Case Report

Ultrasound-guided computed tomography angiography for the diagnosis of rotational vertebral artery occlusion: 2 case reports and technical notes

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Rotational vertebral artery occlusion is a rare cause of ischemic stroke in the vertebrobasilar arteries. While computed tomography angiography (CTA) is less invasive for the diagnosis of rational vertebral artery occlusion than digital subtraction angiography and more useful for elucidating the correlation between vertebrobasilar arteries and the surrounding structure, carotid ultrasound is noninvasive and more beneficial for the real-time evaluation of the hemodynamic change with neck rotation compared to CTA. Here, we reported 2 cases of rotational vertebral artery occlusion in patients aged 81 and 38 years and proposed a novel technique for its diagnosis using ultrasound-guided CTA. We suggest that the combination of ultrasound and CTA is useful for diagnosing rotational vertebral artery occlusion, which would compensate for the disadvantages of CTA alone.

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Introduction

Rotational vertebral artery occlusion (RVAO), which is well known as “bow hunter’s syndrome,” is an infrequent cause of vertebrobasilar ischemia, insufficiency, and dissection. Head and neck rotation can induce occlusion of the vertebral artery (VA) due to the physiological compression of bones, osteophytes, or ligaments. Although the VA blood flow of the RVAO...
in the neutral position is usually normal, it dramatically changes after rotating the neck and head. Rotation triggers occlusion, insufficiency, or section of the VA due to the compression of the VA by an anatomical structure, trauma, and so forth. The etiology of ischemia is a hemodynamic mechanism in many cases, but a thromboembolic mechanism is sometimes present, as in our previous report [1].

Many cases have reported that digital subtraction angiography (DSA) has been adopted for the diagnosis of RVAO. Although the angiogram is accurate and applicable for determining whether the VA flow changes in real-time, it is invasive and difficult to detect how arteries are obstructed by bones, osteophytes, or ligaments [2]. While we cannot see the dynamic change of VA flow associated with rotation during computed tomography angiography (CTA), CTA is less invasive and useful for diagnosing the position and relation between VA and bony structures. Ultrasound is a powerful tool for the evaluation of dynamic blood flow in real-time and compensates for the disadvantages of CTA. Therefore, we performed ultrasound-guided CTA for RVAO diagnosis.

Discussion

In our 2 cases, we determined RVAO using carotid ultrasound as a screening tool with a change in the blood flow pattern due to neck rotation to the contralateral side. Carotid ultrasound also showed a VA occlusive point at the C1/C2 level. We confirmed RVAO with the surrounding tissue structures such as bones, osteophytes, or ligaments using ultrasound-guided CTA. The ultrasound diagnostic criteria for the site of occlusion in the vertebral arteries (VAs) were established [3] based on the pattern of the Doppler waveform pattern in the cervical portion, such as the C3-6 levels of the cervical spine. The preserved peak systolic flow velocity and EDV of 0 cm/s indicated a VA occlusion before branching of the posterior inferior cerebellar artery (PICA). RVAO can be diagnosed as the cessation of the end-diastolic flow in the VA on head rotation to the opposite side; meanwhile, the blood flow pattern in the neutral position was normal [1].

Although DSA is the gold standard for the definite diagnosis of RVAO, other medical technologies, including CTA, carotid ultrasound, and MRA, could be useful tools for diagnosing RVAO [4]. The advantage of dynamic DSA is that it can detect the very moment of VA occlusion by performing both angiography and rotation of the neck simultaneously. Although DSA is a powerful diagnostic tool for RVAO, it cannot elucidate the correlation between the artery and the surrounding structure. Moreover, DSA and CTA require a large amount of radiation and contrast media to try many rotational degrees and positions. CTA with rotation presenting neurological symptoms replicating near occlusion of the right VA was reported [5], and various positions, including flexion, extension, neutral position, and rotation, were attempted during CTA [6]. Because CTA with 3-dimensional reconstructions reveals the relationship between arteries and compressing structures, including bony structures and ligaments, CTA is a powerful tool for determining the therapeutic strategy for spinal surgery. Compared to DSA, because images of CTA and MRA are acquired in one recording, it is not possible to check the images before the complete data acquisition, whether the

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Case 1

An 81-year-old man experienced gait disturbance for several years. Magnetic resonance imaging (MRI) was performed and a spotty high-intensity area on diffusion-weighted imaging (DWI) was incidentally detected in the left cerebellum (Fig. 1A). Magnetic resonance angiography (MRA) showed the dominant normal left vertebral artery (Fig. 1B). Carotid ultrasound showed that the blood flow in the left vertebral artery at the C4/5 level was normal in the neutral position (Fig. 1C), and that the end-diastolic flow velocity (EDV) of the left VA disappeared when his head was rotated to the right (Fig. 1D). The blood flow velocity in the left vertebral artery at the C4/5 level gradually decreased with neck rotation and subsequently disappeared, which showed an obstructed point.

In the gantry of computed tomography (CT), the patient was asked to rotate his neck gradually to the left just before the disappearance of the EDV of the left vertebral artery at the C4/5 level using the duplex ultrasound (Figs. 1E and F). We asked the patient to maintain the rotational position of the neck, and CTA was performed immediately. We detected stenosis of the left VA at the C1/C2 level when his neck was rotated to the right (Figs. 1G and H). We diagnosed RVAO of the left VA at the C1/2 level.

Case 2

Two months ago, a 38-year-old man was cutting down trees as a carpentry work while looking down and experienced dizziness for approximately 10 minutes. One month ago, after he had used his cell phone looking down for 10 minutes with his neck rotated to the left, it was difficult for him to step on the brakes using his right foot. Two weeks prior, he dropped a doughnut from his right hand after looking down his cell phone. In addition, he could not skillfully turn a doorknob and felt vertigo for a while. However, MRI did not show significant abnormalities, including the DWI at the former hospital, and the intracranial MRA of the vertebrobasilar arterial system did not indicate definite abnormalities. Although the blood flow in the right vertebral artery at the C4/5 level was normal in the prone neutral position, the EDV of the right VA disappeared after the head was rotated to the left (Figs. 2A-C). At the C1/2 level, just distal to the C2 level, the systolic blood flow in the right VA by gradual rotation to the left was first accelerated and subsequently disappeared, which showed the obstruction point (Figs. 2D-F). To determine the RVAO, we performed an ultrasound-guided CTA, as shown in Case 1. We detected the stenosis of the right VA at the C1/C2 level when his neck was rotated to the left (Figs. 2G and H), which corresponded to the ultrasound findings. We diagnosed RVAO caused by right VA at the C1/2 level.
Fig. 1 – In Case 1, (A) DWI-MRI showed a high intensity spot in the left cerebellar hemisphere. (B) MRA indicated that the right VA was a hypoplastic VA ending at the PICA and that the left VA was normal. (C) The blood flow of the left VA was normal in the neutral position on pulse Doppler waveform image at the C4/5 level. (D) The end-diastolic flow of the left VA gradually decreased with the neck rotated to the right before finally disappearing (arrow). (E) In the gantry of computed tomography, we examined the carotid ultrasound to reproduce the nearly occlusive state of the left VA. (F) Doppler waveform showed that the blood flow velocity decreased with the neck rotated to the right just before the end-diastolic flow velocity in the left VA vanished, which showed VA occlusion before the branching PICA, and the position was kept during the CT data acquisition. (G) Ultrasound-guided CTA showed the severe stenosis at C1/C2 level (arrow). (H) Magnified figure enclosed in square in G.
Fig. 2 – In Case 2, (A, B) the blood flow of the right VA was normal in the neutral position at the C4/5 level. (C) The end-diastolic flow of the right VA gradually decreased and finally disappeared with the neck rotated to the left. (D, E) The Doppler waveform in the right VA at neutral position of C1/2 level. (F) The systolic blood flow velocity was first accelerated (arrow) with the neck rotated to the left, which showed the obstruction point. (G) Ultrasound-guided CTA with neck rotation showed severe stenosis at the C1/C2 level (arrow) by the bone. (H) The bone suppression image of G.
VA is rotationally occluded. Once the VA has been completely occluded, because the very occluded point and the distal VA cannot be visualized, we cannot detect the 3-dimensional cause of RVAO (bony structures, ligaments, etc.). Each RVAO patient has a certain rotational degree of VA occlusion and cannot be easily positioned without dynamic evaluation. Furthermore, DSA and CTA have disadvantages in terms of the amount of radiation, contrast media, and invasive procedures. To resolve these problems, we used ultrasound-guided CTA as a novel technique. Therefore, using carotid ultrasound, we can evaluate hemodynamic changes in the VA blood flow in real time with neck rotation and confirm the degree of rotation that showed near occlusion.

In conclusion, we presented a simultaneous combination of ultrasonography and CTA for the clear diagnosis of RVAO. The combination of ultrasonography and CTA was very informative and beneficial, because ultrasound-guided CTA compensated for the disadvantages of DSA and carotid ultrasound while watching the dynamic change of VA flow.

**Patient consent**

Informed documented consents were obtained from the patients for publication of these findings.

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