Correlation between XRA and Radial Sliding Window MRA of Arteriovenous Malformations

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Introduction:

MR-based angiography has replaced catheter angiography in most vascular beds. However, many hospitals routinely perform catheter angiography of the intracranial vasculature. The intracranial vasculature remains a challenge for MRA due to the increased importance of flow dynamics for diagnosis. For example, the prompt arrival of contrast agent in the venous system is indicative of A-V shunting or fistulae. Furthermore the treatment of intracranial arteriovenous malformations relies on mapping out the vascular architecture of the lesion, including: size, location and venous drainage patterns. Imaging of small arterial feeders is of particular utility in pre-surgical embolization.

Method and Results:

We have developed a high frame rate MRA pulse sequence that is capable of mapping the vascular architecture of intracranial AVMs. This pulse sequence uses a radial k-space trajectory (in plane) and Cartesian sampling through plane in a "stack of stars" sampling scheme. We have coupled this acquisition with a sliding window reconstruction to allow for frame rates at 3 frames/sec or higher, comparable to x-ray angiography.

Sliding Window MRA is Able to Visualize Small (< 2 mm) Feeding Arteries in Confirmed Intracerebral Arterioveneous Malformations.

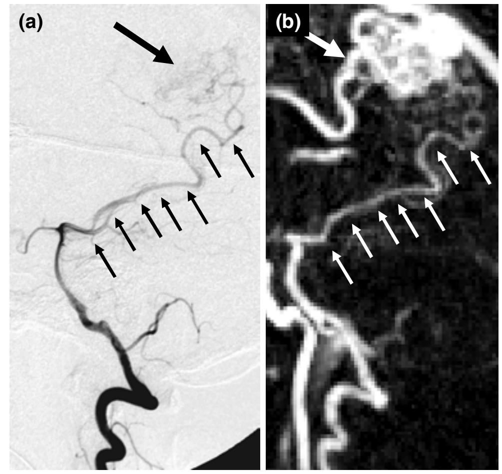

Figure 1: (a) A right vertebral injection demonstrates a 1.8 mm arterial feeder (thin black arrows) to a Spetzler-Martin Grade II cerebral arteriovenous malformation in a 41 year old female patient. **(b)** In a arterial phase sliding window MRA the same feeder is well visualized (thin white arrows). The thick white arrow in (b) denoted an additional feeder originating from the middle cerebral artery, which is not visualized on the X-ray exam due to the selective vertebral injection.

In addition, sliding mask subtraction was used for better separation of arterial and venous phases. Although contrast-to-noise ratio (CNR) is reduced from sliding subtraction, we have determined that for an interval of about 30 frames (10 seconds), contrast is sufficiently recovered. For an AVM patient, the CNR was 278 for initial mask and 270 for sliding mask (30-frame interval), with a better separation between arterial and venous phases for the sliding mask.

We compared MRA results with catheter angiography in a series of patients. To determine the minimum requirements we have performed a study of 17 consecutive AVM patients using X-ray DSA. We have measured the size of the AVM feeding vessel to assess whether the spatial resolution matches the size of arterial feeding blood vessels. In these patients, a neurosurgical resident physician retrospectively measured the size of the arterial feeders on the X-ray angiogram. There were between 1 and 6 feeders per patient identified in these subjects (mean +/- std = 2.50+/- 1.41, range=1-6), a total of 44 feeders were examined. We found the diameters of the feeding arteries to be 2.39 mm +/- 0.96 mm, range = 1.0 mm-4.8mm.

A series of patients who were scheduled for pre-treatment endovascular embolization of intracranial AVMs' were recruited for this IRB approved study. Patients were imaged on a 3.0T MRI scanner (Trio, Siemens, Medical Solution) equipped with multi-channel (TIM) capabilities. Based on the feeder study, we implemented a MRA protocol with the following pulse sequence parameters (N_p=128, FOV=220mm $N_{readout}$=256, N_{slices}=16, thickness=2.0 mm). A multi-injection protocol was used to acquire right lateral, left lateral and coronal scans with stepped contrast dosage, not exceeding 0.3 mmol/kg*(body weight)

Figure 1 shows a representative example of an MRA/X-ray comparison in a confirmed Spetzler-Martin grade II AVM. In this case, we were able to identify the smallest feeding artery in this patient which was measured to be 1.8 mm in the X-ray angiogram. In this case, MRA performed better than X-ray by detecting an additional feeder not identified by X-ray due to selective vertebral injection.

Conclusion:

We have developed an MRI pulse sequence with sub-millimeter spatial resolution capable of acquiring images at 3 frames/sec. Correlative studies of this sequence and X-ray DSA in neurosurgical patients were done. Optimal sliding subtraction mask interval was determined for best contrast.

Reference:

1. Spetzler, Martin J Neurosurg 1986
2. Reiderer SJ, et al MRM 1988.
3. Cashen TA, et al, ISMRM 2006.