 Case report

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The authors present the case of a 62-year-old man with a 4-month history of progressive left-sided C-5 radiculopathy and dizziness. Neuroimaging studies revealed a looped vertebral artery (VA) that had migrated into the widened left C4–5 intervertebral foramen. The patient underwent vascular reconstruction of the VA loop, in which there was minimal manipulation of the C-5 nerve root, via a left-sided anterolateral approach after a balloon occlusion test. Postoperatively the patient’s symptoms improved immediately, and there were no signs of recurrence within the 2-year follow-up period. This excellent outcome supports the belief that a proper surgical reconstruction of the compressive, tortuous VA should be the therapeutic option of choice, which carries a lower risk of the nerve root injury and improves the hemodynamics in the posterior circulation.

KEY WORDS • vertebral artery • tortuosity • vertebral artery loop • vascular reconstruction • cervical spine • radiculopathy • vertebrobasilar insufficiency

V A R T E R B A L. artery tortuosity or loop formation is a rare cause of enlargement of cervical intervertebral foramen and cervical radiculopathy.1–21,23,24 In reviewing the operative procedures for symptomatic tortuous VAs, decompressive laminectomy and/or foraminotomy, microvascular decompression, and rootlet section have been used to treat this rare condition.1,2,6,8,13,20,23,24 It is uncertain, however, that decompressive surgery, in which the pulsatile, space-occupying loop of the VA is left in a narrow bone canal, provides sufficient and long-term relief. Both complete separation of the VA loop from the affected nerve root or the placement of nonresorptive material to eliminate pulsatile compression have a considerable risk of causing nerve root damage because of the adhesive process and the extensive periarterial venous plexus in the unusual complicated anatomical relationship. We present the first report of a case of curative vascular reconstruction of the VA loop that had caused cervical radiculopathy and VBI.

Case Report

History. This 62-year-old man presented with a 4-month history of progressive left-sided shoulder pain radiating to his left arm, which was associated with dizziness. There was no history of cervical spine injury or family history of neurofibromatosis. The patient was referred to our institution for a suspected spinal cord tumor after undergoing radiographic evaluation.

Examination. A physical examination revealed a slightly diminished left-sided biceps jerk, with mild telangiectasia and brachial paresthesia. No vascular bruit was detected. No remarkable change in his neurological symptoms was recognized during or after neck movement.

Radiography of the cervical spine revealed a widening of the left C4–5 intervertebral foramen due to well-defined erosion of the posterolateral aspect of the VB and the inferior portion of the pedicle of the C-4 vertebra (Fig. 1A). Degenerative changes were compatible with the patient’s age. Magnetic resonance imaging revealed cork screw–like signal voids in the widened C4–5 intervertebral foramen (Fig. 2). Left-sided VA angiograms demonstrated a tight loop migrating into the C4–5 intervertebral foramen (Fig. 1B and C). Angiograms obtained during neck movements revealed no remarkable hemodynamic or morphological changes in the cervical region. A 20-minute balloon occlusion test of the left VA proved there was sufficient right VA collateral circulation, and the right VA was slightly smaller than the left; brainstem auditory evoked potential and stump pressure monitoring were simultaneously conducted. During inflation of the balloon catheter, no obvious improvement of his radicular symptoms was recognized, probably because of the remaining pulsatile compression caused by enough stump pressure.
**Operation.** The patient underwent a vascular decompressive procedure via a left-sided anterolateral cervical approach. The anterior wall of the left transverse foramen of the C-4 and C-5 vertebrae, the left posterolateral aspect of the C-4 VB, and the left posterolateral portion of the intervertebral disc at C4–5 were removed. The left VA loop tightly pinched the C-5 nerve root in the intervertebral foramen (Fig. 3A). The complete release of the adhesive VA loop from the affected nerve root was thought to have a considerable risk of causing nerve root damage. Therefore, the left VA was severed at the proximal and distal aspects of the loop, and an end-to-end anastomosis was performed during brainstem auditory evoked potential monitoring (Fig. 3B). This vascular reconstructive procedure required minimal neurovascular dissection of the C-5 nerve root. Postreconstruction, intraoperative pulse Doppler ultrasonography revealed a reduction in the turbulence and increased blood flow in the left VA.

**Postoperative Course.** The patient’s radicular symptoms and dizziness resolved immediately after surgery. He was discharged with no neurological deficits after undergoing postoperative left VA angiography (Fig. 4). There were no signs of recurrence within the 2-year follow-up period.

**Discussion**

Since Hadley\(^1\) first reported the destructive change occurring in the VB caused by tortuosity of the VA, more than 30 cases of bone erosion, neurovascular compression, and/or VBI due to VA tortuosity or loop formation have been reported.\(^{1-10,12-21,23,24}\) In reviewing reports on symptomatic tortuous VA, including the case presented here,\(^{1-3,6,8,12,13,17-21,23,24}\) we found six cases of C4–5 lesions, followed by four cases of C5–6 lesions, three cases of C1–2 lesions, and three cases of C3–4 lesions. Nine cases

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**Fig. 1.** A: Left anterior oblique cervical radiograph revealing a widening of the left C4–5 intervertebral foramen caused by erosion of the posterolateral aspect of the VB and the inferior portion of the pedicle of C-4 (arrow). B and C: Left anteroposterior (B) and right anterior oblique (C) VA angiograms demonstrating a tight loop formation and migration into the C4–5 intervertebral foramen.

**Fig. 2.** Axial magnetic resonance images obtained at C-4 (A) and C4–5 (B), demonstrating the left VA loop in the widened C4–5 intervertebral foramen.
had left-sided, six had right-sided, and one had bilateral lesions. There was no evidence of sex predominance (age range 37–75 years, mean 55 years).

The clinical and neuroimaging characteristics of VA tortuosity have been described in detail elsewhere.\textsuperscript{1–3, 6–9,12,15,18,19,21,23,24}

The mechanism by which the VA loop forms and migrates into the intervertebral foramen is unclear. Oga, et al.\textsuperscript{15} have reported a detailed prospective study of the VA tortuosity in 22 cases in which anterior cervical decompression was performed, and they concluded that the extent of the VA tortuosity was correlated with the grade of the cervical spondylosis. Some authors have speculated that hemodynamic stress might be a factor in the formation of this lesion because of the frequent association of high blood pressure and arteriosclerosis.\textsuperscript{2, 5, 24} In reviewing the nine cases in which data were provided on bilateral VAs, we found that the affected VA was larger than or equal in size to the contralateral artery in all cases.\textsuperscript{12–15, 17,18,20,23} Therefore, it is likely that the relative elongation of the VA, which is fixed at the transverse foramen, is caused by narrowing of the disc space, which is followed by the

Fig. 3. A: Intraoperative photograph and corresponding drawing (right) of the left VA loop tightly pinching the C-5 nerve root in the intervertebral foramen. The structures were exposed after removal of the anterior wall of the left transverse foramen of the C-4 and C-5 vertebrae, left posterolateral aspect of the C-4 VB, and left posterolateral portion of the intervertebral disc at C4–5; the procedure was performed via a left anterolateral approach. B: Intraoperative photograph and corresponding drawing (right) after a vascular reconstruction of the VA loop. The artery was severed at the proximal and distal portions of the loop, and an end-to-end anastomosis was performed.
A tortuous VA has occasionally been known to cause VBI.\textsuperscript{3,11,15,17} It remains unclear whether the VBI demonstrated in our patient was a consequence of the VA loop. Unequivocal improvement of the arterial flow confirmed by the intraoperative pulse Doppler ultrasonography, as well as the patient’s excellent postoperative outcome (no recurrence of dizziness), are thought to be evidence implicating the role of the VA loop in the occurrence of VBI.

Reports in which this rare entity has been documented have been scarce, and little attention has been focused on the migrated VA during the anterior cervical decompressive procedure.\textsuperscript{15,22} The information provided in this report is also of critical importance when using the usual anterior cervical approach so as to avoid a serious or fatal complication of VA injury.

Conclusions

The authors have presented the first case in which vascular reconstruction was successfully performed to treat a symptomatic VA loop; this procedure has a lower risk of the nerve root injury, even if the offending artery loop is tightly adhesive. Theoretically, this reported procedure provides complete and probably permanent relief of the radicular and/or circulatory symptoms, while sparing the main part of the bony structures of the vertebrae.

The authors believe that proper and comprehensive vascular reconstruction of a symptomatic VA loop should be the therapeutic option of choice, after comprehensive pre-operative evaluation including the balloon occlusion test to avoid vertebrobasilar ischemia.

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References

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