Comparision of high temporal resolution 2D time resolved blood bolus tagging MRA and 3D time resolved contrast enhanced MRA for the assessment of hemodynamics in patients with cerebral arteriovenous malformations

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Introduction and Background

Cerebral arteriovenous malformations (AVMs) are congenital vascular malformations that result in direct arteriovenous shunts presenting with a variety of clinical symptoms. While some of the symtoms are directly related to the angioarchitecture of the malformations, newer studies have shown that especially the risk of bleeding and the results to radiosurgical treatment are mainly related to the hemodynamics of the malformations (Essig et al). MR imaging and MR angiography are noninvasive diagnostic tools which allow for the assessment of the architecture but also for the hemodynamics of even complex vascular malformations as cerebral AVMS.

Currently there are two approaches to assess the hemodynamics:

1st a non contrast enhanced time resolved 2D thick slap MRA based on a blood bolus tagging technique and 2nd new contrast enhanced 4D techniques bes on parallel imaging and time-resolved imaging with stochastic trajectories (TWIST). Especially the second offers combined anatomic and hemodynamic information. Both methods obtain pure arterial and venous phase images consistently and rapidly without a timing run. Regarding the time resolution the nonenhanced technique provide a superior temporal but inferior spatial resolution.

The aim of the current study was therefore to non-invasively assess the hemodynamic characteristics of patients with cerebral arteriovenous malformations (AVMs) using dynamic tagging MRA (dMRA) and a time resolved contrast enhanced TWIST MRA.

Patients and Methods

In an ongoing prospective protocol we examined so far 20 patients with angiographically proven AVMs using both methods in an intraindividual comparison

The dMRA sequence is based on the spin labeling sequence (STAR) in which a bolus of blood upstream the AVM is tagged by an inversion pulse and imaged downstream at different time intervals after tagging. The method is based on a 2D time resolved technique acquiring a thick slap projection. The time resolution was 100ms for each volume allowing for a perfect hemodynamic evaluation of the malformations. For hemodynamic information the time between the arterial feeders and the draining veins was estimated as the AVM shunt time.

The 3D time resolved TWIST angiography was used as previously described for the assessment of the carotid arteries. Using a 32 chanel headcoil and the injection of 0,1mmol of Gd-BOPTA (MultiHance, Bracco, Princeton, USA), we could drop the time resolution to 250ms and the spatial resolution to 1x1x1 mm^3.

The method was used in combination with a fast (3cc/sec) contrast injection to provide dynamic clinical information, including the evaluation of abnormal vascular anatomy as well as vascular hemodynamics, and perfusion measurements.

To compare the two methods independent readers wer asked to assess the visibility of the vascular components of the malformation – feeding arteries, the AVM nidus and the draining veins. The assessment of the hemodynamics was based on a visual score and the measurement of a AVM shunt time defined as time between feeding arteries and draining veins.

Results

Both methods were able to assess the hemodynamics of the vascular malformations (Figure 1-2).

The tagging method with high temporal resolution could prove our concept that smaller AVMs generally showed shorter shunt times, however, a short shunt-time was associated with a higher risk of bleeding, independent of the AVM size.

In the direct comparison the tagging method was due to the lack of spatial resolution substantially inferior in the assessment of the angioarchitecture and could show significantly less feeding arteries ($p<0.05$).

The current temporal resolution of the TWIST angio was sufficient to assess large AVMs, however if the shunt time was too short one could not calculate an AVM shunt time at the used temporal resolution.

From a practical perspective the tagging technique was easy to manage with only 15 single angiograms as a 2D projection. With about 3000 plus images the TWIST technique requires postprocessing of the data.

Conclusion

The combined evaluation of the angioarchitecture and hemodynamics of cerebral AVMs is best possible wit a CE TWIST MRA. However the calculation of hemodynamic parameters is best with the dMRA based on the taggin – but the techniques lacks a sufficient spatial resolution for the assessment of the angioarchitecture.

Further studies have to show the potential of the contrast enhanced technique in the assessment of the AVM flow and to correlate these findings with the clinical symptoms and treatment results of such malformations. Technical improvements regrading the TWIST technique have to focus on the data management and data analysis.

Figure 1: 18 out of 4000 TWIST MRA images – upper row showing the time series between arteries and veins, the lower row adjacent slices at different time points. Note the high spatial resolution and the 3D possibilities.

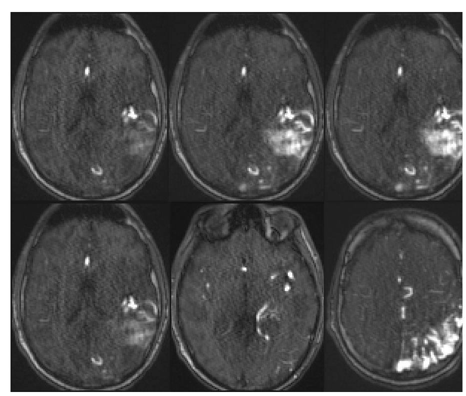

Figure 2: 10 out of 12 dynamic tagging angiograms presenting a large cerebral AVM in a 25 year old patient. Note the high temporal resolution of 100ms of these 2D projection MRAs