Utility of Non Contrast 3D Volumetric Time-Resolved MRA combining Multiple Phase FAIR (CINEMA-FAIR) as a diagnostic tool for intracranial AVM and AVF in comparison with CE-dMRA

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Introduction&Purpose

Detailed information on anatomy and hemodynamics in cerebrovascular disorders such as AVM and AVF is mandatory for not only diagnosis but treatment planning. DSA is a gold standard for diagnosis and contrast-enhanced dynamic MR angiography (CE-dMRA) was reported as a useful technique[1)]. But they poses a risk associated with contrast agent or cathetel insertion. Recently, a new technique was presented for non-contrast volumetric time-resolved MRA (Non Contrast 3D Volumetric Time-Resolved MRA combining Multiple Phase FAIR; CINEMA-FAIR)[2)]. CINEMA was developed as a technique that enables diachronic observation of hemodynamics as in CE-dMRA and extensive 3D volume acquisition with the whole brain as a target. The purpose of this study is to assess the effectiveness of CINEMA-FAIR compared with CE-dMRA as a diagnostic tool for intracranial AVM and AVF.

Material & Method

Four consecutive patients with 6 intracranial AVF and 6 consecutive patients with 6 intracranial AVM were recruited. All patients were examined with CINEMA-FAIR, CE-dMRA and DSA. All MR examinations were performed on a Philips Achieva 3.0 Tesla scanner and equipped with a 32-element neuro-vascular coil. CINEMA-FAIR technique combines ASL with 3D segmented T1 weighted gradient echo sequence. FAIR preparation scheme with the Look-Locker sampling was used for spin tagging in this study (Fig 1). CINEMA-FAIR was implemented with the following parameters: FOV=220×200mm^2, Matrix=224×162, 3D acquisition with 100×1mm slices, voxel size =0.50×0.50×0.60mm^3, flip angle=10°, TR=8.5ms, TE=4.2ms, SENSE factor=3.0, TI/ΔTI/final TI=100ms/197ms/1.4s, number of acquired time points=7. Total acquisition time is approximately 7 min. CE-dMRA was implemented with 4D TRAK MRA (4D Time Resolved Angio using Keyhole) using keyhole, CENTRA, partial Fourier, and parallel imaging; 24 dynamic scans were obtained with a temporal resolution of 2 sec and a spatial resolution of(0.68x0.68x1.0)mm^3 after power –injection of 0.1ml/Kg of magnescope. CINEMA-FAIR and CE-dMRA were independently reviewed by two neuroradiologists for feeding artery, nidus size and type of drainage vein with respect to Spetzler-Martin classification in patients with AVM, and for fistula site, main feeding artery, type of drainage vein with respect to Borden classification in patients with AVF. And then they were compared with gold standards from consensus reading of DSA by another two neuroradiologists. For qualitative assessment, same two neuroradiologists scored the delineation of feeding arteries and drainage veins in 4 points scale as : 3:excellent 2:good 1:fair 0:poor, in another session. Kappa were calculated to compare inter-observer agreement and inter-modality agreement. Qualitative scores were statistically analyzed by Wilcoxon signed rank test.

Results

Results of reading were summarized in table 1 and figure 2.

Conclusion

As a diagnostic tool for intracranial AVF and AVM, CINEMA-FAIR showed comparable results from many view points, but was apparently inferior to CE-dMRA in deliniating drainage vein of AVM. Although further sequence optimization should be needed, this technique could play an important role in assessing structure and hemodynamics of intracranial arteries without using any contrast agents.

Table 1. Summary of CINEMA-FAIR, CE-dMRA and DSA findings and interobserver and intemodality agreement of AVF and AVM

AVF	CINEMA-FAIR obs1	CINEMA-FAIR obs2	CE-dMRA obs1	CE-dMRA obs2		CINEMA※ -FAIR	※ CE-dMRA	DSA	
shunt point									
cavernous sinus	2	2	2	2		2	2	2	
Lt.Sigmoid sinus	1	1	1	1		1	1	2	
Rt. Sigmoid sinus	0	0	0	0		0	0	1	
dura	0	0	0	0		0	0	1	
undetected	3	3	3	3		3	3	0	
Inter-Observer agreement		κ=1.00	κ=1.00			inter-modality agreement	CINEMA/CE-dMRA		κ=1.00
							CINEMA/DSA		κ=0.40
							CE-dMRA/DSA		κ=0.40
main feeding artery									
Rt.ICA	0	2	0	2		2	2	1	
Rt.AphA	0	0	0	0		0	0	1	
Rt.MMA	0	0	0	0		0	0	1	
Lt.MMA	1	0	0	0		0	0	0	
Lt.OA	0	1	0	1		1	1	2	
Rt.ACA	0	0	0	0		0	0	1	
undetermined	5	3	6	3		3	3	0	
Inter-Observer agreement		κ=0.14	κ=0.00			inter-modality agreement	CINEMA/CE-dMRA		κ=1.00
							CINEMA/DSA		κ=0.13
							CE-dMRA/DSA		κ=0.13
Borden cllasification									
Type 1	1	0	1	1		1	1	3	
Type 2	2	2	2	2		2	2	2	
Type 3	0	0	0	0		0	0	1	
undetermined	3	4	3	3		3	3	0	
Inter-Observer agreement		κ=0.70	κ=1.00			inter-modality agreement	CINEMA/CE-dMRA		κ=1.00
							CINEMA/DSA		κ=0.38
							CE-dMRA/DSA		κ=0.38

AVM	CINEMA-FAIR obs1	CINEMA-FAIR obs2	CE-dMRA obs1	CE-dMRA obs2		CINEMA※ FAIR	※ CE-dMRA	DSA	
feeding artery									
MCA	2	2	3	4		2	2	2	
PCA	2	1	1	1		1	1	2	
MCA+PCA	0	2	1	1		2	2	1	
AICA	0	0	0	0		0	0	1	
undetermined	2	1	1	0		1	1	0	
Inter-Observer agreement		κ=0.36	κ=0.18			inter-modality agreement	CINEMA/CE-dMRA		κ=1.00
							CINEMA/DSA		κ=0.57
							CE-dMRA/DSA		κ=0.57
drainage vein									
Superficial	2	4	6	5		4	6	6	
deep	0	0	0	0		0	0	0	
both	0	0	0	1		0	0	0	
undetermined	4	2	0	0		2	0	0	
Inter-Observer agreement		κ=0.40	κ=0.00			inter-modality agreement	CINEMA/CE-dMRA		κ=0.00
							CINEMA/DSA		κ=0.00
							CE-dMRA/DSA		κ=1.00
nidus size									
undetected	1	1	1	1		1	1	0	
0-3	4	4	4	5		4	4	5	
3-6	1	1	1	0		1	1	1	
6	0	0	0	0		0	0	0	
Inter-Observer agreement		κ=1.00	κ=0.60			inter-modality agreement	CINEMA/CE-dMRA		κ=1.00
							CINEMA/DSA		κ=0.60
							CE-dMRA/DSA		κ=0.60

※ consensus reading of the two readers

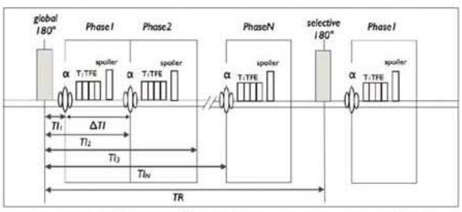

Fig 1 .Timing scheme of the CINEMA-FAIR sequence. Afteran initial global or slice selective 180° inversion pulse a series of T1-TFE images is acquired. Each of these image readouts is preceded by a low flip-angle excitation, which drives the longitudinal magnetization into a dynamic steady state.

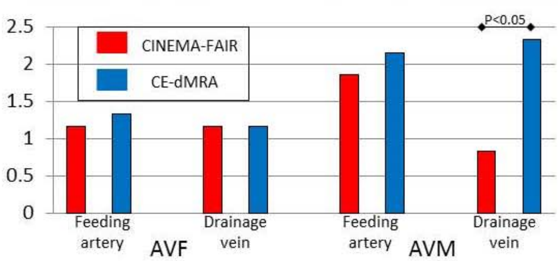

Fig 2 . The average scores of delineation of feeding artery and drainage vein in AVF and AVM patients each.

Reference
1)Hadizadeh DR, et al. Radiology 2008;246:205–213.
2)Nakamura M et al, 2011;Proc. ISMRM.3878.