B-2

Hemodynamic Changes on Phantoms of the Internal Carotid Arterial Stenosis: Comparison of Magnetic Resonance Angiography (MRA), Digital Subtraction Angiography (DSA) and Computational Fluid Dynamics (CFD)

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Purpose: The most important cause to discredit the reliability of MRAs is the overestimation of the degree of stenosis in the internal carotid artery (ICA). The purpose of this study is to evaluate the secondary hemodynamics and the causes for the overestimation of degree of variable stenotic phantoms of carotid artery using steady-state flow on MRAs.

Materials and Methods: We constructed normal and variable stenotic phantoms of the bifurcated carotid artery using acrylic materials (40 % and 65 %). Flow patterns were evaluated with axial and coronal imaging of MRAs (2D-TOF and 3D-TOF) and DSAs of phantoms constructed of an automated closed-type circulatory system filled with 10 % glucose solution. These findings were then compared with the findings obtained from CFD.

Result: 3D-TOF axial MRA of asymmetrically 40 % stenotic phantom revealed 40 % stenosis identical to the stenotic region of phantoms with continued poststenotic signal loss whereas 3D-TOF axial MRA of symmetrically 65 % stenotic phantom showed markedly decreased signal intensity at the poststenotic segment resembling occlusion. Source image of 2D-TOF coronal MRA showed redistribution (from the internal to external carotid artery side) of central axis of inflow depending upon the degree of stenosis of the ICA, and this distribution can be a cause for the decreased signal at the poststenotic segment due to reducing flow volume through the stenotic segment. The general hemodynamics of the variable stenotic phantoms on MRA were identical to the hemodynamics on DSA and CFD.

Conclusion: Although dephasing from turbulent flow and character of maximum intensity projection (MIP) were suggested as the main cause of the decreased poststenotic signal, our study indicated that hemodynamically redistributed central axis of inflow and reduced flow volume through stenotic channel is one of the basic factors of the decreased signal intensity at the poststenotic segment on MRA.