through the C1 transverse foramen and without osseous anomaly is a very rare condition. Furthermore, there have been no reported cases of posterior atlantoaxial screw-rod fixation in a patient with an aberrant VA course without osseous anomaly, combined with bilateral high-riding VA. There could be other treatment options in upper cervical surgery of VA anomalies such as aberrant VA and high-riding VA in addition to our surgical technique.

In case of aberrant VA, other treatment modalities such as occipitocervical fusion, superior lateral mass screwing, TSF, or fixation with C1 hook could be considered. Translaminar screw fixation also could be another treatment option in case of high-riding VA. However, we believe that taking patient's condition and disease into account is more important in deciding possible surgical options.

Hott et al.³⁾ described that instrumentation-augmented C1 lateral mass screw-C2 pars screw construct is biomechanically similar to the TSF. Payer et al.⁹⁾ confirmed that posterior atlanto-axial fixation with C1 lateral mass screws and C2 pars screws is a safe and effective surgical option in the treatment of atlanto-axial instability through 12 consecutive cases.

CONCLUSION

We present a case of successful treatment by posterior atlantoaxial screw-rod fixation of a patient with an aberrant VA course without osseous anomaly combined with bilateral high-riding VA which carries a risk of VA injury. It is important to consider the possibility of an abnormal VA course both preoperatively and intraoperatively in order to avoid grave surgical results in many procedures which require exposure or control of the VA, such as skull base or craniocervical surgery. Therefore, preoperative evaluation of these vascular anomalies of the VA should always be taken into account.

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