Sectioning of C2 nerve roots during C1–2 fusion: report of aberrant vertebral artery during C2 nerve root sectioning. Illustrative case

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BACKGROUND Sectioning the C2 nerve root is increasingly utilized during posterior C1–2 fusion, as the nerve overlies the entry point for C1 lateral mass screws and the C1–2 joint. Nerve sectioning improves visualization for screw placement and enables joint decortication for arthrodesis. While rare, vascular injury is a devastating complication of atlantoaxial fusion. Anomalous vascular anatomy at C1–2 greatly increases risk of iatrogenic injury.

OBSERVATIONS A 78-year-old female with rheumatoid arthritis and prior C2–7 fusion presented with myelopathy from a compressive pannus at C1–2. She underwent C1 laminectomy and C1–2 posterior instrumented fusion. Intraoperatively, arterial bleeding occurred as the right C2 nerve root was sectioned. Vertebral artery injury was suspected, and tamponade was performed while vascular control was established. The artery passed aberrantly beneath the nerve root in the C1–2 foramen. It was repaired microsurgically, and patency was confirmed using indocyanine green. The remainder of the fusion was aborted. The patient wore a cervical collar and was treated with aspirin for 6 weeks before undergoing instrumented fusion. The patient suffered no deficits.

LESSONS Although rare, anomalous vertebral artery anatomy increases risk of injury at time of C2 nerve root sectioning. Preoperative assessment of the vasculature is vital.

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KEYWORDS aberrant vertebral artery; vertebral artery injury; sectioning C2 nerve root; atlantoaxial fusion; C1–2 fusion

The Goel–Harms procedure is a commonly used posterior C1–2 fixation technique,¹ frequently used at our institution when stabilization at these levels is required. While remaining distinctly infrequent, vascular injury while operating in this area is a potential complication with potentially devastating consequence. As such, recognition of anatomical variance is vital to patient safety and surgical efficacy. Details of such aberrancy have been described; however, descriptions of resultant iatrogenic injury and the subsequent intraoperative management, postoperative course, and outcomes are less commonly reported. Here, we report a case of vertebral artery (VA) injury due to anomalous anatomy during C2 nerve root sectioning and the subsequent management, as well as a brief review of the literature regarding vascular aberrancy in this anatomical region.

Illustrative Case

Clinical Presentation and Neuroimaging

A 78-year-old White female with a history of progressive myelopathy treated previously via a cervical laminectomy of C3–7 with concomitant fusion from C2–T2 represented with complaints of fairly rapidly progressive myelopathy. Over the previous 2 months, she reported progressive quadriparesis with several falls. Imaging obtained at the time of presentation demonstrated a solid fusion mass extending from C2 to T2 with interval development of a retro-odontoid pannus causing kinking of her upper cervical cord at the craniocervical junction (Fig. 1). Given her rapid deterioration, the patient was offered an extension of her fusion to C1 with laminectomy and decompression.

ABBREVIATIONS CTA = computed tomography angiography; DSA = digital subtraction angiography; MRI = magnetic resonance imaging; PICA = posterior inferior cerebellar artery; VA = vertebral artery.

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FIG. 1. Sagittal computed tomography image demonstrating solid fusion mass, as well as a retroodontoid pannus.

Operative Intervention

After exposure of her previous construct and confirmation of a solid fusion mass, attention was turned to placement of bilateral C1 lateral mass screws. The C2 pars screws were removed for better visualization, and the venous complex within the C1–2 foramen was cauterized with bipolar cautery bilaterally. It is routine practice at our institution to sacrifice the C2 nerve root when placing C1 lateral mass screws. During sharp dissection around the cephalad aspect of the right C2 nerve root beneath the C1 posterior arch, bright, pulsatile red blood was encountered. Suspecting vertebral artery injury and previously unrecognized aberrancy, the foramen was packed and the bleeding controlled. Attention was then turned to obtaining proximal and distal control of the injured vessel. Both points of control were obtained several millimeters from the site of injury, and temporary Yasargil aneurysm clips were placed.

The operative microscope was quickly brought into the field, and the arteriotomy site was inspected, revealing approximately 60–80% transection of the artery with clean, sharp margins. Having no knowledge regarding the patient's collateral viability, the distal temporary clip was momentarily removed to assess for retrograde flow. Bleeding was found to be brisk, suggesting adequate basilar perfusion. Despite favorable retrograde flow, the decision was made to attempt to repair the arteriotomy given clear dominance of the right VA flow void on T2-weighted sequences on her preoperative imaging. The lumen was copiously irrigated with pure heparin, and all debris was removed. The arteriotomy was then closed using a running 6–0 Prolene suture from either end. Prior to closure of the lumen, the site of injury was flushed with both antero- and retrograde bleeding before being filled with pure heparin. Indocyanine green was then used to verify patency through the site of injury. The total cross clamp time was approximately 50 minutes.

Given the dominance of the injured vessel, the decision was made to forgo placing contralateral instrumentation so as not to

place the left VA at risk of injury. A C1 laminectomy was performed to afford adequate spinal cord decompression, and the decision was made to abort the procedure with plans to place the patient in a cervical collar and obtain definitive vascular imaging.

Postoperative Course/Outcome

Postoperatively, the patient emerged without neurological deficits outside of her previous myelopathy. The patient was placed in a cervical collar and digital subtraction angiography (DSA) demonstrated patency and dominance of the right VA (Fig. 2). Computed tomography angiography (CTA) demonstrated aberrancy of the right VA, showing it lying within the C2 foramen under the posterior ring of C1 (Fig. 3). Ultimately, the patient was discharged home and underwent an occipital–C4 fusion with placement of a right C1 lateral mass screw and left C2 pedicle screw under navigation guidance (Fig. 4). Two month's postoperatively, imaging and follow-up have demonstrated resolution of her retroodontoid pannus without progression of her symptomatology (Fig. 5).

Discussion

Observations

While rare, anomalous vascular anatomy remains a vital consideration for surgeons performing surgeries at the atlantoaxial/craniocervical junctions. The consequences of these abnormalities remaining unrecognized or unanticipated are potentially devastating. We have described an unrecognized aberrant loop of a dominant V3 within the

FIG. 2. Postoperative DSA with selective right VA injection demonstrating patency after repair of the iatrogenic arteriotomy.

FIG. 3. CTA demonstrating aberrancy of the right VA with a course of travel within the C2 foramen overlying the lateral mass of C1, under the posterior arch.

FIG. 5. Postoperative MRI demonstrating resolution of the retroodontoid pannus 2 months after occiput to C4 fusion.

C1–2 foramen, overlying the dorsum of the C1 lateral mass along with its resulting injury and subsequent repair.

In his review of developmental anomalies of the distal VA and posterior inferior cerebellar artery (PICA), Myoung Kim theorizes an embryological origin of such anomalies stemming from development of the posterior/lateral spinal arteries. In an analysis of 3,927 patients using both DSA and CTA, Kim describes 44 instances of anomalies in a total of 36 patients. Within this cohort are described 19 aberrant intradural courses at C2, 7 of which had an accompanying normal VA. Further described are 4 instances of V3 fenestration, as well as 9 and 3 patients with PICA origin at the levels of C1 and C2, respectively.²

FIG. 4. Postoperative lateral radiograph demonstrating an occiput to C4 fusion with placement of a right C1 lateral mass screw and left C2 pedicle screw.

There are several bony anatomical findings on imaging that should prompt concern for a potentially aberrant vertebral artery. Lall et al., in their review of complications associated with craniocervical fusions, found an overall rate of vertebral artery injury as high as 5.8%, with increased risk of vascular injury in patients with an arcuate foramen at C1.³ Wang et al. found that patients with occipitalization of C1 had as many as 4 different potential courses of the vertebral artery, including entering the spinal canal both above and below C1.⁴ Uchino et al., in their series characterizing vertebral artery anatomy in MRA, found an overall rate of aberrant vertebral artery anatomy at C1–2 in 5.0% of patients. They noted that there were 3 main subtypes: a PICA arising from C1–2 (1%), a fenestrated vertebral artery (1%), and a persistent fetal first intersegmental artery (3%).⁵ Another group, Brinjikji et al., further noted that even in the absence of aberrant anatomy, the caudal loop of the PICA can descend as far as C1–2 in up to 1% of patients' angiograms.⁶

At our institution, routine angiographic imaging of the axial spine is not obtained in the absence of high-impact trauma prior to atlantoaxial arthrodesis in patients without bony anatomical variations. Sectioning of the preganglionic C2 nerve root is surgeon-dependent with the 2 highest-volume surgeons routinely performing sectioning, citing improved, soft tissue-free access to the C1–2 joint, improved hemostasis, and decreased instances of postoperative neuralgia. In their series, Dewan et al. also reported lower blood loss and decreased incidence of postoperative C2 neuralgia when sectioning the C2 nerve root compared to those patients in whom it was left intact.⁷ Dewan et al. also reported that those few patients reporting postoperative C2 numbness found it not at all disabling, while those patients who reported C2 neuralgia (with intact nerve roots) found it severely disabling.⁷ Yamagata et al. also reported a very low incidence of postoperative neuralgia when sectioning the C2 nerve root.⁸

The described patient is the first known instance at our institution to have a complication due to gross vascular aberrancy during a Goel–Harms arthrodesis. In that the aberrant loop was overlying the entire C1 lateral mass, we argue that sparing of the C2 nerve

root would likely not have avoided vascular injury in this instance. Indeed, it is hypothesized that without prior sectioning of the nerve root, rapid control and repair of the injury would have been much more challenging. Given the low overall prevalence of these aberrant anatomical variations, we would not recommend CTA imaging on every patient undergoing C1–2 posterior instrumentation. Rather, we recommend careful review of the preoperative imaging, and if the operating surgeon suspects vascular aberrancy based on abnormal flow voids or bony architecture, further characterization with CTA is then warranted.

Nassr et al. reported on a case in which such a scenario occurred.⁹ In that case, a patient was undergoing occiput–C6 posterior instrumentation and suffered a vascular injury to an aberrant PICA coursing adjacent to the C1 nerve root. The injury was not detected until the postoperative period, when the patient was noted to have dysarthria and dysdiadochokinesia, and magnetic resonance imaging (MRI) revealed a PICA distribution infarct. In that case, the patient was treated with anticoagulation.

In general, at our institution, once an iatrogenic vertebral artery injury is incurred, attempts are made at primary repair in the manner described above; further exposure is carried out, proximal and distal control are obtained, and direct primary repair carried out, with angiography immediately postoperatively to assess patency of the vessel. Packing for the purpose of tamponade is generally a temporary measure at our practice, while preparing for primary repair. If packing, we recommend avoidance of injectable hemostatic matrices, as they carry potential risk of thrombosis and distal embolism. Other options include endovascular intervention, or even packing alone, although some authors report a high risk of pseudoaneurysm and arteriovenous fistula in those cases.¹⁰

Lessons

While rare, unrecognized vascular aberrancy at the atlantoaxial junction greatly increases the risk of a potentially devastating vascular complication during C1–2 fusion procedures. Routine preoperative vascular imaging may reduce the frequency of such events, particularly given the potentially dire consequences of iatrogenic vascular injury at this location. In the setting of sharp injury, direct repair of the vertebral artery is possible but likely requires sacrifice of the C2 nerve root for proper control and creation of an appropriate working corridor.

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Disclosures

Dr. Fassett is a consultant and scientific advisory board member of Aesculap Implant Systems.

Author Contributions

Conception and design: Kahn, MacMahon, Fassett. Acquisition of data: MacMahon, Klopfenstein, Fassett. Analysis and interpretation of data: Kahn, Russell, Fassett. Drafting the article: Kahn, MacMahon, Fassett. Critically revising the article: Kahn, MacMahon, Russell, Fassett. Reviewed submitted version of manuscript: Kahn, Russell, Klopfenstein, Fassett. Approved the final version of the manuscript on behalf of all authors: Kahn. Administrative/technical/material support: Russell.

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