Radiology Case Reports 13 (2018) 917–920

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Case Report

Elevated end-diastolic ratio of the common carotid artery due to cerebral arteriovenous malformation: Two case reports

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ARTICLE INFO

Article history:
Received 31 May 2018
Revised 5 June 2018
Accepted 7 June 2018

Keywords:
Carotid ultrasonography
Cerebral arteriovenous malformation
End-diastolic ratio

ABSTRACT

An elevated end-diastolic (ED) ratio of the common carotid artery (CCA) is an indicator of occlusive lesions of the distal portion of the internal carotid artery. We report 2 cases of cerebral arteriovenous malformation (AVM) showing an elevated ED ratio of the CCA, which decreased after surgery. Case 1 was a 28-year-old man with chronic recurrent headache with aura, and case 2 was a 29-year-old woman with sudden-onset headache and intracerebral hemorrhage without neurologic abnormality. In both cases, digital subtraction angiography revealed a Spetzler-Martin Grade IV AVM, which was mainly fed by branches of the left middle cerebral artery with venous drainage into superficial and deep cerebral veins. Preoperative carotid ultrasonography showed an elevated CCA ED ratio (1.38 in case 1 and 1.47 in case 2; left > right) without atherosclerotic lesions. Patients' AVMs were successfully resected. In both cases, the ED ratio was decreased after surgery (to 1.05 in case 1 and 1.20 in

Acknowledgments: We thank Doran Amos, PhD, from Edanz Group (www.edanzediting.com/ac) for editing a draft of this manuscript.
Competing Interests: The authors have declared that no competing interests exist.
Funding: This study was supported by a Grant-in-Aid for Scientific Research from the Japan Society for the Promotion of Science (16K10727).

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https://doi.org/10.1016/j.radcr.2018.06.007

case 2). A decrease in vascular resistance on 1 side caused by cerebral AVM can result in an increase in the CCA ED ratio comparable to that of carotid axis occlusion.

Introduction

Duplex ultrasonography is a primary noninvasive screening procedure for the evaluation of carotid arteries. The end-diastolic (ED) ratio is the ratio of the left and right ED flow velocities (EDVs) calculated by dividing the faster velocity by the slower one. An elevated ED ratio of the common carotid artery (CCA) indicates occlusive lesions of the distal portion of the internal carotid artery (ICA) on the side with the lower flow rate [1]. However, either a vascular resistance increase on one side or a vascular resistance decrease on the opposing side can result in an elevated CCA ED ratio. Recently, an elevated CCA ED ratio was reported in a series of patients with dural arteriovenous fistula (dAVF) on the side with the higher flow rate [2,3]. Cerebral arteriovenous malformation (AVM) is an arteriovenous shunt disease, in which an abnormal tangle of blood vessels forms where arteries shunt directly into veins with no intervening capillary bed, which can contribute to decreasing vascular resistance [4]. We report 2 cases of cerebral AVM showing an elevated CCA ED ratio, which decreased after surgery.

In both cases, patients lay in a supine position, with the head turned away from the scanning side and the neck extended during scanning. Using pulsed wave Doppler, the EDV of the CCA was measured in the longitudinal plane and corrected using the Doppler angle. The sample volume was 2 cm or greater proximal from the bifurcation in the CCA, and the Doppler angle was kept at $<60°$.

Case report

Case 1

A 28-year-old man with chronic recurrent headache with aura was admitted to hospital for observation. He had no history of illness, and the physical and neurologic examination results were normal. Brain T2-weighted magnetic resonance imaging showed vascular flow voids in the left superior temporal gyrus, which suggested cerebral AVM. Digital subtraction angiography (DSA) revealed a Spetzler-Martin Grade IV AVM of approximately 5 cm in length, which was fed primarily by branches from the inferior trunk of the middle cerebral artery (MCA), with venous drainage into deep and superficial Sylvian veins (Fig. 1a). Preoperative carotid ultrasonography showed an elevated CCA ED ratio of 1.38 (left [ipsilateral] 34.0 cm/s; right [contralateral] 24.6 cm/s), without atherosclerotic lesions (Fig. 1b). The resistance index (RI) of the left and right ICAs was 0.61 and 0.67, respectively. The patient underwent radical resection of the AVM after endovascular embolization. DSA performed 1 week postoperatively showed that the AVM had almost completely disappeared (Fig. 1c). Furthermore, in carotid ultrasonography performed at 13 days postsurgery, the CCA ED ratio had decreased to 1.05 (left [ipsilateral] 19.4 cm/s; right [contralateral] 18.4 cm/s; Fig. 1d).

Case 2

A 29-year-old woman was referred to hospital because of a severe headache lasting for 3 days. Brain computed tomography scans showed intracerebral hemorrhage in the deep white matter of the left frontal lobe with intraventricular perforation. Furthermore, computed tomography angiography revealed a cerebral AVM located on the Sylvian surface of the frontal lobe in the pars orbitalis. The patient had no history of hypertension, and the results of her physical and neurologic examination were normal. DSA showed a Spetzler-Martin Grade IV AVM, which measured approximately 4 cm in length fed by M3 opercular branches and drained by Sylvian veins, both superficial and deep (Fig. 2a). Preoperative carotid ultrasonography showed an elevated CCA ED ratio of 1.48 (left [ipsilateral] 38.4 cm/s; right [contralateral] 25.7 cm/s), without atherosclerotic lesions (Fig. 2b). The RI of the left and right ICAs was 0.61 and 0.69, respectively. She received elective radical surgery at 14 days after headache onset. DSA performed 1 week postoperatively showed an almost complete disappearance of the AVM (Fig. 2c). Subsequent carotid ultrasonography performed at 23 days postsurgery revealed that the CCA ED ratio had decreased to 1.20 (left [ipsilateral] 24.5 cm/s; right [contralateral] 29.4 cm/s; Fig. 2d).

Discussion

Although many cerebral AVMs are asymptomatic, they can cause acute hemorrhagic stroke due to rupture, especially in young adults, along with seizures or recurrent headaches. Roughly half of patients with cerebral AVMs present with hemorrhage, which is associated with a mortality rate of 10% and a long-term disability rate of 20% [5,6]. Therefore, early diagnosis of cerebral AVM could be beneficial for its therapeutic management, even in asymptomatic cases.

Previous reports have demonstrated that the pathologic consequences of cerebral AVM cause Doppler parameter changes in the feeding arteries, including a reduced RI and increased peak systolic flow velocity and EDV [4,7–9]. To the best of our knowledge, this is the first to demonstrate that the CCA ED ratio increases because of cerebral AVM on the side with the higher flow rate. The ED ratio is a nondimensional index that minimizes variability between individuals with similar carotid arterial systems. Yasaka et al. showed

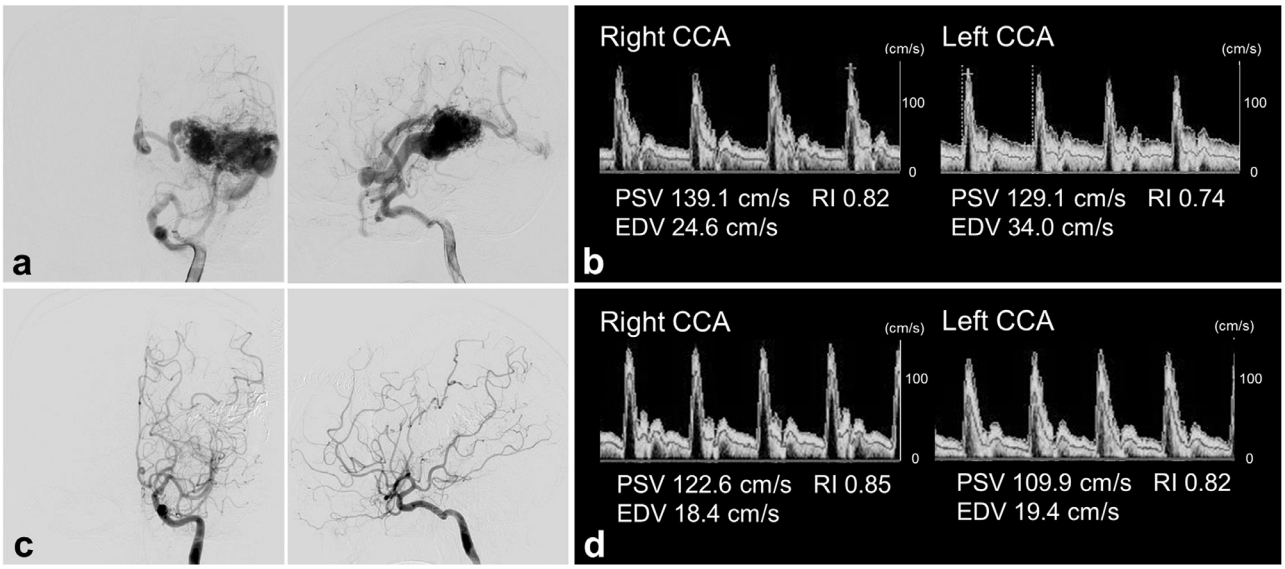

Fig. 1 – Case 1. (a) Preoperative left internal carotid arteriography (ICAG). Frontal (left) and lateral (right) projections show the arteriovenous malformation (AVM) and draining veins. (b) Preoperative carotid ultrasonography shows an increased end-diastolic flow velocity (EDV) in the left common carotid artery (CCA). PSV, peak systolic flow velocity; RI, resistance index. (c) Postoperative left ICAG. Frontal (left) and lateral (right) projections show that the AVM almost completely disappeared. (d) The elevated EDV in the left CCA is no longer evident in postoperative carotid ultrasonography.

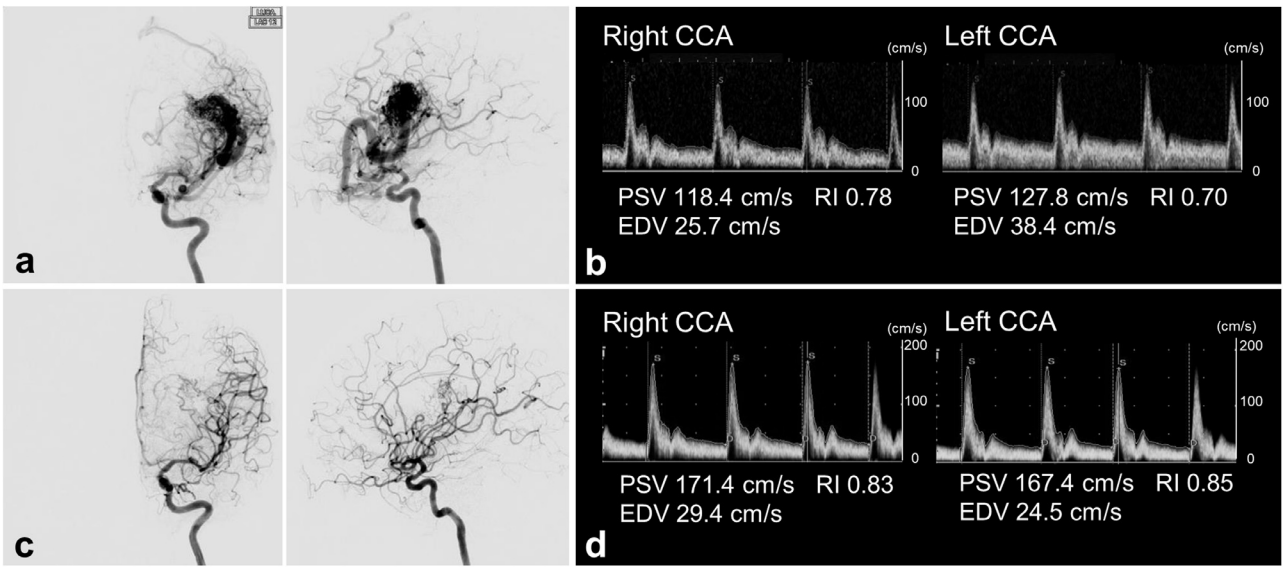

Fig. 2 – Case 2. (a) Preoperative left ICAG. Frontal (left) and lateral (right) projections show the AVM and draining veins. (b) Preoperative carotid ultrasonography shows an increased EDV in the left CCA. (c) Postoperative left ICAG. Frontal (left) and lateral (right) projections show the disappearance of most parts of the AVM. (d) The elevated EDV in the left CCA is no longer evident in postoperative carotid ultrasonography.

that a CCA ED ratio of 1.3 or more distinguishes patients with occlusive lesions in the ICA or proximal portion of the MCA from those with branch occlusion in MCA or controls [10]. Likewise, Kimura et al. reported that patients with ICA occlusions showed a CCA ED ratio of 1.4 or more [11]. Similar to a dAVF [2,3], our findings show that a cerebral AVM leads to an increase in the ED ratio comparable to that of carotid axis occlusion by opposite changes of the carotid vascular resistance on the ipsilateral side. Although AVMs that are small, bilaterally distributed, or fed by arteries from posterior circulation may not be detectable using the CCA ED ratio, it is nonetheless helpful for detecting cerebral AVM. Although carotid ultrasonography screening for asymptomatic carotid artery stenosis is not recommended in the general adult population [12], our findings suggest that this method is more broadly useful, especially for arteriovenous shunt diseases.

In the cases presented here, differences in Doppler parameters between the affected and unaffected sides of ICAs were not pronounced. This contrasts with previously reported cases of dAVF showing significantly higher EDV and lower RI on the affected side than the unaffected side of the external carotid arteries [2,3,13,14]. This might be because a decrease in vascular resistance is more apparent in these arteries than in the ICA because they have a higher vascular resistance and lower diastolic flow at baseline.

In conclusion, a decrease in vascular resistance on 1 side caused by cerebral AVM, as shown here, can result in an increase in the ED ratio of the CCA. In such cases, assessment of intracranial arteries should be conducted even in the absence of atherosclerotic lesions to the extracranial carotid arteries. Further investigation is warranted to validate our results and clarify which characteristics of AVMs cause changes in the CCA ED ratio.

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