CASE REPORT

A Pitfall of the Volume Rendering Method with 3D Time-of-Flight MRA: A Case of a Branching Vessel at the Aneurysm Neck

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We present a case in which the origin of the branching vessel at the aneurysm neck was observed at the wrong place on the volume rendering method (VR) with 3D time-of-flight MRA (3D-TOF-MRA) with 3-Tesla MR system. In 3D-TOF-MRA, it is often difficult to observe the origin of the branching vessel, but it is unusual for it to be observed in the wrong place. In the planning of interventional treatment and surgical procedures, false recognition, as in the unique case in the present report, is a serious problem. Decisions based only on VR with 3D-TOF-MRA can be a cause of suboptimal selection in clinical treatment.

Keywords: aneurysm, angiography, magnetic resonance imaging, time-of-flight, volume rendering

Introduction

Cerebral aneurysms are reported to be present in approximately 1 to 10% of the general population.1,2 The annual risk of rupture is estimated to be approximately 1 to 2% per year and is affected by many factors (i.e., site, size, etc.).3–5 A previous study clarified the high hazard ratio for aneurysm with a history of subarachnoid hemorrhage (SAH).6 Therefore, follow-up with prophylactic treatment in selected cases is clinically important.

Digital subtraction angiography (DSA) is considered the gold standard for the diagnosis and analysis of cerebral aneurysms. However, the invasive nature of DSA is a disadvantage, carrying an approximately 0.5% rate of persistent neurological complications and an approximately 1% complication risk related to arterial puncture and catheter manipulation.7,8

The introduction of 3T magnetic resonance (MR) systems that achieve higher signal-to-noise ratio (SNR) and longer T1 relaxation time than earlier systems, combined with advances in parallel imaging techniques, has greatly improved the performance of time-of-flight magnetic resonance angiography (TOF-MRA) in terms of spatial resolution, acquisition time, and coverage for the evaluation of cerebrovascular diseases.6 Recently, the utility of the volume rendering method (VR) with 3D time-of-flight MRA (3D-TOF-MRA) and improved image quality in 3T were shown in several reports, and VR has been used as a screening tool for spatial recognition of 3 dimensions in MRI.9–12 Maximum intensity projection (MIP) image is superior in depicting a thin (low signal intensity) blood vessel simultaneously with a thick (high signal intensity) blood vessel, but is inferior in understanding of spatial recognition compared with VR imaging. Therefore, it is common practice that data of 3D-
TOF-MRA are displayed with 2D, MIP, and VR images in 3T systems.

We experienced a pitfall while using the VR with 3D-TOF-MRA. We report a case in which the origin of the branching vessel at the aneurysm neck was observed at the wrong place. In 3D-TOF-MRA without contrast agents, it is often difficult to observe the origin of the branching vessel, but it is extremely unlikely for the vessel to be observed at the wrong place.

Case Report

A 63-year-old man with an unruptured aneurysm of the left internal carotid artery was referred to our neurosurgical department for detailed imaging examination. Image data were obtained with 3 modalities (i.e., rotational angiography (RA), computed tomography angiography (CTA), and MRA). In the planning of interventional and surgical treatment procedures, initial imaging was performed with MRI mainly for the purpose of examination of the cerebral pathology. Secondary imaging was performed using CT for the spatial recognition of bone and blood vessels, and further imaging was performed using angiography for detailed imaging of the blood vessel anatomy. Even in cases where we can refer to images (i.e., CT, MRI, and angiography) from other institutions, we perform the examination in our institution for the planning of interventional and surgical treatment procedures mainly to ensure convenience of image comparison in follow-up and because of the high reliability of imaging in our institution.

The 3D-RA was performed using a rotational angiography system (ALLURA XPER FD 20/10, PHILIPS). The vessel bearing the aneurysm was selectively catheterized via a femoral approach. We injected nonionic contrast medium into the left internal carotid artery with a power injector. There were 120 angiographic images with a matrix size of $1024 \times 1024$ pixels obtained with a 17-inch field of view. These images were converted to isotropic 3D volume data with a voxel size of 0.27 mm in the equipped workstation.

MRA was performed using 3T MR system (Signa EXCITE HDx, GE Healthcare). An 8-channel brain phased-array coil was used as the receiver coil. For the 3D-TOF-MRA, the parameters were as follows: fast spoiled gradient-echo sequence; TR, 26 ms; TE, 2.8 ms; flip angle, 20°; $512 \times 512$ matrix (using zero-fill interpolation); 20-cm field of view; 84 partitions; section thickness, 0.8 mm; magnetization transfer, 1 acquisition; and acquisition time, 4 min and 45 s. The voxel dimensions of source images were $0.391 \text{ mm} \times 0.391 \text{ mm} \times 0.8 \text{ mm}$.

CTA was performed using an area detector CT scanner (Aquilion ONE, Toshiba). Injection of nonionic contrast medium was performed using a power injector. The area of interest was scanned 1 rotation in 1 s. Other parameters were $512 \times 512$ matrix, 120 kV, 270 mA, 13 cm field-of-view, and reconstruction index of 0.5 mm. The voxel dimensions of source images were $0.508 \text{ mm} \times 0.508 \text{ mm} \times 0.5 \text{ mm}$.

We show the targeted VR images with 3 modalities in Fig. 1, 2D images of 3D-TOF-MRA in Fig. 2, and partial MIP image of 3D-TOF-MRA in Fig. 3. The VR images were created on a computer workstation (Advantage Workstation, VolumeShare 2, GE Yokogawa Medical Systems). In 3D-DSA and 3D-CTA, the origin of the branching vessel was observed at the aneurysm neck. However, in 3D-TOF-MRA the origin of the branching vessel was observed at the internal carotid artery.

At first, we planned coil embolization for the aneurysm because the origin of the branching vessel was observed at the internal carotid artery in the VR with 3D-TOF-MRA. However, we changed the treatment plan to a clipping from a coil embolization because the origin of the branching vessel was observed at the aneurysm neck in 3D-DSA and 3D-CTA. Thus, a decision only on the basis of 3D-TOF-MRA may lead to suboptimal selection in clinical treatment.

Discussion

Our report showed that the origin of the branching vessel with VR with 3D-DSA was consistent with that of 3D-CTA, and the operating surgeon also confirmed that the origin of the branching vessel was observed at the aneurysm neck (Fig. 4). However, these findings differed from the result of 3D-TOF-MRA. Because DSA is considered the gold standard for the diagnosis, we think that the origin of the branching vessel at the aneurysm neck was observed at the wrong place with VR and 3D-TOF-MRA. In other words, the diagnosis using only 3D-TOF-MRA resulted in false recognition. False recognition has serious problems. We perform additional inspection with other modalities when the origin of the branching vessel at the aneurysm neck is not observed, but false recognition may lead to an incorrect plan of interventional treatment and surgical procedures. A more experienced physician who is used to radiological diagnosis may know the importance of checking 2D images. However, if a doctor does not have much experience of performing 3D spatial recognition.
Fig. 1. a: Volume rendering (VR) with 3D rotational angiography (RA). b: VR with 3D computed tomography angiography (CTA). c: VR with 3D time-of-flight magnetic resonance angiography (TOF-MRA) (comparable angle to other modalities). d: VR with 3D-TOF-MRA (oblique view). a, b, and c: Rotation to 130° right from front. d: Rotation to 130° right from front after rotation to 60° up from front. In b, low signal intensity compared with routine signal level was included to opacity curve for VR visualization because the branching vessel has a thin lumen and low signal intensity. In 3D-RA and 3D-CTA, the origin of the branching vessel was observed at the aneurysm neck. However, in 3D-TOF-MRA the origin of the branching vessel was observed at the internal carotid artery.

Fig. 2. 2D images (axial slice) with 3D time-of-flight MRA. A, P, R and L indicate the anterior, posterior, right, and left sides of the patient. White arrow indicates branching vessel. Upper left image is superior slice, and bottom right image is inferior slice.

Fig. 3. Partial maximum intensity projection (MIP) image with 3D time-of-flight MRA. White arrow indicates branching vessel. Thickness of partial MIP is 5 mm.

Fig. 4. Intraoperative photograph
from 2D images (i.e., axial images), the 3D image is preferred, and when the doctor neglects checking the 2D images, a pitfall as reported in the present study, may become a serious problem. In the present case, the branching is not clarified on 2D image (Fig. 2), and the origin of the branching vessel was observed at the internal carotid artery with partial MIP image (Fig. 3). It can be explainable if the origin of the branching vessel is observed at the wrong place or is not observed in MIP and VR images if the origin of the branching vessel is not observed in 2D images. We must not forget the disadvantages of MRA. The main disadvantages of 3D-TOF-MRA are artifacts due to flow phenomena, patient motion, high-intensity structures (i.e., SAH from a ruptured cerebral aneurysm), and relatively big voxel-size. We think that the signal loss of the branching part and the partial volume effect were causes of false recognition in 3D-TOF-MRA in the present report. We infer that this signal loss arose due to turbulent flow and/or susceptibility effect because metal artifacts and motion artifacts are hardly observed with source images.

A major limitation in our report is that the 3D-TOF-MRA acquisition protocol used may not have been the best. The competing requirements for adequate coverage and limited acquisition time often force a compromise in the spatial resolution of screening examination relative to that of detailed imaging examination. We think that the protocol used is reasonable in the setting of screening studies. Because visualization with VR is influenced by the threshold setting, we identified VR images in plural threshold settings. As a result, the depiction ability of 3D-TOF-MRA at the peripheral vessel in the patient was equal to or even higher than that of 3D-CTA. In addition, our protocol is relatively unaffected by turbulent flow compared to those described in previous studies because shorter TE was employed. However, the effect of turbulent flow remains in the present case with MRA.

In conclusion, we think that these examinations, except the MRI, should be conducted for the decision of the treatment plan. MRI at 3T has the potential to enhance the performance of MRA without the disadvantages of radiation exposure, risk of nephrotoxicity from intravenous contrast agents, and image degradation arising from vascular calcifications and the bony calvarium. Therefore, for screening and repeated follow-up studies, a more appropriate approach may be MRA compared with CTA and DSA. However, we must not forget the pitfalls of the VR on 3D-TOF-MRA. In the planning of interventional and surgical treatment procedures, false recognition has posed serious problems. Decision based on only the VR on 3D-TOF-MRA can be a cause of suboptimal selection of clinical treatment.

References