Comparison of TOF MRA and CE MRA with 3-D X-ray Angiography: An *In Vitro* Study

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Introduction:

Contrast-enhanced magnetic resonance angiography (CE-MRA) provides advantages for neurovascular imaging, especially for aneurysms of the circle of Willis. These malformations are characterized by slow flow within the aneurysm and in-plane flow through the circle of Willis, both of which are confounding factors for flow-based MRA techniques. New x-ray imaging techniques, such as computed-rotational angiography (CRA) are also being developed for use during neurointerventional procedures and may prove to be the "gold standard" for neuroangiography. In this work we describe a comparative study of CRA, MRA, and CE-MRA in an anthropomorphic flow model of the intracranial vessels.

Methods:

In vitro investigations were carried out with an intracranial flow phantom (Figure 1a, Elastrat, Geneva Switzerland) cast from cadaveric vessels and including a saccular aneurysm.[1] Computed-rotational angiography was performed by a prototype system (Siemens Multistar) that acquires a 400 x 400 x 400 cube of 0.55 mm isotropic voxels during a 4.5 s intraarterial injection of iodinated contrast.[2] Conventional MOTSA and CE-MRA techniques[3] were performed with a clinical MR scanner (GE 1.5 T CVMR). MOTSA parameters were: TR/TE 32/3 ms. 30° flip angle, 15.6 kHz bandwidth, 22 cm FOV, 256x192 matrix, 1 NEX and 1.4 mm slices (total time 10 minutes). A spoiled gradient echo sequence was used for CE-MRA acquisition with the following parameters: TR/TE 5.2/1.3 ms. 40° flip angle, 62.5 kHz bandwidth, 22 cm FOV, 256x160 matrix, 1 NEX and 1.6 mm slices (total time 30 s). Pulsatile flow (10 ml s^{-1} mean, 42.5 ml s^{-1} peak) was provided by a computer-controlled pump, using a 60:40 glycerol: water mixture as a blood mimic.

For CE-MRA acquisitions, the fluid was doped with dilute Gd-DTPA in appropriate concentrations, ranging from 0 to 20 m*M*. This approach greatly simplifies the experimental protocol, while mimicking the contrast that would occur within the vessels during the plateau phase.

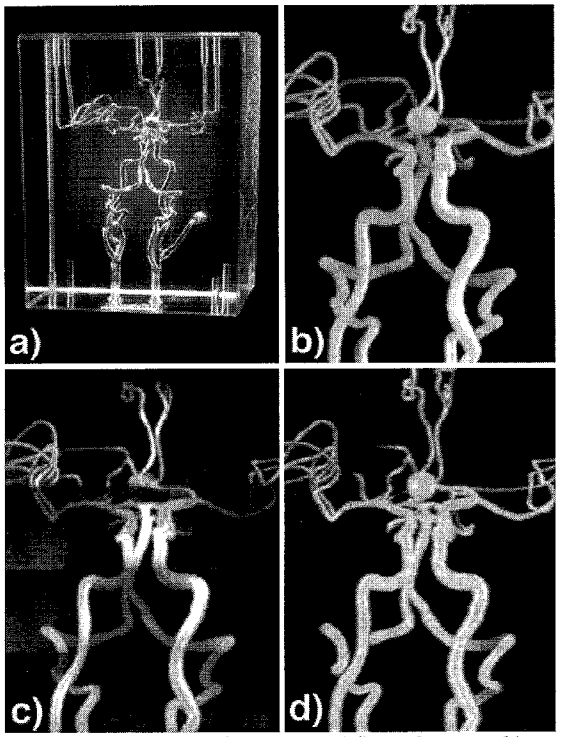

Figure 1 : a) photo of intracranial flow phantom, b) CRA, c) MOTSA and d) CE-MRA angiograms.

Results:

Figure 1 shows MIP images of the CRA, MOTSA and CE-MRA data. Signal dropout and artifacts in the TOF MRA are reduced in the CE-MRA, which is nearly equivalent to 3-D CRA. Signal-difference-to-noise ratio (SDNR) was measured for each of the CE-MRA images, where signal is measured in the lumen of a vessel and noise is taken as the standard deviation in the background. Figure 2 shows the SDNR *vs* Gd-DTPA concentration, with the x-ray CRA SDNR (~40) shown for comparison.

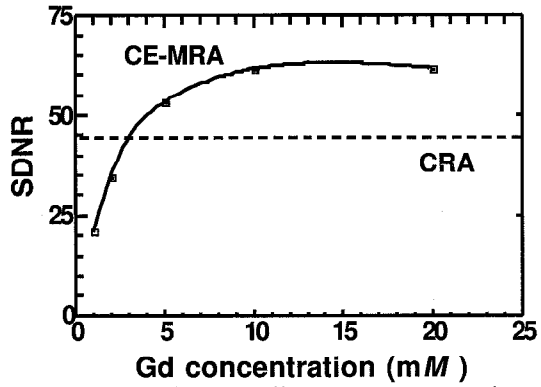

Figure 2 : Plot of signal-difference to noise ratio for CE-MRA at various Gd concentrations.

Discussion and Conclusions:

CE-MRA eliminates most artifacts that plague flow-based MR neuroangiographic techniques. Image quality and contrast-to-noise ratio (~50) in CE-MRA images is nearly equivalent to high-resolution, high-contrast x-ray techniques such as CRA. Improvements in CE-MRA image quality are evident for increasing concentration of Gd-DTPA, up to a concentration of about 5 m*M*.

Acknowledgments:

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References:

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