

Implications of Vertebral Artery Blunt Injury to Cervical Spine Trauma Treatment: Short Narrative Review of the Literature Based on Four Cases

Elias Antoniadēs¹, Athanasiou Alkinoos¹, Sarlis Panagiotis², Polyzoidis Stavros², Keramidiotis Iraklis¹, Patsalas Ioannis³ and Magras Ioannis³

¹Residents of First Department of Neurosurgery, AHEPA University General Hospital, Aristotle University of Thessaloniki, 54124, Thessaloniki, Greece

²Consultants of First Department of Neurosurgery, AHEPA University General Hospital, Aristotle University of Thessaloniki, 54124, Thessaloniki, Greece

³Professors of Neurosurgery of First Department of Neurosurgery, AHEPA University General Hospital, Aristotle University of Thessaloniki, 54124, Thessaloniki, Greece

Correspondence to:

Elias Antoniadēs
Residents of First Department of Neurosurgery
AHEPA University General Hospital
Aristotle University of Thessaloniki
Thessaloniki, Greece
E-mail: eliasantoniad@yahoo.gr
Tel: +306945402822

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Abstract

Background: Vertebral injury after blunt cerebrovascular injury remains an underdiagnosed clinical entity. Its relatively indolent course may not raise physicians' suspicions and inadequate screening may be used. Even in cases, whereby it is confirmed with an angiographic examination, further dilemmas ensue regarding the administration of antithrombotic medication and the period of time when trauma treatment should take place.

Case Series: Herewith, we report of four patients who were treated in our clinic. Two of them suffered a subluxation warranting surgical reduction and anterior stabilization with plate and screws preceded by low- molecular-weight heparin administration. Both of them had intact motoric function of their upper extremities. The other two patients required no surgical procedure for their trauma and antithrombotic treatment initiated after completion of digital subtraction angiography.

Conclusions: We support that a scheduled operation should not dissuade surgeons from administering antithrombotic treatment. A definite operative treatment for underlying cervical spine trauma should be delayed until high risk period for stroke has passed, if no severe neurological deficit exists. Computed tomography angiography is an adequate, time and cost-effective method for VAI screening and diagnosis. As long as, no strong recommendations exist multicenter prospective trials have to be conducted.

Keywords

Vertebral artery, Vascular system injuries, Cerebrovascular trauma

Introduction

Blunt cerebrovascular injury (BCVI) involving the vertebral artery is considered an uncommon and still underdiagnosed entity [1], owing to inadequate screening and to initially indolent or even completely asymptomatic course of traumatic injuries of vertebral artery (VAI). Despite initial presentation, secondary adverse outcomes, including stroke and death are not uncommon, scaling up from 27-28% stroke rates for vertebral artery pseudoaneurysm and luminal occlusion to almost 100% in case of transection [2-4]. Considering that stroke risk is greater during the first 7 days, peaking within first 24hrs, and that clinical presentation remains the best predictor for BCVI, screening for the condition based upon the expanded Denver criteria has been established as the mainstay for diagnosis, initial management and definite treatment [1, 5-7]. Nowadays, the multiplicity

of radiological modalities and improved technology renders the detection of VAI easier, as non-invasive Computed Tomography Angiography (CTA) has proven to provide adequate screening and follow-up accuracy, boasts cost and time effectiveness and has shown similar patient outcomes to invasive four-vessel digital subtraction angiography [1, 2, 8-10]. Nonetheless, while outcomes have overall significantly improved and mortality or strokes rates have dropped, clinical recommendations remain at low or moderate level of evidence at best with regards to imaging build-up and BCVI treatment regimens [1, 11, 12]. Moreover, clinical questions regarding the implications of BCVI on treatment of underlying or concomitant cervical spine trauma have only recently been touched [12, 13]. Among others, treating surgeon has to often manage cervical spine trauma stabilization [14] against anticoagulation treatment for VAI, leading to delay of definite operative treatment, or evaluate intervention for the vascular injury [13]. In the context of this clinical discussion, we hereby present four patient cases with VAI due to BCVI that were treated in our department. None of the patients had demonstrated any major neurological deficit. Nonetheless, the proximity of the injury to foramen transversarium incited us to perform angiography which disclosed vertebral artery injuries.

Cases Series

1st patient

A 62-year-old male patient was admitted after a high-speed vehicle overturn with Glasgow Coma Scale (GCS) 15/15 and no neurological deficit. He suffered right side 2nd to 4th rib fractures, concomitant pneumothorax and pulmonary contusions. Brain and cervical spine CT showed a left traumatic ipsilateral subluxation of C2/C3 facet joint, C2 and C3 laminae fractures, C2 lateral mass fracture and left transverse foramen fracture. Supplementary cervical spine magnetic resonance imaging (MRI) demonstrated soft tissues edema and small spinal cord contusion at C3/C4 level (Figure 1a). CTA of cervical and cranial vessels was performed at admission, which revealed a flow void at the C2 segment of left vertebral artery (VA) (Figure 1b). MRI depicted small hemorrhagic foci

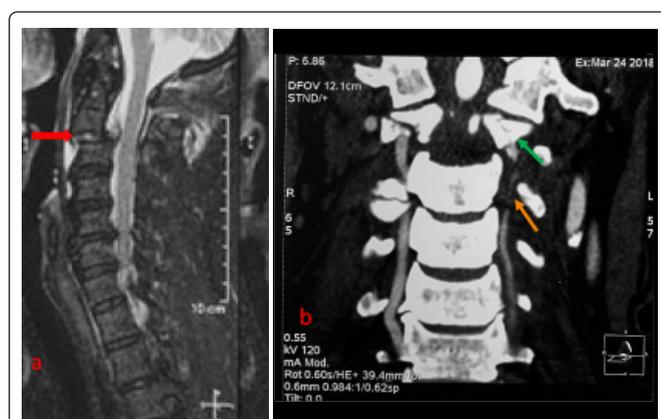


Figure 1a: C2/C3 subluxation as shown with red arrow.

Figure 1b: Stenosis of the left vertebral artery as shown with orange arrow and left lateral mass fracture as shown with the green arrow.

of internal capsule posterior limb bilaterally. He was initially transferred to our intermediate care unit (IMC), until cardio-pulmonary stabilization, a rigid cervical collar was Magnetic resonance angiography (MRA) of cervical region was also carried out and revealed thrombosis of V2 segment of the left VA. Brain applied and was treated with administration of high dose low molecular weight heparin (LMWH, tinzaparin sodium 14000 anti-Xa/0.7ml). Cervical stabilization was delayed for 15 days and he then underwent an anterior cervical discectomy at C2/C3 level with interbody fusion (ACDF) with polyetheretherketone (PEEK) cage and metal plate and screws placement. On second postoperative day anticoagulation treatment was administered again. His overall postoperative course was uneventful with no neurologic deficit and the patient was transported seven days later to a rehabilitation center continuing his anticoagulant treatment for the next six months. Twelve months after the accident the patient is fully mobile without neurologic deficits.

2nd patient

A 23-year-old male patient was admitted after a motorcycle accident while wearing helmet. With GCS 15/15 and no motor deficits. He had a slight hypesthesia over his right lateral forearm according to C6 nerve root distribution. Brain and cervical spine CT scan revealed a C5/C6 subluxation with a comminuted right C5/C6 facet and right C6 transverse process fractures (Figure 2a); in addition to that osseous fragments inside C6 transverse foramen were noticed. MRI/MRA demonstrated a slight canal stenosis and extensive vertebral artery occlusion of V2 segment. Treatment was initiated

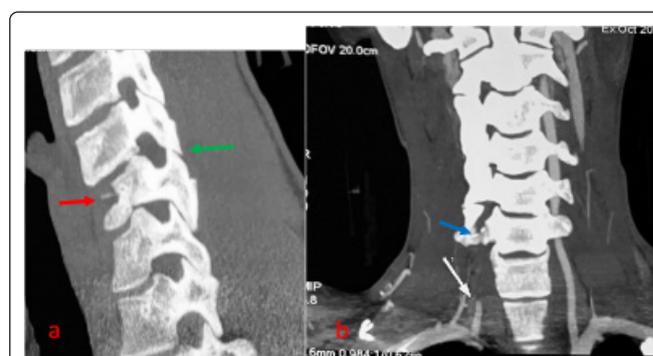


Figure 2a: Fracture of C6 body and C5/ C6 partial facet entrapment (red and green arrows, respectively).

Figure 2b: Thrombotic Occlusion of V2 segment of the right vertebral as shown with the white arrow and fracture of right C6 transverse process as shown with the blue arrow.

with tinzaparin sodium 14000 anti-Xa/0.7ml. On the following day cervical spine CTA showed the occlusion beginning just before the entrance of VA into the right transverse foramen of C6 vertebra (Figure 2b). On the contrary V4 and V3 segments were depicted. On the eighth day, DSA confirmed the thrombosis of V1 and V2 segments, while on 12th day a second CTA was performed which revealed a threadlike intraluminal flow of V1 and V2 segments. He was operated on the 15th day with a C5/C6 arthrectomy via a posterior approach

and an ACDF with plate and screws. On second postoperative day anticoagulation treatment was administered again. He was discharged one week later without hypesthesia, continuing his anticoagulation therapy for six months. One year afterwards his neurological status remains intact.

3rd patient

A 19-year-old male was admitted due to a car accident with intact neurological status. Whole body CT, performed at ER, showed C6 left lateral mass fracture (Figure 3a). His only subjective complaint was a mild neck pain. Twenty-four hours afterwards he started suffering frontally located headaches while in semi-sitting and sitting position, which made him remain bedridden intermittently. Thus, a CTA was performed and exhibited an absence of blood flow of V1 and V2 segments ipsilaterally to the fracture. Adjunct to that, MRI/MRA (Figure 3b) confirmed the aforementioned findings whereas ischemic infarction of spinal cord and brain were excluded. Finally, he underwent a DSA, which demonstrated collateral circulation and retrograde flow from the contralateral VA. He was treated with tinzaparin sodium 14000 anti-Xa/0.7ml and, upon completion of the angiographic investigation, 75 mg of clopidogrel per day, while the C6 lateral mass fracture was treated conservatively (no collar).



Figure 3a: C6 right lateral mass fracture in the proximity of the foramen (red arrow).

Figure 3b: Stenosis of the right vertebral artery (blue arrow).

4th patient

A 50-year-old patient was admitted after high speed collision to a wall with his car, presenting with no neurological symptoms. CT of cervical region depicted a non-dislocated fracture of type 1 C2 body fracture and left transverse process fracture extending to the adjacent vertebral foramen. The rest of the whole-body CT-examination was negative. Due to the radiological findings we proceeded to a CTA, which disclosed a stenosis of the V2 segment (Figure 4a, 4b). The diagnostic workup ended up with DSA, which confirmed the stenosis. We treated both the fracture and the vessel impairment non-operatively with rigid cervical collar and administering Xarelto® 20 mg as a daily dose, respectively. The patient was discharged intact after ten days having achieved full mobilization.



Figure 4a: Non-dislocated fracture of patient's C2 body and left transverse process (red thin arrows) extending to the juxtaposed foramen (red thick arrow).

Figure 4b: Non-injured right vertebral artery (orange arrow), partial blood flow (green arrow) owing to dissection and thrombus formation (blue arrow).

Discussion

Despite the low incidence of VAI (400 to 770 per 100.000) the correlation with serious morbidity and mortality is well documented [15-18]. Definition of high-risk patients has evolved since the first observations of Willis et al. [19] who attempted to define high-risk patients including parameters such as transverse foramen fracture violation and bilateral facets dislocation using DSA. Further have broaden the spectrum by estimating neurologic deficits, Horner syndrome, presence of midface fractures Le Fort I and II, skull base fractures and expanding neck soft tissue injuries [20]. In the context of nonpenetrating cervical injury, stretching is the attributed mechanism of lesion as observed in cadaveric models [21]. Intimal tunic continuity is initially disrupted with consequent thrombus formation or dissection with both of them leading to occlusion. Due to its robust adventitia only by high energy events pseudoaneurysm or transection is to be observed [22].

DSA can reveal the alterations of intimal consistency and remains the gold standard of detecting VAI but CTA has demonstrated adequate screening and follow-up accuracy, cost and time effectiveness and similar patient outcomes [1, 2, 8-10, 23]. CTA can also be more easily incorporated to emergency room protocols [24], while MRA constitutes a non-invasive and non-ionizing alternative, that has been found in animal models comparable to DSA as a modality of imaging for VAI [25].

Both VAs may not contribute equally to blood supply and VA dominance is defined as more than one millimeter's difference in width. In a cadaveric study VAs were found to be equally wide in 61,5%, left was dominant in 21.2 % and right was dominant in 17.3% of cadavers, while hypoplastic VAs (diameter less than two millimeters) were found in 20.2% (left), 14.4% (right) and 4.8% (both) [26]. In other studies, left VA is considered dominant in 50% of cases, the right one in 25% and codominance is present in 25% of cases [27]. Despite that, ipsilateral VA occlusion is strongly associated with ischemia and devastating consequences [28]. Paired VAs behave as a parallel circuit of flow resistances. According to Kirchoff's second law current in those circuits is inversely proportional

to resistance. In addition to that Hagen-Poiseuille's law states that a minimal alteration in vascular diameter will significantly reduce flow due to the fact that the effect of alteration is raised to the fourth power. That means practically that a stenosis of 60-70% reduces flow by 90-95% and spontaneous thrombosis may ensue [29].

Early treatment of BCVI and VAI with antithrombotic has been shown to greatly reduce adverse neurological effects and improve patient outcomes, lowering mortality rates to 4-8% in case of VAI and stroke rates to ~0.5% in treated patients [1]. Endovascular treatment is to be considered in failure of conservative, possibly in pseudoaneurysms and in active extravasation, while operative treatment of BCVI is generally uncommon [6, 10, 12]. As a consequence, operative treatment of concomitant and underlying spinal trauma is subject to a difficult decision process that needs to take into account the patient neurological status and the urgency of decompression and stabilization against the degree of vascular injury and the need for early antithrombotic and possibly anticoagulant treatment [13]. As there is no clear evidence that cervical stabilization may actually positively affect the course of VAI [13], in cases where the patient neurology and cervical trauma permits, it can be considered safe to delay the definitive operative treatment until the stroke high risk period had passed. In our cases we demonstrate that initial management with LMWH possibly allows for a safe compromise during the diagnostic build-up and waiting period, regardless of final decision to operate or not.

Conclusions

- In vertebral artery injury, paired VAs and their interconnections provide an initial compensation of blood supply decelerating the manifestations of symptoms.
- CTA is an adequate, time and cost-effective method for VAI screening and diagnosis, allowing for imaging build-up (DSA and/or MRA) accordingly.
- We support that a scheduled operation should not dissuade surgeons from initiating antithrombotic treatment.
- Similarly, a definite operative treatment for underlying cervical spine trauma should be delayed until high risk period for stroke has passed, if neurology permits.
- Strong recommendations, though, do not exist. Multicenter, prospective, randomized trials, therefore, have to be conducted.

Conflicts of Interest

Authors declare no conflict of interest.

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