Operative V2 decompression for traumatic vertebrobasilar insufficiency: illustrative case

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BACKGROUND Blunt vertebral artery injuries after cervical trauma due to the close anatomical relationship of the vertebral artery to the cervical spine may have fatal consequences because of posterior circulation ischemia and vertebrobasilar insufficiency. While the standard of care remains medical treatment by anticoagulation or antiplatelet therapy, surgical decompression of the vertebral artery is rarely indicated.

OBSERVATIONS The authors present a case of selective decompression of a traumatically constricted vertebral artery within the transverse foramen of C2 presenting with vertebrobasilar insufficiency due to bilateral aplasia of the posterior communicating arteries and contralateral hypoplasia of the vertebral artery.

LESSONS Because of their close relationship to the cervical spine, the vertebral arteries are at risk for blunt injury, which may present asymptptomatically or with symptoms of posterior circulation ischemia or vertebrobasilar insufficiency either immediately or after a latency phase. The anatomical variability of (1) the vertebral arteries, (2) collateral brainstem perfusion, and (3) the individual injury pattern demands individualized treatment strategies. If endovascular treatment of hemodynamically relevant stenosis of the V2 segment of the vertebral artery poses too high a risk for vessel injury, decompression of the transverse foramen can be performed safely and without risk to the biomechanical stability of the cervical spine.

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KEYWORDS vascular spinal neurosurgery; blunt vertebral artery injuries; vertebrobasilar insufficiency

Illustrative Case

History and Examination

An 84-year-old female patient with chronic rotational vertigo and new neck pain after a fall on the back of the head was admitted to the neurosurgical department of an associated hospital. Computed tomography (CT) imaging of the head and neck showed a moderately dislocated C2 odontoid fracture similar to type III according to Anderson and D’Alonzo1 with involvement of the transverse foramen (Fig. 1) and with traumatic stenosis of the V2 segment of the left vertebral artery as well as a fracture of the spinous process of the left vertebral artery in the transverse foramen of C2 after a C2 fracture presenting with vertebrobasilar insufficiency due to concomitant bilateral aplasia of the posterior communicating arteries and contralateral hypoplasia of the vertebral artery, rendering the stenotic vertebral artery the only major vessel perfusing the brainstem.
C3. Stenosis of the left vertebral artery was confirmed by ultrasound and CT angiography (Denver grade 2). After extensive consultation with the patient, an attempt at conservative treatment with a cervical orthosis was made. However, after 2 days, the patient showed new symptoms of vertebrobasilar insufficiency with multiple syncopy episodes and reduced consciousness after sitting up in bed. While repeat CT imaging of the cervical spine showed no change in the fractures, repeat ultrasound of the left vertebral artery showed progressive stenosis. Because of the increasing threat of brainstem perfusion with bilateral aplastic posterior communicating arteries and a hypoplastic right vertebral artery (Fig. 2), the patient was transferred to our institution for additional diagnostics and definitive treatment. Digital subtraction angiography showed high-grade stenosis of the V2 segment of the left vertebral artery in the transverse foramen of C2 (Fig. 2). While the fracture itself was treatable via a conservative approach, obstruction of the left vertebral artery led to clinical signs of increasing vascular insufficiency of the posterior circulation—being the only blood supply due to the individual anatomy of circle of Willis (Fig. 2). We discussed this case extensively in our neurovascular board. Given the obstruction by bone fragments, endovascular intervention was ruled out because of the risk of piercing the blood vessel. Without options for interventional therapy, the indication for selective surgical decompression of the left vertebral artery at the transverse foramen of C2 was given.

Operative Treatment

The patient was put in the prone position with a slightly elevated upper body and the head fixated in a head clamp. The left half of C0 to C3 was exposed via a dorsal median skin incision. Intraoperatively, an elongated left vertebral artery with a caudal curve of V3 beneath the stenosis of V2 in the transverse foramen of C2 was microsurgically exposed. The stenosis was confirmed by both a microDoppler ultrasound probe (16 MHz) and indocyanine green (ICG) videoangiography. Afterward, circumferentially constricting bone fragments and the intervertebral disc herniated laterally toward the transverse foramen were carefully removed from V2 with Kerrison punches and micro-scissors. Sufficient perfusion of the left vertebral artery after operative decompression was again confirmed by ICG videoangiography and microDoppler ultrasound before the patient was closed up. The extent of decompression is shown in Fig. 3.

Postoperative Course

CT angiography on postoperative day 1 showed complete removal of the vertebral artery stenosis. Postoperatively, all signs of vertebrobasilar insufficiency receded immediately, and the patient was mobilized with physiotherapy while still wearing a cervical orthosis due to her C2 fracture. While the patient was able to walk with a rollator, she remained insecure after her traumatic experience and still intermittently experienced attacks of chronic rotational vertigo, which differed significantly in character from the vertebrobasilar insufficiency experienced previously and subsided after a few weeks. The patient was able to climb 40 steps on a staircase when discharged. At the 3-month follow-up, the patient’s symptoms had resolved completely (Fig. 4), and magnetic resonance imaging and Doppler ultrasound showed a patent left vertebral artery without stenosis and an adequate healing process without increasing dislocation, pseudarthrosis, or spinal stenosis.
Discussion

Observations

The close anatomical relationship of the vertebral artery to the cervical spine predisposes it to blunt traumatic injury, which is commonly classified according to the Denver criteria, originally used to evaluate for angiographic diagnosis of blunt carotid arterial injuries and later transferred to blunt cerebrovascular injuries in general (Table 1).²

BVAIs can have fatal consequences due to posterior circulation ischemia in up to 25% of cases and show an overall mortality of 4%–8%.³,⁴ Particularly the V2 segment of the vertebral artery appears to be at risk of injury due to its relative immobilization within the foramina transversa. Characteristic patterns of cervical spine fractures associated with BVAI are fractures of the foramen transversum, subluxation, and fractures of C1–3. Overall, these injury types comprise approximately 70% of all cervical spine fractures.⁵–⁷ Multisegmental fractures of the foramina transversa show a particular predilection for BVAI.⁸ Within the upper cervical spine, fractures of C2 are a high-risk constellation with an incidence of BVAI

<table>
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<tr>
<th>Grade</th>
<th>Description</th>
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<tr>
<td>I</td>
<td>Irregularity of the vessel wall or a dissection/intramural hematoma with &lt;25% luminal stenosis</td>
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<tr>
<td>II</td>
<td>Intraluminal thrombus or raised intimal flap is visualized, or dissection/intramural hematoma with ≥25% luminal narrowing</td>
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<tr>
<td>III</td>
<td>Pseudo-aneurysms</td>
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<td>IV</td>
<td>Vessel occlusion</td>
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See also Desouza et al.⁴
of approximately 17% in odontoid fractures and 27% in traumatic spondylolisthesis of C2. However, depending on the individual degree of collateralization of the posterior circulation, BVAI may stay asymptomatic or show delayed development of symptoms after hours to days, which impedes screening for BVAI solely based on clinical grounds. Therefore, screening of trauma patients for BVAI with CT angiography has been widely established, with ongoing controversy regarding the exact indications for radiological screening for BVAI. The early diagnosis of BVAI could be increased to almost 100% through the use of expanded Denver screening criteria, which take into account major concomitant injuries in addition to spine fractures and which have since been evaluated for CT angiography. Nevertheless, 4-vessel cerebrovascular angiography remains the gold standard of BVAI diagnosis due to relevant rates of false-positive and false-negative results after CT angiography, depending on the technique used.

Either anticoagulation or antiplatelet therapy is considered the standard of care for BVAI, while endovascular stenting or vertebral artery occlusion remain in case anticoagulation is contraindicated. Surgical treatment of BVAI is technically challenging with high morbidity and mortality, which is why it is usually reserved for traumatic transections with severe hemorrhage or as an individual case-by-case decision. Iatrogenic surgical injury of the vertebral artery is a feared complication in surgery of the upper cervical spine, with an incidence of up to 1.35% in posterior fixation of C1–2. Here, we present a rare case of selective surgical decompression of a BVAI by external compression of the left vertebral artery fracture fragments in the foramen transversum, which presented with clinical signs of vertebrobasilar insufficiency due to lack of collateralization (bilateral aplastic posterior communicating artery and with clinical signs of vertebrobasilar insufficiency). The early diagnosis of BVAI could be increased to almost 100% through the use of expanded Denver screening criteria, which take into account major concomitant injuries in addition to spine fractures and which have since been evaluated for CT angiography. Nevertheless, 4-vessel cerebrovascular angiography remains the gold standard of BVAI diagnosis due to relevant rates of false-positive and false-negative results after CT angiography, depending on the technique used.

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This surgery was deliberately carried out in a minimally invasive way by sole decompression of the left transverse foramen without stabilizing the C2 fracture. This is in accordance with Zaidi et al., who already emphasized the adequacy of selective decompression without fusion via resection of a part of the posterior C1 arch for bow hunter syndrome without a traumatic etiology. We chose not to stabilize this patient despite a dislocated cervical fracture for multiple reasons. First, the patient’s age was considered a significant risk factor for a bigger surgery such as a combined ventro-dorsal approach for posterior decompression of the transverse foramen and anterior instrumentation of the odontoid process or a purely dorsal instrumentation of the upper cervical spine. Second, any instrumented surgery of C1 and C2 bears a relevant risk of injury to the patient’s last remaining vessel perfusing the brainstem. The compressed left vertebral artery displayed an aberrant ecstatic course with a larger risk for injury. Last, we considered limited decompression of an already fractured and dislocated transverse foramen not to be a significant contribution to destabilization of the upper cervical spine. The craniovertebral junction possesses a wide array of ligamentous support structures, and a C2 fracture with abundant surface area of cancellous bone at the interface of fracture fragments usually shows a good healing tendency.

Lessons
In summary, this case illustrates one option for the rare surgical treatment of a BVAI in high-risk patients. The anatomical variability of (1) the vertebral arteries, (2) collateral brainstem perfusion, and (3) the individual injury pattern demands individualized treatment strategies. If endovascular treatment of hemodynamically relevant stenosis of the V2 segment of the vertebral artery poses too high a risk for vessel injury, decompression of the transverse foramen can be performed safely and without particular risk to the biomechanical stability of the cervical spine.

References
Disclosures
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Conception and design: ML Moskopp, Sannwald, D Moskopp. Acquisition of data: all authors. Analysis and interpretation of data: all authors. Drafting of the article: ML Moskopp, Sannwald. Critically revising the article: all authors. Reviewed submitted version of the manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: ML Moskopp. Administrative/technical/material support: all authors. Study supervision: D Moskopp. Operating surgeon: D Moskopp.

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