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Significance of Magnetic Resonance Imaging in the Diagnosis of Vertebral Artery Injury Associated with Blunt Cervical Spine Trauma

Hiroyuki Yokota, Takahiro Atsumi, Takashi Araki, Akira Fuse, Hidetaka Sato, Makoto Kawai and Yasuhiro Yamamoto

Department of Emergency and Critical Care Medicine, Graduate School of Medicine, Nippon Medical School

Abstract

Vertebral artery injury associated with non-penetrating cervical trauma is rare. We report 11 cases of vertebral artery injury diagnosed with magnetic resonance imaging (MRI) after blunt trauma to the cervical spine and discuss about the importance of MRI in the diagnosis of this injury. Seven cases were caused by motor vehicle accidents, three by diving accidents, and one by static compression of the neck. All of the patients had documented cervical spine fractures and dislocations. In three patients, the diagnosis of complete occlusion of the vertebral artery was made on the basis of MRI and digital subtraction angiography (DSA). In the other patients, mural injuries of the vertebral artery were demonstrated with DSA. These 11 patients presented with acute, nonspecific changes in neurological status. Two had infarctions of the cerebellum and brainstem. None were treated with anticoagulants. All of them survived and were discharged to other hospitals for physical and occupational therapy. Although DSA remains the gold standard for diagnosing vertebral artery injuries, MRI is a newer modality for assessing cervical cord injury, and it may be useful for evaluating the presence of vertebral injury after blunt cervical spine trauma.

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Key words: vertebral artery injury, blunt cervical spine trauma, magnetic resonance imaging

Introduction

Vertebral artery injury after blunt trauma does not have any specific signs, and it frequently remains undiagnosed[4]. In cases of fracture or dislocation involving the cervical spine, cervical four-vessel arteriography (CFVA), the gold standard for diagnosing these injuries, should be performed. However, unstable vital signs make it difficult to perform CFVA on all patients with cervical injury. Vertebral artery injury after blunt trauma to the cervical spine is rare, but the exact incidence of such injuries is unknown. In this report, we discuss about the significance of magnetic resonance imaging (MRI) in evaluating and diagnosing vertebral artery injury after blunt cervical trauma.

Correspondence to Hiroyuki Yokota, MD, Department of Emergency and Critical Care Medicine, Nippon Medical School Hospital, 1–1–5 Sendagi Bunkyo-ku, Tokyo 113–8603, Japan
E-mail: yokota@nms.ac.jp
Journal Website (http://www.nms.ac.jp/jnms/)

Materials and Methods

Between July 2000 and March 2005, 36 patients with blunt cervical cord injury and acute fracture and dislocation of the neck were admitted to our department. Eight of the patients had bilateral cervical facet dislocation, and 12 had unilateral cervical facet dislocation. Twenty-eight (77.8%) of the injuries had been caused by motor vehicle accidents, 7 (19.4%) by falls or diving, and 1 (2.8%) by static compression of the neck. Neck immobilization was carried out on all patients immediately on admission. After initial resuscitation, MRI of the cervical spine was performed on all patients to assess their cervical cord injuries, and to determine the patency of their vertebral arteries based on the degree of asymmetrical flow void or absence of flow void. In patients with asymmetrical flow void and/or without flow void in either or both of the vertebral arteries on MRI, DSA was performed to confirm the type of vertebral artery injury (occlusion or intimal injury). The presence of vertebral artery injury was compared with the degree of dislocation of the cervical vertebrae.

Results

The patient population included thirty-one men and five women, with a median age of 28 years (17–76 yrs). In 26 cases (72.2%), the injuries were limited to the cervical spine alone or involved minor injuries elsewhere. The remaining ten (27.8%) involved multiple severe injuries, including pelvic and extremity fractures, pneumo-hemothoraces, and intra-abdominal hemorrhage. Eleven patients had associated head injuries.

Vertebral angiography was performed on 26 patients in our series, and vertebral artery injury was found in 13 of them. The vertebral artery abnormalities on MRI cited above as indicating the potential presence of vertebral artery injury were observed in 11 patients, and DSA was performed to confirm whether vertebral artery injury was indeed present. All 11 patients with impaired patency in one or both vertebral arteries on MRI showed angiographic abnormalities. The findings included narrowing (4 cases), irregularity (3 cases), and complete occlusion (4 cases) of the vertebral artery. No cases of other conditions that also suggest vertebral artery injury, such as dissection, pseudoaneurysm, or intimal flap, were observed. These findings indicate that the sensitivity and specificity of MRI for the diagnosis of vertebral artery injury were 100% and 84.6%, respectively.

Table 1 Characteristics of blunt vertebral artery injury (n=11)

・male : female=10 : 1	
・age: 24 ～ 52 yrs (mean: 34.6 yrs)	
・cause of trauma	
motor vehicle accidents	7 cases
diving injuries	3
static compression	1
・osseous lesion	
anterior dislocation	9 cases
posterior dislocation	1
occipito-atlantal dislocation	1
・VA findings on DSA	
complete occlusion	3 cases
narrowing	4
irregularity of vessel wall	4

MRI: magnetic resonance imaging; VA: vertebral artery

The 11 diagnosed cases of blunt vertebral artery injury can be characterized as follows. Seven were caused by motor vehicle accidents, three by diving accidents, and one by static compression of the neck. All 11 patients had documented cervical spine fractures and dislocations (**Table 1**). In three patients, the diagnosis of complete occlusion of the vertebral artery was made on the basis of MRI and DSA. In the other patients, mural injuries of the vertebral artery were demonstrated with DSA. All 11 patients presented with acute, nonspecific changes in neurological status. Two had infarctions in the cerebellum and brainstem. None were treated with anticoagulants. All of the patients survived and were discharged to other hospitals for physical and occupational therapy.

Case 1

This 51-year-old male driver struck the front of his head in a motor vehicle accident. He arrived by

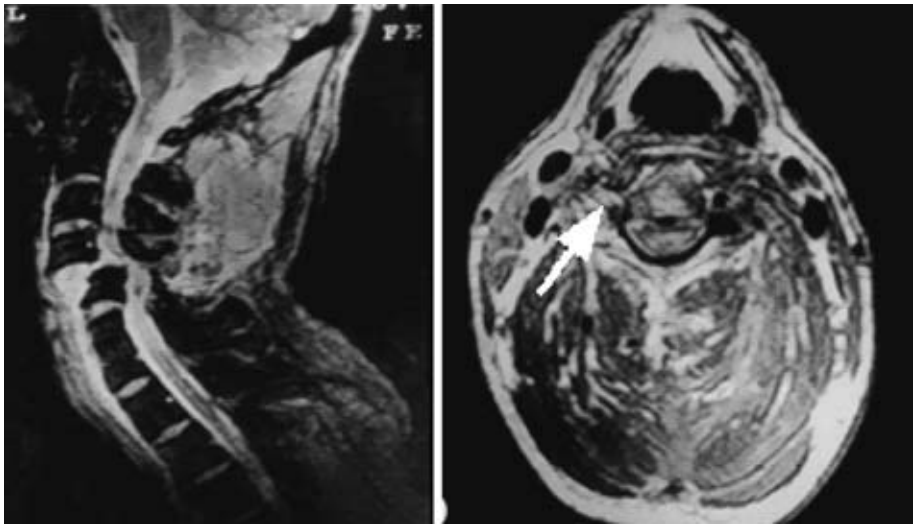

Fig. 1A MRI performed after initial resuscitation demonstrated the anterior dislocation of C4 (left) and the absence of flow void of the right vertebral artery at C4 level (right: **arrow**).

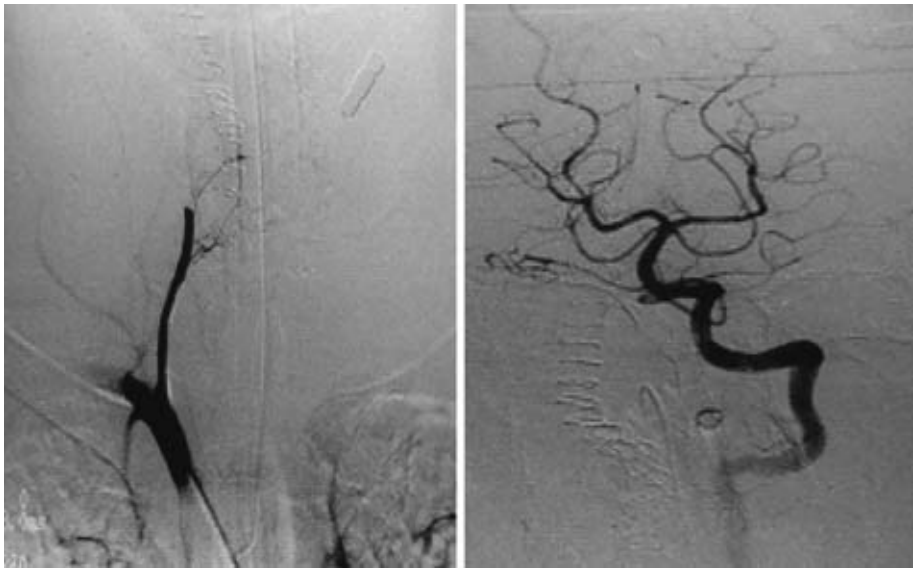

Fig. 1B Complete occlusion of the right vertebral artery was demonstrated by angiography. The basilar artery was perfused with blood from the left vertebral artery.

ambulance 20 minutes after the accident, presenting with tetraplegia. MRI performed after initial resuscitation demonstrated an anterior dislocation of C4 and the absence of flow void in the right vertebral artery at the level of C4 **(Fig. 1A)**. Complete occlusion of the right vertebral artery was demonstrated by angiography and his basilar artery was perfused with blood from the left vertebral artery **(Fig. 1B)**.

Cervical traction was used to restore normal alignment, and a halo jacket was attached temporarily. Because anterior fixation surgery was performed to achieve bony fusion, no anticoagulation treatment was given for the occluded right vertebral artery. Following minimal improvement in his neurological deficits, he was transferred to a rehabilitation institute 1 month after injury.

Case 2

This 20-year-old man was involved in a motor

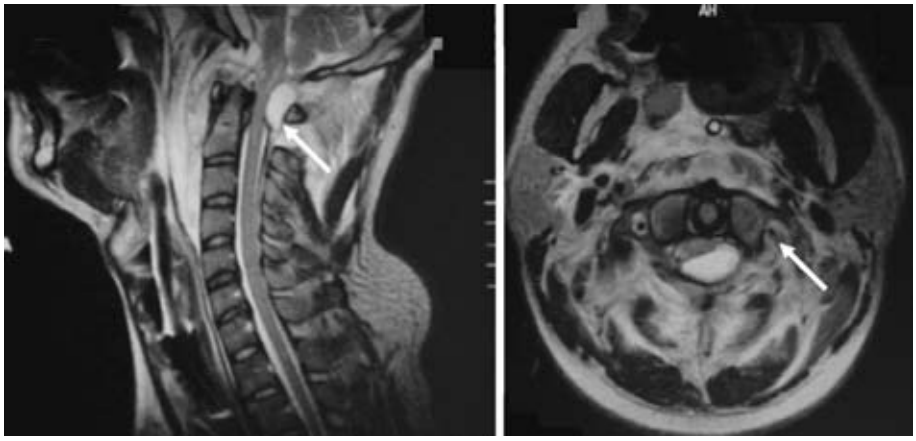

Fig. 2A MRI of the cervical spine shows an epidural hematoma located at the level of C1 (left: **arrow**). The axial view of MRI at the level of C1 shows narrowing of flow void in the left vertebral artery (right: **arrow**).

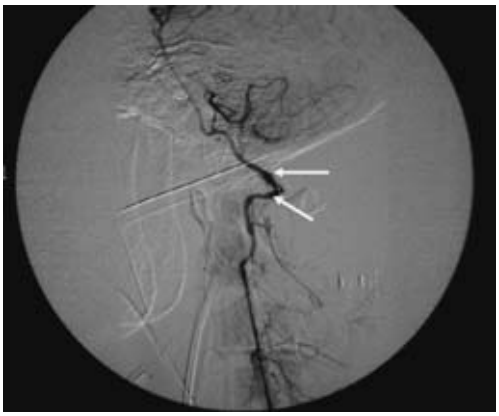

Fig. 2B Vertebral angiography revealed irregularity in the intimal wall of the left vertebral artery at the level of C1, suggesting blunt vertebral injury (**arrows**).

vehicle accident. He was apneic at the scene of the accident and was given ventilation en route to the hospital. On arrival, he showed tetraplegia, disturbance of consciousness, and unstable vital signs. After initial resuscitation, tracheal intubation and placement on a ventilator, MRI was performed to evaluate the cervical spinal cord injury. Plain x-ray films and MR images of the cervical spine showed occipito-atlantal dislocation and an epidural hematoma located at the level of C1. The MRI axial view of the C1 level showed narrowing of the flow void in the left vertebral artery (**Fig. 2A**). Vertebral angiography revealed an irregularity in the intimal wall of the left vertebral artery at the level of C1, suggesting blunt vertebral injury (**Fig. 2B**). The epidural hematoma was treated conservatively because of his unstable vital signs. Although MRI of the brain performed 2 days after injury demonstrated brainstem infarction (**Fig. 2C**), no anticoagulation therapy was carried out because of the presence of the epidural hematoma. Three months later his clinical condition was not improved, and he was transferred to another hospital.

Discussion

Incidence and Mechanism of Vertebral Artery Injury Caused by Blunt Cervical Trauma

Vertebral artery injury has often been reported as a result of penetrating wounds caused by knives, shrapnel, gunshot, etc.[2–4], but cases of vertebral artery injury after blunt cervical spine fracture or dislocation are thought to be rare[5–11]. Parent et al.[7] have reported three cases of associations between vertebral artery injury and lateral cervical spine dislocation. In a retrospective review of 640 patients with cervical spine dislocations who had injuries to the vertebral arteries, only 5 had been diagnosed with associated vertebral artery injuries[7]. Three of these patients presented with or developed symptoms of cerebellar ischemia.

The initial injury to the vertebral artery most likely involves intimal disruption by excessive distraction and stretching of the artery between two

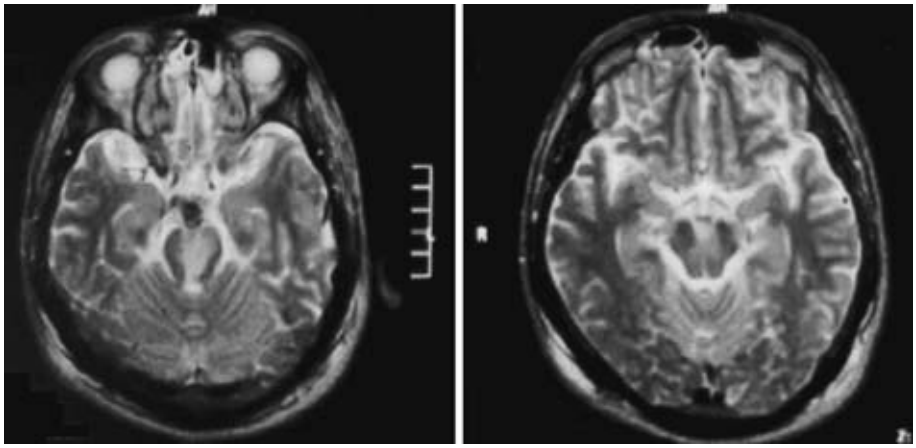

Fig. 2C MRI of the brain performed 2 days after injury demonstrated brainstem infarction.

adjacent foramina transversaria or by direct impact to the vessel wall. The primary intimal disruption might be caused by a number of secondary events. Thrombus formation at the site of intimal disruption might promote thrombotic occlusion of the artery or precipitate shower emboli into the vertebrobasilar circulation. Intramural hematomas might also play a role in the evolution of thrombosis. In our series, brainstem infarction was a complication in the two cases described above.

We carried out prospective studies with vertebral arteriography on 26 patients with cervical spine trauma, and vertebral artery injury was identified in thirteen of them. Vessel occlusion and narrowing were the most common findings in the intimal injuries to the vertebral artery. Other findings included intimal irregularity.

Louw and colleagues[12] have studied consecutive patients prospectively to assess the incidence of vertebral artery injury. Using DSA, they documented vertebral artery occlusion in 9 of 12 consecutive patients with cervical spine facet dislocation. Advances in vascular imaging have led to increased detection of vertebral artery injury associated with blunt cervical spine trauma. Our study suggests that as many as half of the cases of blunt cervical spine fractures or dislocations might involve vertebral artery injury.

Diagnosis and Treatment of Vertebral Artery Injury Caused by Blunt Cervical Trauma

Prompt recognition and treatment of vertebral artery injuries are unlikely without a high level of suspicion on the part of the attending physician. The causes of blunt vascular trauma to the neck can be classified into two types: stretch injuries; or direct trauma with compression of the cervical vertebral bone. Fakhry reported that blunt trauma accounted for 3 to 10% of cervical vascular injuries[10,13]. Hyperextension injuries to the neck, with or without rotation or lateral flexion, seem to be most heavily implicated[1,12,14,15]. When the head is rotated, more than 50% of the rotation occurs at the level of the atlantoaxial joint before any rotation is detectable in the lower vertebrae, causing a stressful kinking of the vertebral artery at the level of C1[16,17].

Bilateral occlusion of the vertebral arteries might result in infarction of the brainstem or cerebellum, but unilateral occlusion of a vertebral artery might be asymptomatic. Collateral circulation in the arteries of the Circle of Willis, the distal branches of the thyrocervical and costocervical trunks, the occipital artery, the interspinal branches, and the muscular branches work to prevent ischemic episodes in the cerebellum and brainstem[14].

A variety of typical signs and symptoms of vertebral injury might be observed, such as aphasia, dysphasia, facial paralysis, aphonia, visual disturbances, nausea, vomiting, vertigo, and tinnitus[1,8,12,18,19]. The neurological deficits sometimes

observed are paresthesia, nystagmus, Horner's syndrome, vocal cord paralysis, absence of the gag reflex, isolated limb weakness, and tetraplegia. Bilateral occlusion may be fatal[12,20]. Lucid intervals sometimes occur before ischemic symptoms of the brainstem or cerebellum[7,12,16], and affected patients might also be hemodynamically unstable[6].

Diagnosis of vertebral artery thrombosis should be made on the basis of CFVA or DSA. CFVA is the most definitive method for detecting vertebral artery injuries[1,5,8,21–23], with a reported detection sensitivity of 97%[5]. Magnetic resonance angiography (MRA) is a relatively new, noninvasive and accurate method for detecting blunt vertebral artery injury[21], and several authors have reported that MRA provides excellent high-resolution images of vertebral artery occlusion[22,23]. MRI is also reportedly more sensitive than computed tomography (CT) scans for detecting early ischemia[18,21]. The high sensitivity and specificity of MRI we experienced in diagnosing vertebral injury in our series suggests that MRI is very useful for detecting injuries to the vertebral artery after blunt cervical trauma.

Anticoagulation therapy for the prevention of embolisms in the cerebral circulation is controversial. Because of the possibility of embolisms, anticoagulation treatment should be considered to prevent thrombus extension or recurrence. Sherman and his associates described eight cases of vertebral artery thrombosis and proposed early anticoagulation therapy to prevent progressive brainstem infarction[24]. Katirji et al. reported five cases of vertebrobasilar insufficiency after vertebral artery injury without any fracture or dislocation of the cervical spine[17]. They advocated the use of anticoagulants, and none of their patients suffered any associated complications as a result of the therapy. Heparin followed by long-term warfarin is the usual regimen. No strict criteria for the duration of anticoagulation therapy exist, but it can range from 1 to 3 months[10,17]. Asymptomatic patients with no neurological deficits have been observed to experience no subsequent neurological deterioration[5,18].

Conclusion

Vertebral artery injury associated with blunt cervical spine trauma is rare. We would like to stress the importance of looking for vertebral artery lesions when a lack of flow void in the vertebral artery is demonstrated with MRI. MRI may be useful for evaluating the presence of vertebral artery injury after blunt cervical spine trauma.

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