

Hemodynamic Research on Intracranial Aneurysms and Vascular Variations for Image Quality of MRA

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Introduction

Magnetic resonance angiography (MRA) is widely being used for the detection of intracranial aneurysms in a non-invasive way and its imaging quality is getting better. In common with any other diagnostic methods, false positive or false negative findings are the main obstacles for MRA in detecting vascular abnormalities. In case of lowered reliability from frequent false positive findings, additional studies such as conventional digital subtraction angiography (DSA) are sometimes needed. However, this weakens the greatest merit of MRA, non-invasiveness. Since there have been only some brief descriptions in the several published papers, the analysis of producing mechanism of false positive findings in MRA may be necessary.

The turbulence and reverse of the blood flow can lead to unexpected signal loss and pseudostenotic changes in MRA using three-dimensional time-of-flight (3D-TOF) technique. Turbulent flow as well as reversed flow may be produced even in the vessels without any pathologic changes. The frequent site of pseudostenosis is at the regions immediately distal to bifurcation where a turbulent flow develops during cardiac pulsatile flow, and these include the common carotid bifurcation, carotid siphon, and terminal bifurcation of the internal carotid artery. In addition, anterior communicating artery (AcoA) complex seems to be another location of pseudostenosis especially when associated with anatomical variation such as hypogenesis of A1 segment. Sometimes the signal losses and pseudostenotic changes were so significant that could be misinterpreted as an aneurysm. AcoA complex is an important region among cerebral arteries, because there is relatively higher incidence of aneurysm and this area is generally included in the field of view of MR angiography. However, the provoking condition and incidence of this phenomenon has not yet been published. Hypoplastic or aplastic A1 segment in the either side of AcoA complex can be found occasionally. We presumed the configuration of AcoA complex may resemble typical shapes of bifurcating

vessels according to the grade of hypogenesis of A1 segment. In this situation, the blood flow contralateral to the hypogenetic A1 segment simulates that in the bifurcating arteries.

Therefore, we tried to assess the flow pattern in the bifurcating vessels by the experimental study. Based upon those results, we tried to determine the relationships between hemodynamically produced aneurysm-mimicking findings in the AcoA complex in 3D-TOF MR angiography and anatomical variation of anterior cerebral artery.

PURPOSE: The aim of this study was to determine the relationships between the anatomical variation of ACA and hemodynamically produced aneurysm-mimicking findings in the AcoA in 3D-TOF MR angiography by clinical and experimental methods.

MATERIALS AND METHODS: For the clinical study, a total of 62 patients who undertook digital subtraction angiography due to rupture of aneurysm in the else where than AcoA were examined with MR angiography. The existence of anatomical variation in the anterior cerebral artery and the occurrence of signal defect at the AcoA in MR angiography were evaluated. For the experimental study, MR angiography and digital subtraction angiography (DSA) of elastic silicon vascular phantoms which had two different bifurcation angles (70, 140) and intraluminal pulsatile flow were performed to evaluate hemodynamical factors producing signal defects and were compared with computational fluid dynamics (CFD).

RESULTS: In clinical study, 21 (34%) of 62 patients had aplastic (4 patients) or hypoplastic (17 patients) A1 segment in either side of ACA and showed remodeled bifurcation shape of the AcoA complex. In MR angiography of patients with hypogenetic A1 segment, signal defects at the axilla areas of bifurcated anterior cerebral arteries were noted in 14 of 21 patients (67%) and 7 patients among them showed moderate (5 patients) or severe (2 patients) signal defects that could be misinterpreted as an aneurysm. In experimental study, MR angiography of vascular phantom with broad-angled bifurcation (140°) showed signal defects at the axilla areas of bifurcation and these were demonstrated as a turbulent flow in DSA and CFD. However, phantom with narrow-angled bifurcation (70°) did not show significant signal defect.

CONCLUSIONS: As demonstrated in the phantom study, a turbulent flow at the axilla areas of bifurcation may cause significant signal defect in MR angiography, especially when the bifurcation angle is broad. Therefore, it should be kept in mind that MR angiography in some patients with hypoplastic or aplastic A1 segment in either side of ACA has the potential of misinterpretation as an aneurysm at the AcoA.