

## Volume Subtraction Three-dimensional CT Angiography for Cerebrovascular Disease: Report of Two Cases

Shigeyuki SAKAMOTO<sup>1)</sup>, Yoshihiro KIURA<sup>1)</sup>, Shinji OHBA<sup>1)</sup>, Masaaki SHIBUKAWA<sup>1)</sup>, Kazunori ARITA<sup>1)</sup>, Minoru ISHIFURO<sup>2)</sup> and Kaoru KURISU<sup>1)</sup>

1) Department of Neurosurgery, Graduate School of Biomedical Sciences, Hiroshima University

2) Department of Radiology, Hiroshima University Hospital

### ABSTRACT

We report two cases in which volume subtraction three-dimensional CT angiography (VS-3DCTA) was used for cerebral aneurysm and vascular stenosis with intramural calcification. Case 1: VS-3DCTA with volume rendering clearly showed carotid cave aneurysm of the internal carotid artery. The location and size of the aneurysm was confirmed by digital subtraction angiography (DSA). In evaluation of the aneurysm, VS-3DCTA was equal to DSA and endovascular findings. Case 2: VS-3DCTA with volume rendering clearly showed stenosis of the middle cerebral artery, and intramural calcification with the cause of the stenosis was subtracted. On the other hand, it was difficult for DSA to reveal the stenosis because of the limitation of the imaging angle. In evaluation of the stenosis, VS-3DCTA was superior to DSA. VS-3DCTA was an important diagnostic tool that enabled visualization of the aneurysm in the area of the skull base and stenosis of the intracerebral artery.

**Key words:** Aneurysm, Cerebrovascular disease, Computed tomographic angiography, Volume subtraction, Stenosis

According to recent innovations in computed tomography scanners and workstation technology, three-dimensional computed tomographic angiography (3DCTA) with helical scanning may be used as a diagnostic tool for examination for cerebrovascular disease (CVD)<sup>2,3,5,6,9)</sup>. On the other hand, by conventional non-subtracted 3DCTA (NS-3DCTA), it is difficult to evaluate a lesion near the skull base due to its bony structure<sup>7)</sup>. If the accuracy of subtracted 3DCTA images is approximately equal to that of intra-arterial digital subtraction angiography (DSA) images, subtracted 3DCTA may serve as an alternative to the DSA as a diagnostic tool. We used a method with volume subtraction (VS), in which non-enhanced volume data were subtracted from enhanced volume data. We evaluated a carotid cerebral aneurysm near the skull base and stenosis with intramural calcification by VS-3DCTA.

### CASE REPORT

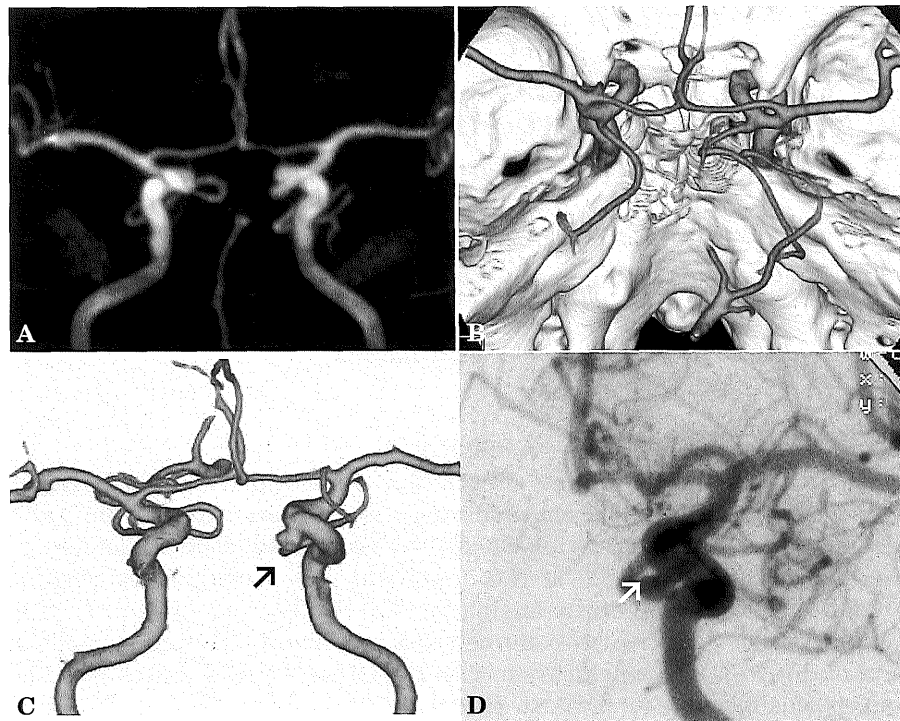
#### Case 1

A 70-year-old woman visited our hospital due to dizziness. Neurological examination was negative. The patient was examined by magnetic resonance

angiography (MRA) to check the CVD, and was incidentally suspected of having carotid cave aneurysm of the internal carotid artery (ICA) (Fig. 1A). The patient was examined by 3DCTA. NS-3DCTA with volume rendering showed only a small portion of an aneurysm near the skull base because the separation of vessels from bony structures was difficult (Fig. 1B). VS-3DCTA images with volume rendering (VR) subtracted the bony structures from the NS-3DCTA images and showed a carotid cave aneurysm of the ICA with a diameter of 5 × 3.5 mm and a right medial and slightly inferior direction (Fig. 1C). The saccular aneurysm of the carotid cave was also visualized by DSA. The location and size of the aneurysm revealed on DSA were the same as those shown in the VS-3DCTA images (Fig. 1D). The aneurysm was treated by endovascular embolization with several Guglielmi detachable coils.

#### Case 2

A 73-year-old man visited our hospital due to headache. Neurological examination was negative. The patient was examined by MRA to check the CVD, and was incidentally suspected of having



**Fig. 1**

- (A) Magnetic resonance angiogram, anterior view, showed an image suspected of being a carotid cave aneurysm.  
 (B) Conventional three-dimensional CT angiogram with volume rendering, superior view, showed only a small portion of an aneurysm in the carotid cave portion of the left internal carotid artery.  
 (C) Volume subtraction three-dimensional CT angiogram with volume rendering, anterior view, clearly showed an aneurysm with a right medial and slightly inferior direction in the carotid cave portion of the left internal carotid artery (arrow).  
 (D) Intra-arterial angiogram with anterior view showed an aneurysm with a diameter of  $5 \times 3.5$  mm with a right medial and slightly inferior direction in the carotid cave portion of the left internal carotid artery (arrow).

stenosis of the right middle cerebral artery (MCA) (Fig. 2A). The patient was examined by 3DCTA. VS-3DCTA with VR showed a stenosis in the proximal dorsal and distal ventral side of the MCA (Fig. 2B, D). NS-3DCTA with maximum intensity projection (MIP) method revealed stenosis with intramural calcifications (Fig. 2C, E). DSA had difficulty demonstrating the stenosis in the dorsal and ventral side of the MCA owing to the limitation of the imaging angle of DSA (Fig. 2F). Oral antiplatelet therapy was initiated for the stenosis.

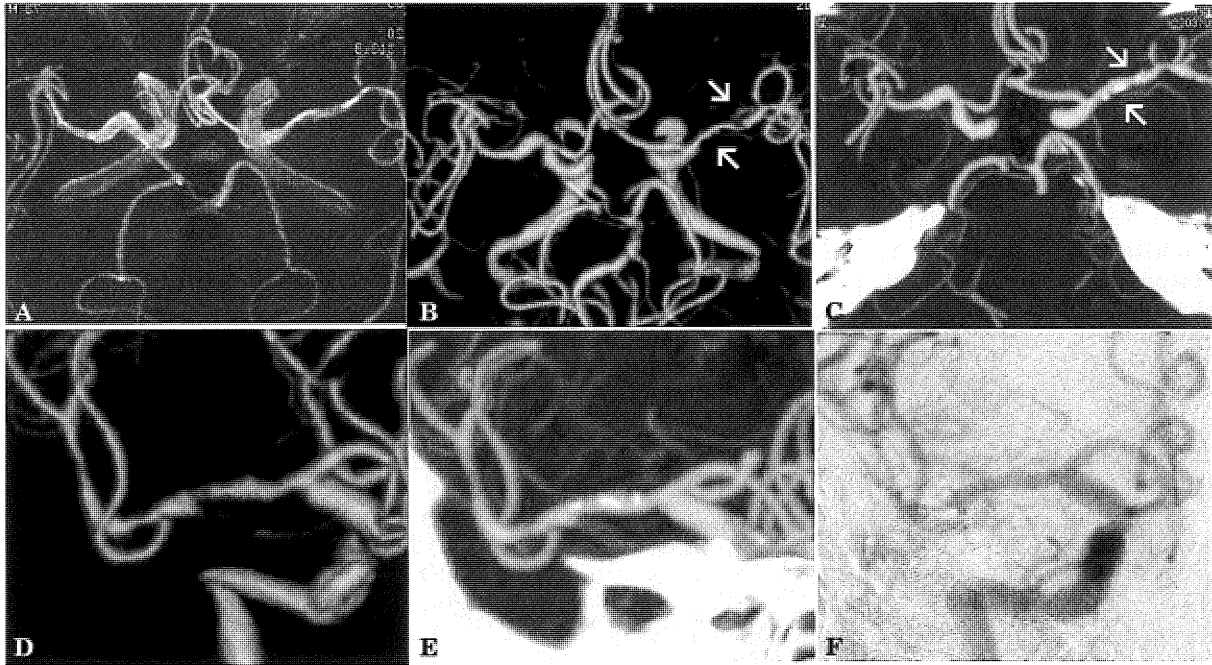
#### **METHOD OF VOLUME SUBTRACTION 3DCTA**

A multislice helical CT scanner (GE Light Speed Ultra 16; GE Medical Systems, Waukesha, WI) was used for 3DCTA. An Advantage Workstation (version 3.1, GE Medical Systems, Waukesha, WI) and Virtual Place Advance (Office Azemoto, Tokyo, Japan) were used for image analysis. The patient was positioned supine with the head maintained in a neutral position. A non-enhanced image (120 kV, 50 mAs, a gantry rotation speed of 0.5 sec per rotation, reconstruction algorithm: soft) was obtained with helical scanning ( $0.625 \text{ mm} \times 16$  collimation; table speed, 5.62 mm). Then 75 mL of non-ionic contrast medium (at a concentration

of 350 mgI/mL) was injected into the cubital vein at a flow rate of 4–5 mL/sec. Enhanced images were scanned after 13 sec with the parameters 120 kV and 200 mAs. Slice-thickness ( $0.625 \text{ mm}$ ) images were reconstructed with an increment of 0.32 mm. The field of view was 25 cm. The two image sets were transferred to the Virtual Place Advance workstation. On the workstation, a subtraction method by which the non-enhanced volume data with 3D image were subtracted from the enhanced volume data with 3D image was automatically performed, and subtracted 3DCTA images were created. The total examination time was about 8 minutes.

#### **DISCUSSION**

3DCTA has been an important tool for evaluating noninvasive vasculature imaging, and there have been many reports on the accuracy and utility of 3DCTA for detecting CVD, especially intracranial aneurysms<sup>2-6,9</sup>. On the other hand, NS-3DCTA was less useful than DSA for detecting aneurysms near the skull base, owing to the difficulty of visually separating vessels from bone<sup>2,7</sup>. Recently, a few subtraction methods on 3DCTA have been reported, and the utility of subtraction 3DCTA has been studied<sup>1-3</sup>. Using subtraction

**Fig. 2**

- (A) Magnetic resonance angiogram, superior view, showed an image suspected of being stenosis of the right middle cerebral artery.
- (B) Volume subtraction three-dimensional CT angiogram with volume rendering, superior view, showed the stenosis on the proximal dorsal and distal ventral side of the right middle cerebral artery (arrows).
- (C) Conventional three-dimensional CT angiogram with maximum intensity projection, superior view, revealed intramural calcifications on the proximal dorsal and distal ventral side of the right middle cerebral artery (arrows).
- (D) Volume subtraction three-dimensional CT angiogram with volume rendering, anterior view, clearly showed a stenosis in the right middle cerebral artery.
- (E) Conventional three-dimensional CT angiogram with maximum intensity projection, anterior view, revealed a few intramural calcifications in the right middle cerebral artery.
- (F) Intra-arterial angiogram with oblique view did not clearly show a stenosis in the right middle cerebral artery.

3DCTA with controlled-orbit helical scanning, Imakita et al<sup>2)</sup> reported that subtraction 3DCTA was superior to conventional NS-3DCTA in detecting aneurysms adjacent to bone in a study of 36 patients. Using subtracted 3DCTA with a simple head-restraining device and slightly modifying the image processing software, Jayakrishnan et al<sup>3)</sup> reported that subtraction 3DCTA was superior to conventional NS-3DCTA for detecting vascular disease of the intracranial and extracranial arteries in a study of 30 patients. Subtracted 3DCTA appears to be superior to NS-3DCTA in detecting an aneurysm near the skull base.

DSA may be considered the gold standard for diagnosis of CVD, but it has a disadvantage in its invasive evaluation of vascular disease. MRA is used as a screening examination for CVD. MRA, in contrast to 3DCTA, has the advantage of not requiring radiation exposure and contrast toxicity. However, MRA has the disadvantage of producing flow-related artifacts; the absence of a contrast medium can allow the degradation of images by motion artifacts<sup>5,8)</sup>. If bony structures in the area of the skull base are completely subtracted and only the vascular anatomy is revealed on 3DCTA,

subtracted 3DCTA images may be as useful as those obtained from DSA. Imakita et al<sup>2)</sup> reported that subtraction 3DCTA was superior or equivalent to conventional DSA in all cases examined. Further, the amount of radiation with 3DCTA is significantly less than that with DSA<sup>8)</sup>.

We utilized VS-3DCTA for two cases of carotid cave aneurysm near the skull base and MCA stenosis with intramural calcification. VS-3DCTA with VR was equal to DSA in the evaluation of the carotid cave aneurysm near the skull base. In the evaluation of vascular stenosis with intramural calcification, VS-3DCTA with VR was superior to DSA for demonstrating the stenosis because it was difficult for DSA to show a stenosis on the ventral and dorsal side due to the limitation of the imaging angle, and NS-3DCTA with MIP was useful for detecting subtracted intramural calcification. VS-3DCTA is a relatively uninvase and important diagnostic tool for detecting an aneurysm in the area of the skull base and stenosis of the intracerebral artery. Although further research is necessary, VS-3DCTA might prove to be an alternative to DSA as a diagnostic tool for CVD.

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