Contrast Enhanced MR Angiography in Intracranial Arterial Stenosis Reveals Collateral Circulation and Angiogenesis

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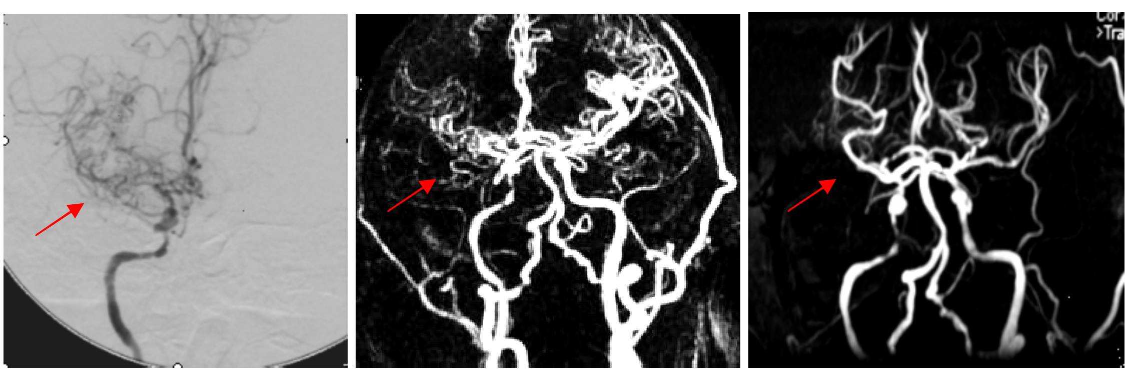
Introduction: The severity of intracranial arterial stenosis needs to be comprehensively evaluated before any drug treatment is administered. Many efforts have been made to develop new non-intrusive angiographic methods such as CTA and MRA because of the intrusive nature of DSA. In this study, contrast enhanced MR angiography (CE MRA) [1] will be used to evaluate intracranial arterial stenosis and investigate collateral circulation and the potential angiogenic response to reduced flow by the brain. Specifically, we will examine both CE MRA and 3D time-of-flight (3DTOF) MRA approaches.

Materials and methods: Thirty three patients with symptomatic intracranial arterial stenosis underwent 3D TOF MRA and CE MRA. Seventeen of them underwent digital subtraction angiography (DSA) within one week. MR angiography was performed on a SIEMENS TRIO 3.0T unit with an eight-channel phased-array head coil. Coronal CE MRA was obtained after a bolus injection of 28 ml gadopentate dimeglumine (GdDTPA). Image reconstruction, evaluation and stenosis measurement were carried out on the SIEMENS AG 2003 workstation. Two radiologists independently assessed the severity of stenosis as well as the establishment of collateral circulation as determined by both TOF and CE MRA without prior information of DSA. The result of DSA was used as the "gold standard". Correlations for 3D TOF MRA, CE MRA and DSA were determined by Pearson correlation coefficient analysis.

Results: 374 intracranial vessels were evaluated for both 3D TOF MRA and CE MRA and 187 of them were evaluated in the DSA images. Correlations of 3D TOF MRA relative to DSA, CE MRA relative to DSA and 3D TOF MRA relative to CE MRA gave correlation values of R^2 =0.815， R^2 =0.847 and R^2 =0.910, respectively. Overall, 3D TOF MRA and CE MRA overestimated stenosis compared to DSA by the Wilcoxon signed rank test although CE MRA did not show overestimation for the major vessels as far as the internal carotid artery and middle cerebral artery were concerned. Further, 3D TOF MRA overestimated the degree of stenosis compared to CE MRA. In one case, CE MRA delineated collateral circulation clearly through the dilated ophthalmic artery in the presence of an occluded ipsilateral internal carotid artery. In another case, with an occluded right middle cerebral artery (MCA), no major infarction in the right cerebral parenchyma was shown. CE MRA demonstrated significant collateral circulation through the anterior cerebral artery and leptomeningeal vessels in the right brain. Of greater interest in this study, three cases showed dilated lenticulo-striate arteries where the corresponding MCA showed a severe stenosis. Two cases showed tiny tangled vessels downstream from the occluded arteries or arteries having severe stenosis. These tiny irregular vessels were assumed to be new born capillaries according to DSA (Figure 1). In our data, 3D TOF MRA had difficulty revealing the full scope of collateral circulation as well as any evidence for angiogenesis.

Discussion and Conclusion: The main advantage of CE MRA lies in the potential for rapid high resolution imaging. It overcomes the well known saturation limitations of 3D TOF MRA [2]. Despite the fact that CE MRA and 3D TOF MRA were nearly identical in evaluating stenosis in this study, CE MRA was superior to 3D TOF MRA in visualizing collateral circulation. The ability to visualize collaterals is very important because it is critical for the survival of the parenchyma when there is occlusion or severe stenosis in a major artery. It explains why patients who have the same major occluded arteries can have different clinical presentations. In addition, CE MRA successfully showed the phenomena of angiogenesis which to date has only been seen in DSA. The likely explanation that they cannot be seen with conventional MRA is that the flow is too slow .These phenomena, collateral circulation and angiogenesis, seem to be a response of the "starved" brain tissue to a reduction of oxygen because of reduced flow in stenotic vessels. With higher resolution, CE MRA may offer further insights into the physiologic response of the brain to reduced perfusion.

References: [1] Vincent et al, Contrast-enhanced MRA Technical considerations for optimized clinical implementation. Top Magn Reson Imaging 2001; 8:283-299. [2] Sohn et al, Contrast-enhanced MR angiography of the intracranial circulation. Magn Reson Imaging Clin N Am 2003; 11:599-614.



A. DSA B. CE MRA C. 3D TOF MRA

Figure 1: DSA (A) shows that the superior branch of the right cerebral artery is occluded and new born capillaries have been formed. CE MRA (B) shows a similar angiogenic effect, while 3D TOF MRA (C) doesn't visualize these small vessels.