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Cervical vertigo and dizziness after whiplash injury

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Abstract Whiplash injury is not only limited to neck injury but also brainstem injury that does not involve direct damage to the neck or head. The symptoms of whiplash injury are polymorphous, with the most common complaints being cervical pain, headache and scapulo-dynia. Vertigo and dizziness are also reported in 25–50% of the cases. In otoneurologic studies, magnetic resonance angiography (MRA) is used for the evaluation of vertebrobasilar hemodynamics in patients who complain of dizziness and vertigo. It is reported that vertebrobasilar artery insufficiency (VBI) leads to brainstem and cerebellar ischemia and infarction following cervical manipulation. Here we examined the correlation between vertigo or dizziness and the right and left side difference in vertebral arteries after whiplash injury using MRA. We studied 20 patients who complained of neck pain with vertigo or dizziness after whiplash injury and 13 healthy volunteers as a control. In the control group,

abnormal MRA findings in the vertebral arteries such as occlusion, stenosis or slow blood flow were seen in 77% of the cases. In the patient group, abnormal MRA findings were seen in 60%. The side difference in blood flow was 3.5 ± 2.5 cm/s in the control group and 6.1 ± 3.0 cm/s in the patient group. Our findings suggest that some subjects with persistent vertigo or dizziness after whiplash injury are more likely to have VBI on MRA. VBI might be an important background factor to evoke cervical vertigo or dizziness after whiplash injury. The side difference between the two vertebral arteries could cause a circulation disorder in the vertebrobasilar system after whiplash injury. However, the VBI on MRA itself was also seen in the control group, and thus it is not clear whether it is due to whiplash injury in the patient group.

Keywords Vertebrobasilar insufficiency · Whiplash injury · MRA

Introduction

In 2002, the incidence of head and neck lesions after traffic accidents was about 30% in Japan according to the Non-life Insurance Rating Organization of Japan [15]. In recent years, however, severe accidents have decreased due to the use of headrest, seat belt and air

bag protection. In contrast, whiplash injury remains a social problem, and some victims suffer persistent chronic pain. The pathophysiology of cervical vertigo and dizziness after whiplash injury is poorly understood. The aim of this study was to clarify the effects of changes in vertebral artery blood flow with regard to the cervical vertigo and dizziness in patients with whiplash injury

(grade II according to the Quebec Task Force classification of whiplash-associated disorders: WAD) [22].

Materials and methods

We studied 20 patients (10 men and 10 women) aged 22–53 years (mean age, 38.5 years), who were seen in our department between January 1999 and December 2000 and complained of persistent neck pain with vertigo or dizziness after whiplash injury from the immediate period to more than 6 months after injury. All patients were examined by cervical X-p and cervical plane magnetic resonance imaging (MRI) and cases with anatomically evident abnormalities were excluded. Only patients with WAD grade II according to the Quebec Task Force classification [22] and vertigo and dizziness were included in the study; those with WAD grades I, III and IV were excluded (grade II includes neck complaints and musculoskeletal signs). We also excluded from this study patients who had suffered head injury, fracture or dislocation of the cervical spine, those who had lost consciousness or those with a previous history of neck injury or vertigo or dizziness. As a control group, we also studied 13 healthy volunteers (10 men, 3 women, mean age, 32.5 years). The study protocol was approved by the Human Ethics Review Committee of the Tokyo Medical University and a signed consent form was obtained from each subject.

The magnetic resonance equipment was a Shimazu 1.5T (Shimazu, Japan). Each subject underwent MRA of the vertebral arteries and direct bolus imaging (DBI) [21], a measurement of blood flow velocity using MRI. The criteria used for the definition of abnormal MRA of the vertebral arteries were the presence of more than double the proportion of vessels in the vertebral arteries.

All data were expressed as mean \pm standard deviation (SD), or median values. The non-parametric Mann-Whitney *U* test was used for comparisons. A *P* value of <0.05 was used as the criterion for statistical significance.

Results

In the control group, MRA showed symmetric vertebral arteries in 10 (77%) subjects, a dominant left side in 2 (15.4%) and a dominant right side in 1 (7.6%). In the patient group, symmetric vertebral arteries were seen in 12 (60%), a dominant left side in 5 (25%), and a dominant right side in 3 (15%) patients. The side difference in vertebral artery blood flow velocity in the systolic phase was significantly larger in the patient group (6.1 ± 3.0 cm/s) than in the control group (3.5 ± 2.5 cm/s, $P < 0.05$).

Case presentation

A 48-year-old woman was a seat-belt driver during a rear-end collision that occurred with an impact speed of about 40 km/h while her car was idle at a red light. Four hours after the accident, she complained of dizziness with mild neck pain and headache. Several hours later, she developed tinnitus and vertigo. A few days later, she complained of disturbance in concentration and nausea. Dizziness and headache were still present 6 months after the accident. Since the accident, she suffered from problems with concentration, difficulties with memory and ideation, and falling asleep. Neurological examination of the neck was normal, and the Romberg test and Mann test were positive. Gravicorder examination showed an abnormal movement at antero-posterior shifts at 0.2 Hz. Electronystagmography (ENG) presented transient upper vertical nystagmus at the upper frontal gaze. The cerebral and cervical X-P and MRI findings were normal. MRA showed narrowing and kinking of the left vertebral artery (Fig. 1). The blood velocity of the left vertebral artery was 20 cm/s slower than the right side (Fig. 2).

Discussion

Persistent symptoms including vertigo and dizziness after whiplash injury are mysterious because it is often difficult to show unequivocal pathology on imaging studies [24]. There is some evidence to suggest that subtle or subclinical brain damage sustained during an accident could cause altered perception of pain, or prolongation of the period of pain [23]. However, Yarnell and Rossie [27] examined patients with severe debility at 12 months after car accidents and concluded that in the subacute period neurological examination, imaging and clinical electrophysiological studies could not locate, structurally or functionally, the source of the dysfunctions. The present study described the background of patients with persistent cervical vertigo after whiplash injury.

Cervical vertigo was first described by Ryan and Cope [20] in 1955. One of the major causes of cervical vertigo is vertebrobasilar insufficiency (VBI) [11, 17]. However, imaging diagnosis is difficult and was especially difficult before the introduction of the MRI technique. Recently, a few studies in which MRA was used have demonstrated a correlation between narrowing of the vertebral artery and certain diseases [13, 25].

With regard to whiplash injury, the term was introduced by Harold Crow [4] in 1928, who described the effects of sudden acceleration–deceleration forces on the neck and upper trunk due to external forces exerting a whiplash-like effect. The report described only the

mechanism, not the pathological or clinical consequences. Crow claimed that prolonged distress and disabilities often lasted several years. In contrast, Bosworth [2] suggested that whiplash injury was a non-scientific phenomenon. The term became popular after Gay and Abbott [8] published their report in 1953, which focused on car accidents with rear-end shunts, in

which they concluded that whiplash injury might be associated with concussion of the brain. Their subjects complained only of dizziness and vertigo but had no neurological abnormalities in the extremities.

The exact incidence of vascular damage after whiplash injury is unknown, although there are studies that confirm that it does occur. Vertigo and dizziness are also reported in 25–50% of cases, depending on the study [26]. Friedman et al. [6] found that 24% of patients with severe cervical trauma (not limited to whiplash, but including whiplash) had abnormal vertebral artery findings. MacNab [12] stated that spasm of the vertebral arteries might explain in some instances the etiology of tinnitus, deafness, and nystagmus. Nibu et al. [14] performed an experiment in cadaver spines, and reported that the vertebral artery could experience elongation during even low speed impacts. Following the development of MRI, some studies showed cerebellar infarction in the vertebrobasilar artery branches due to cervical occlusive injuries including whiplash injury [16]. However, in general, these dysfunctions are often difficult to identify on imaging studies. In the majority of cases, there is no correlation between the complaints and the objective findings, including the results of MRI [19]. On the other hand, it is known that some clinical signs and complaints may indicate brain/brainstem involvement [18]. On the other hand, vertigo and dizziness could be due to psychological factors. We excluded late-onset cases and patients who had previously been treated.

In otoneurologic studies, MRA is used for the evaluation of vertebrobasilar hemodynamics in patients who complain of dizziness and vertigo [1, 7]. VBI could lead to brainstem and cerebellar ischemia and infarction, which are rare but often have devastating complications of cervical manipulation and neck trauma [5, 9]. A characteristic feature of VBI is that it can occur in otherwise healthy young adults, often with a close temporal relation to common neck movement, cervical spine manipulation, or trauma. However, we should notice that the causes of vertigo and dizziness are also thought to include peripheral vestibular deficits and neck soft tissue injury [3, 10].

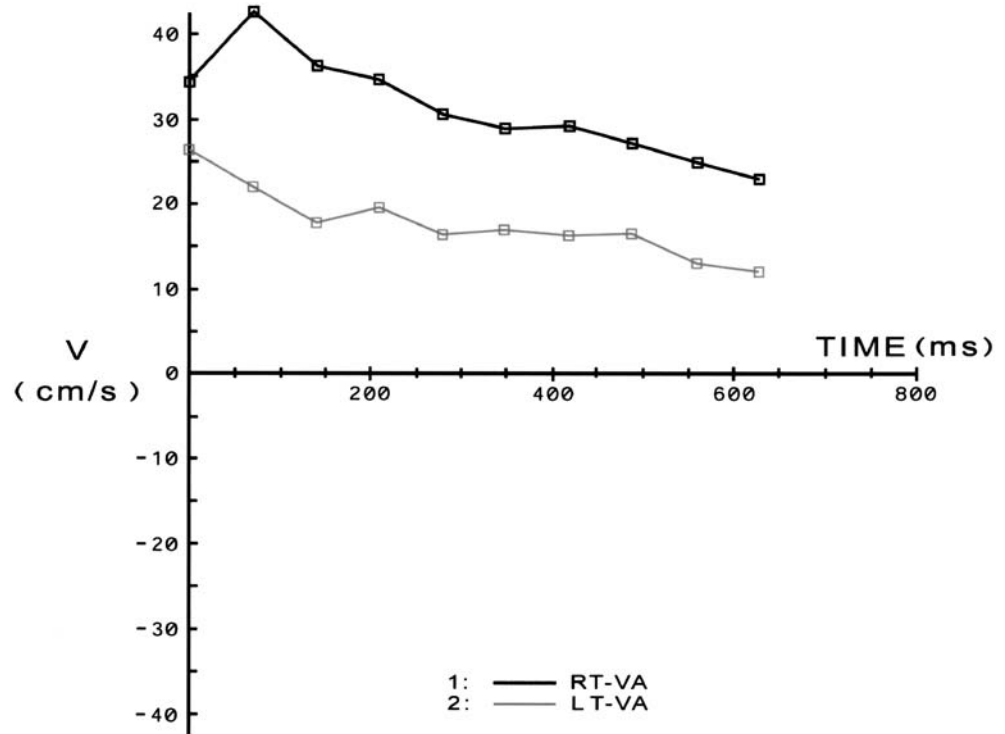
In the present study, we used MRA and equilibrium tests and a thorough clinical evaluation of prospective whiplash trauma patients who were followed more than 6 months after the trauma. Our study showed that vertebral artery asymmetry (34%) as shown on MRA was more frequent in patients than in the control group (23%). These results are similar to those of other VBI studies [25]. We also identified a significant difference in side differences in the vertebral arteries between the patient group and normal control group, and there were also significant difference in blood velocity in the vertebral artery between the patient group and normal control group. These results suggest that the side difference between the two vertebral arteries noted in our study



Fig. 1 *Top:* MRA of the case presented in the text with stenosis of the left vertebral artery (arrow). There is no stenotic region in the basilar artery. *Bottom:* upper deflections represent blood flow in arteries. From left side, left carotid artery, left vertebral artery, right vertebral artery (arrow), and right carotid artery. Lower deflections represent blood flow in veins. Flow is expressed as volume per second

Fig. 2 Case presentation.

Changes in vertebral artery blood flow through the systolic and diastolic phases. In this case, the left side blood velocity is slower than that of the right side through each phase. *RT-VA* right side vertebral artery, *LT-VA* left side vertebral artery



could cause a circulation disorder in the vertebrobasilar system after a whiplash injury. However, the VBI on MRA was also noted in 23% of the control group, and thus the cause of the side differences in the vertebral arteries is not clear i.e., whether it is due to whiplash

injury or not. It should be also noted that no cases with dizziness or vertigo, even with the very thorough investigation conducted in our study, could provide a definite proof of a link between whiplash injury and vertebrobasilar blood flow abnormalities.

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