Vertebral artery injury and severely displaced odontoid fracture: the case for early reduction

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Abstract

Purpose To report a novel treatment method for vertebral artery occlusion. Vertebral artery injuries have a high association with specific cervical fractures including atlanto-axial fractures, displaced fracture patterns, and transverse foramen fractures. Optimal medical management of the occluded vertebral artery has yet to be determined; however, there is an extremely high complication rate with systemic anticoagulation in these patients. Furthermore, unlike appendicular skeleton fracture-dislocations with vascular injury, there is no clear consensus as to the optimal acute management of the displaced odontoid fracture with or without vertebral artery injury.

Methods We report on a severely displaced odontoid fracture that was found to have a vertebral artery injury. Medical records and imaging were reviewed.

Results An 82-year-old female presented to our hospital with a type IIb odontoid fracture after sustaining a ground-level fall. Pertinent physical exam findings were ecchymosis on the left side of her forehead and posterior cervical pain without neurologic deficits. An MRA showed an occluded left vertebral artery. The patient was placed in early cervical traction and the fracture was reduced within 12 h of presentation. Following surgical stabilization, an MR angiogram showed complete reperfusion of the vertebral artery without intimal tear.

Conclusion To our knowledge, this is the first report of a displaced odontoid fracture in which cervical traction was used to restore the perfusion of the vertebral artery. Cervical traction may obviate the need for systemic anticoagulation and should be considered in patients who have an identifiable compression of the vertebral artery even if neurologically intact.

Keywords Vertebral artery injury · Odontoid fracture · Cervical traction · Computed tomography angiography · Cervical spine injury

Case presentation

An 82-year-old female with multiple medical co-morbidities presented to the emergency department after a hyperextension neck injury from a ground-level fall. Physical examination identified a neurologically intact patient with forehead ecchymosis and posterior cervical tenderness.

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Fig. 1 Injury films **a** lateral C-spine radiograph and **b** sagittal C-spine CT scan demonstrating a trans-odontoid atlanto-axial posterior luxation fracture

Fig. 2 MRA prior to reduction. Arrows point to areas of left vertebral artery flow voids. Arrow head points to an unrelated patent vascular structure

Radiographs identified a trans-odontoid atlanto-axial luxation fracture (Fig. 1a) [1]. A non-contrast CT scan was obtained for improved visualization of the fracture

anatomy (Fig. 1b) and an MRA was performed to evaluate the cervical vascular anatomy prior to surgical stabilization (Fig. 2). There was decreased flow signal in the mid-V2 segment of the left vertebral artery and no flow within the V3 and V4 segments. The right vertebral artery was patent without flow-limiting stenosis. No anticoagulants or anti-platelet medications were started at that time. The odontoid fracture was displaced 100 % posterior from the C2 vertebral body.

Of note, on close examination of Fig. 2 there is an intervening vascular structure between areas of flow void (arrow head). This is no doubt a non-related patent vascular structure due to the 3D reformation technique used. This structure does not correspond with the size, or morphology, or location of the left vertebral artery. As a result, our interpretation of the intervening space between the two long arrows is complete flow void within the left vertebral artery V3 and V4 segments.

Historical review

Injury to the vertebral artery has received considerable attention and the pathway of the vertebral artery has been extensively mapped. Risk factors associated with VAI include cervical subluxations [2–4], fractures involving the transverse foramen [3–5], and fractures involving the upper cervical spine [3, 4, 6]. Presenting factors suggestive of VAI include facial hemorrhage, expanding cervical hematoma, lateralizing neurological deficit, cervical hyperextension–rotation or hyperflexion mechanism, closed head injury with diffuse axonal injury, near hanging and seat belt

injuries to the neck [7]. The rate of vertebral artery injury associated with cervical spine injuries within the literature is reported between 11 and 80 % [4, 7, 8]. The literature suggests an 18 % prevalence of VAI in patients with C2 fractures and noted displacement to be a risk factor [9].

CT catheter angiography is the gold standard for diagnosis of VAI but has significant risks, including iatrogenic injury, stroke and death [2, 9–11]. Friedman et al. [8] first described magnetic resonance angiography (MRA) as an imaging modality to detect vertebral artery injuries. Ren et al. [12] confirmed the accuracy of MRA but noted it may lack the ability to identify small intimal tears. More recently, computed tomography angiography (CTA) has been shown to be a highly sensitive and specific modality for diagnosis of vertebral artery pathology in the setting of acute cervical spine trauma as well as chronic vertebral artery pathology [13–15]. The benefit of CTA is its decreased cost compared to MRA, extremely rapid performance time, and accessibility. The most significant detriment is its reliance on IV contrast.

Rationale for treatment

Vertebral artery injury is a relatively common sequelae of cervical spine injuries, and specifically displaced odontoid fractures. Due to the proximity of the atlanto-axial articulation with the transition from V2 to V3 segments, it follows that this would be an expected area of vertebral artery flow void. Subsequently, the questions become, is there a need to do a preoperative vascular study (MR or CT angiography) when C2 injuries are present and once a vertebral artery injury has been identified, how should one proceed?

Surgery at the atlanto-axial level carries the risk of iatrogenic vertebral artery injury: injury during the exposure of the C1 or C2 posterior arch and/or during the placement of screws (Magerl, Judet, or Harms techniques) are well-known risks. Anomalies of the VA and posterior inferior cerebellar arteries (PICA) at the C1–C2 levels are observed in 2.3–4.7 % of the cases and the knowledge of these variations is helpful in planning such surgeries [16]. Additionally, in the elderly there may be a preexisting pathology of one of the vertebral arteries and knowledge of the anatomy and bilateral patency before proceeding with surgery may be helpful.

Unfortunately, there is very little high-quality data driving the management of VAI. Treatment for symptomatic vertebral artery injury varies from watch and wait, to antiplatelet medications, anticoagulant infusions, endovascular treatment and surgery [7]. Treatment of

asymptomatic patients likewise remains controversial with no current level 1 recommendation [6, 11, 17]. Anticoagulation carries significant risks. Up to 14 % of patients anticoagulated with IV heparin for VAI will experience significant complications. Consequently, the American Association of Neurological Surgeons neither recommends for nor against anticoagulation in asymptomatic patients and refrains from making recommendations for symptomatic patients [7]. Long-term studies have noted that most VAIs do not reconstitute with current treatment strategies [18]. To our knowledge, neither cervical traction for treatment of a VAI has been described nor have high level of evidence guidelines for treatment of traumatic VAI been put forth.

A basic tenant of management of appendicular skeleton fractures and dislocations with vascular compromise is prompt reduction to establish flow through the obstructed vessel; typical examples are the brachial artery in pediatric supracondylar humerus fractures and the popliteal artery in knee dislocations. Vertebral artery injuries are more complex as they tend to be asymptomatic, at least initially. There is, however, no reason why the vertebral artery injury should behave differently than the vascular injuries mentioned above with respect to prompt reduction and restoration of flow. Based on the rationale that both symptomatic and asymptomatic VAI-related C2 fracture dislocation warrant prompt reduction and the previous reports that have identified an 18 % incidence of VAI in C2 fractures, we perform an MRA or CTA as a screening tool in displaced odontoid fractures [9].

Intervention

Upon presentation to our trauma center this patient underwent multiple diagnostic imaging studies including plain film, CT, and MRA. From the combination of MRA findings described above and the significant amount of displacement, our index of suspicion for vertebral artery injury was extremely high. As such, we opted not to proceed with a CT angiogram to confirm what we already thought to be true; a flow void within the left vertebral artery. Additionally, we did not feel a CTA would change our management.

Because of the significant displacement of the fracture, we elected for fracture dislocation reduction without preoperative anticoagulation. In the absence of neurologic compromise, we deemed it most appropriate to reduce the injury at the bedside with skeletal traction as opposed to bypassing medical clearance for an emergent closed reduction under anesthesia in the operating room.

Fig. 3 **a** Lateral radiograph confirming the reduction of the C2 fraction with 30 lbs of cervical traction. **b** After posterior fusion with Harms and Judet screws

Within 12 h of presentation, preoperative odontoid fracture reduction was complete with 30 lbs of cervical traction. Radiographs confirmed the reduction (Fig. 3a). The patient then underwent posterior stabilization with a screw and rod construct from C1 to C2 after medical clearance (Fig. 3b). Surgery was performed with great care, suspecting that the patient had only one patent vertebral artery. There were no cortical breaches appreciated during the procedure. Neuromonitoring was used and no change in baseline was detected during placement of instrumentation. An acute hypotensive episode of unknown etiology occurred near the end of the procedure after all instrumentation was placed. This was associated with loss of neuromonitoring. Additionally, the patient was unresponsive postoperatively for several hours and unable to be extubated in the operating room. As such, it was feared that perhaps the right vertebral artery (preoperatively patent VA) had been compromised intraoperatively. Imaging was obtained immediately after surgery to evaluate vascular patency and cerebrovascular perfusion. No evidence of infarction was identified and the C2 screws were encapsulated in bone within the pedicle. The MRA of the vertebral arteries with metal subtraction sequences showed complete flow throughout all four segments of the left vertebral artery (Fig. 4). The patient was subsequently extubated on postoperative day 1.

Fig. 4 MRA after reduction and C1–C2 posterior instrumentation. Arrows show the complete return of flow

Outcome and follow-up

The remainder of this patient's hospitalization was uneventful. At the time of extubation on postoperative day 1, there were no neurological deficits and the patient was discharged on postoperative day 7. The patient was immobilized in a brace for 6 weeks and the follow-up lasted 6 months. At 6 months post-surgery the fracture looked to be united and the instrumentation intact.

Conclusion

From this case report of a trans-odontoid atlanto-axial luxation fracture with vertebral artery injury, we recommend an MRA or CTA as a screening tool in displaced odontoid fractures for vascular injury. If a vertebral artery flow void is present and the patient is not obtunded, we recommend cervical traction to reduce the fracture regardless of neurologic status followed by immediate MRA or CTA. Reperfusion within the vertebral artery may obviate the need for anticoagulation or antiplatelet therapy, which carry a high risk of complications. Furthermore, three-dimensional reconstructions will help the surgeon better understand the upper cervical vascular anatomy, potentially avoiding a catastrophic breach of an anomalous vertebral artery.

Conflict of interest None of the authors has any potential conflict of interest.

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