

Visualization of Hemodynamics in intracranial arteries after EC/IC bypass surgery using Time-Resolved Three-Dimensional PC (4D-Flow) MRI



Ryo Takagi MD, Yasuo Amano MD, Tetsuro Sekine MD,
Yasuo Murai* MD, Akira Teramoto* MD PhD and
Shinichiro Kumita MD PhD

Department of Radiology and Neurosurgery*

Nippon Medical School TOKYO JAPAN

BACKGROUND : 4D-MRI

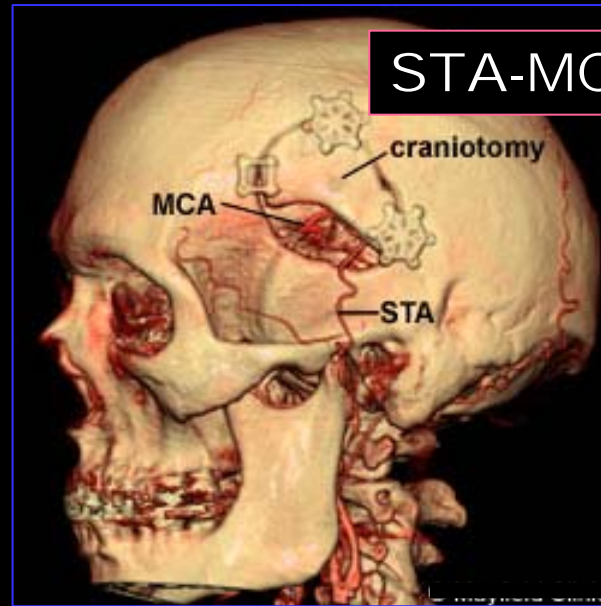
4D-flow MRI offers the visualization of the temporal evolution of complex flow and motion pattern in three dimensional volume.



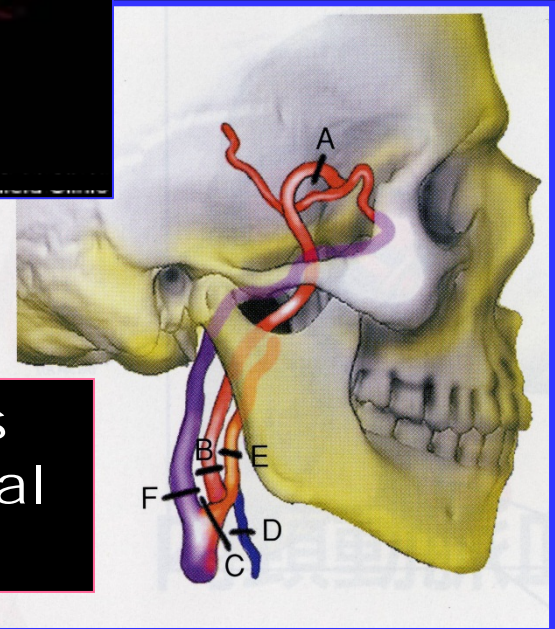
BACKGROUND : EC/IC bypass

Several variants of EC/IC bypass surgery have been performed in patients with IC occlusion.

No imaging technique can demonstrate the post-operative bypass-flow in vivo.



STA-MCA anastomosis



High flow bypass using a long radial artery graft

PURPOSE

- To demonstrate the clinical feasibility of 4D flow MRI at 3T in the evaluation of hemodynamics in patients after extracranial/intracranial (EC/IC) bypass surgery.

MATERIALS

- 12 pts after EC/IC bypass surgery
 - 9 female / 3 male mean age; 65 years
 - 6: IC occlusion due to arteriosclerosis
 - 6: post ligation of IC giant aneurysm
 - 6: High flow bypass using radial artery graft
 - 4: High flow bypass & STA-MCA
 - 2: STA-MCA anastomosis
- 4 of 12 pts underwent MRI before and after bypass surgery.

Imaging Technique

- 3-Tesla MRI : Achieve 3T Philips
- Imaging parameters :

3D T1 TFE

TR/TE/NEX= 8.4msec / 5.4msec / 1

FA=13,

FOV=210X210mm,

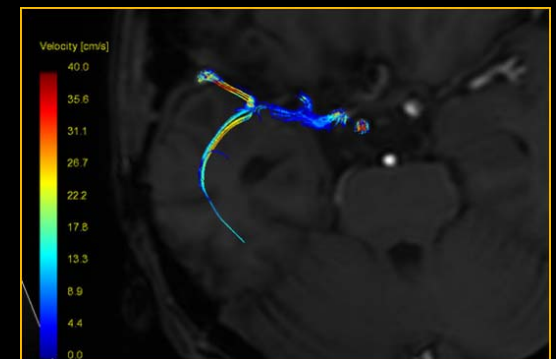
VENC=70cm/sec,

voxel size=1.19X1.36X1.4mm

- Scan Coverage : from ICA siphon to MCA M2
- 15 phases of flow data during cardiac cycle

4D-MRI ANALYSIS

- Acquisition of 4D-MRI data
Time : about 15 minutes
Images : about 3000 images
- The data was transported to another personal computer with 4D flow visualization software (GTFlow; GyroTools).
- Time-resolved 3D-streamline images of MCA and EC/IC bypass graft were generated.

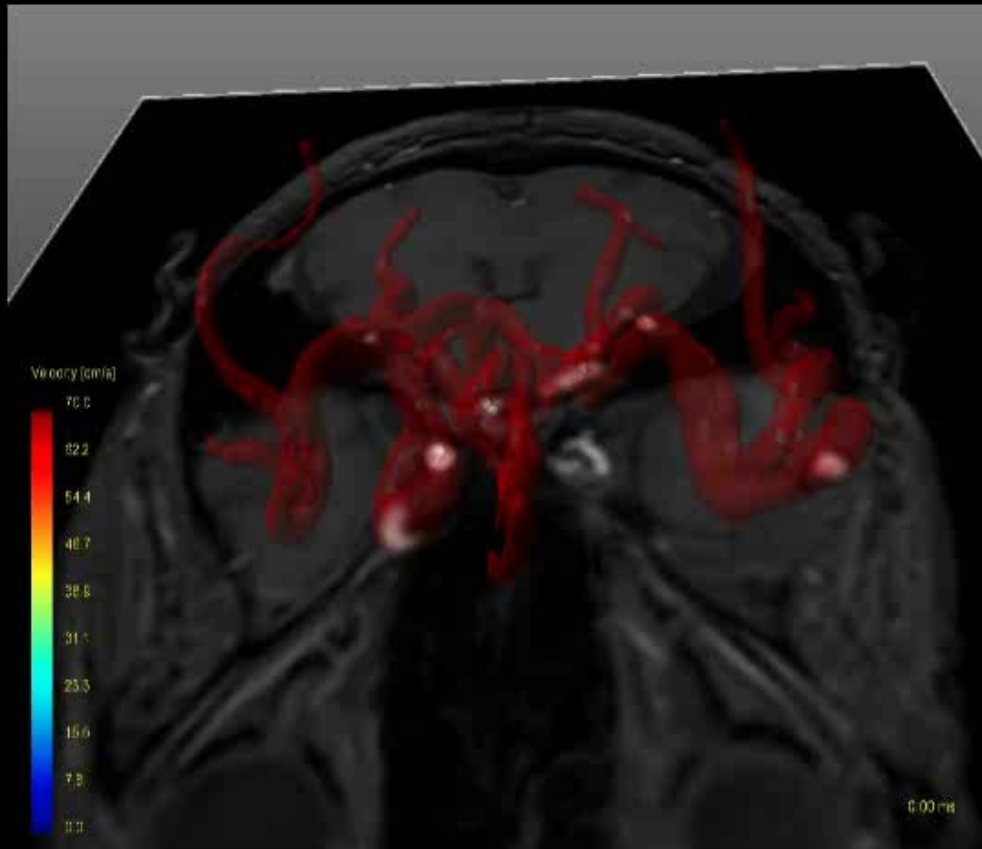


METHODS

1. To evaluate the hemodynamics of the MCA and bypass graft
2. To measure the flow of MCA and bypass graft using PC-technique.

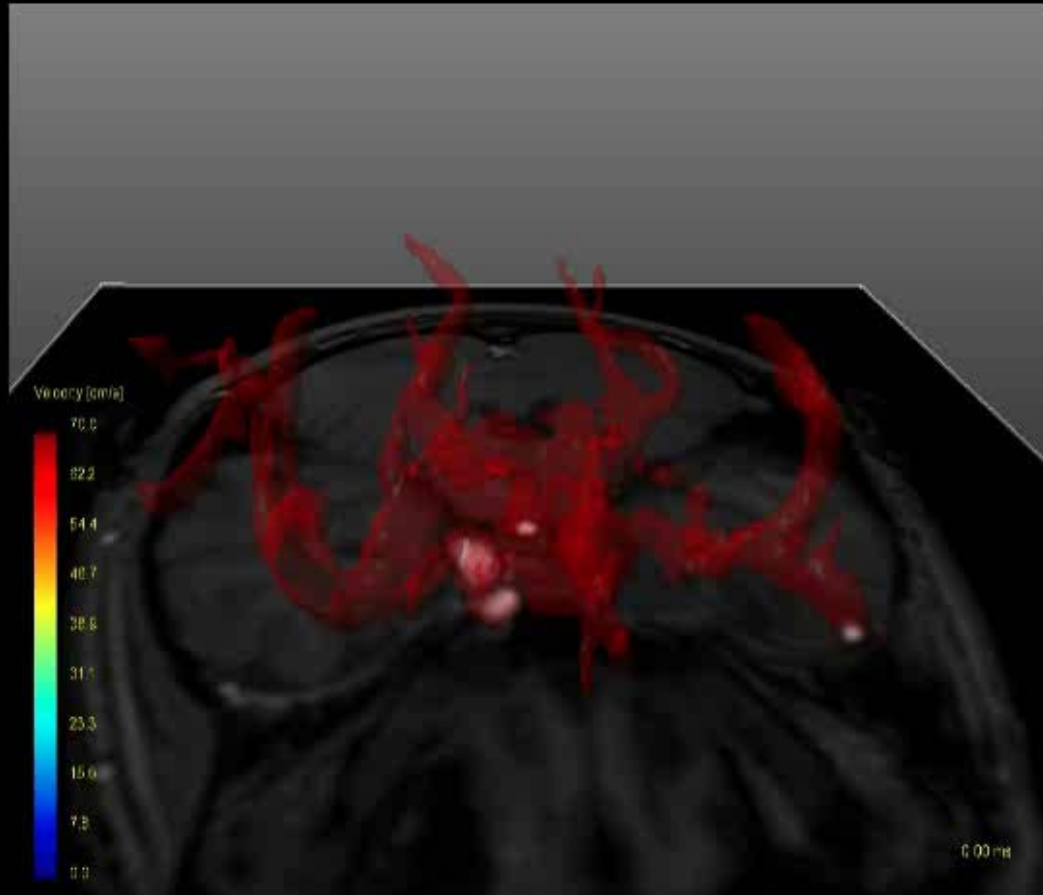
Case 1 72 y.o. Female, High flow graft post ligation of ICA due to giant ICA An.

MCA flow : M1-M1/2 : Retrograde M2: Antegrade flow



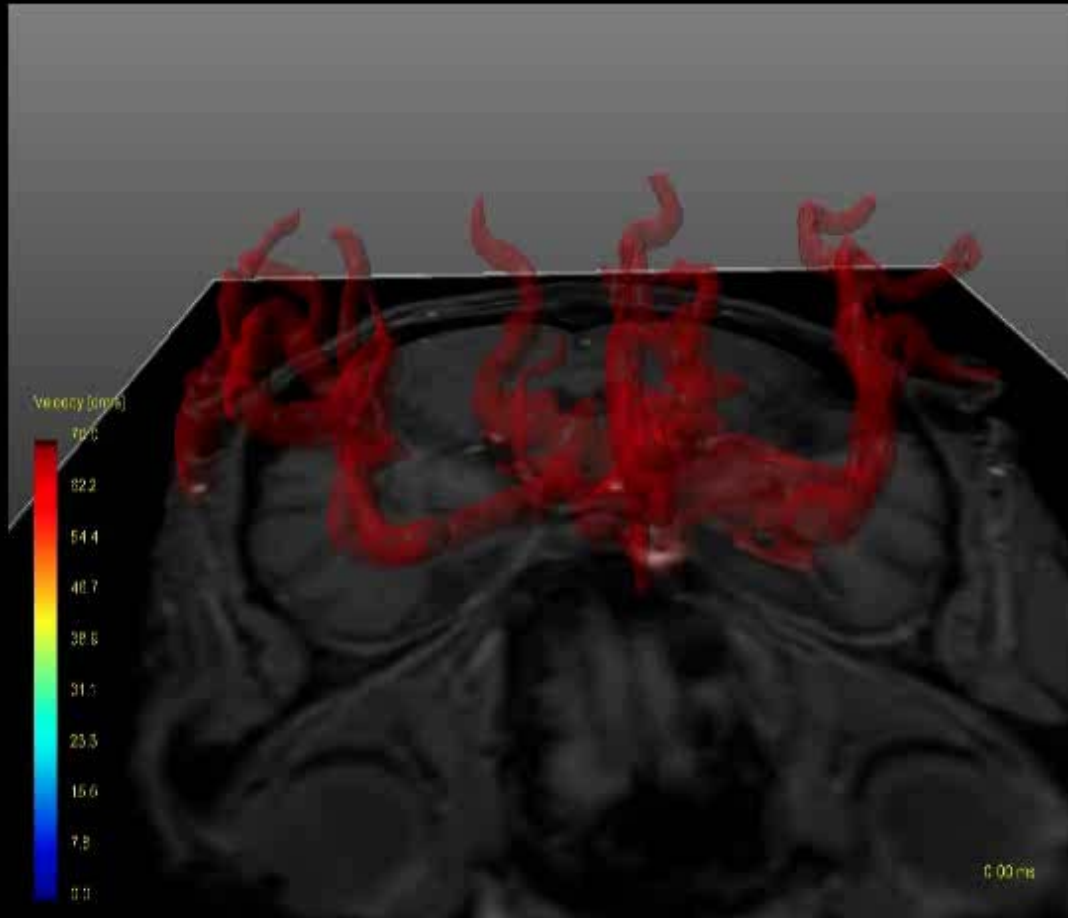
Case 2 48 y.o. Female, High flow graft post ligation of ICA due to giant ICA An.

MCA flow : M1-M1/2 M2 : Antegrade flow



Case 3 73 y.o. Male, High flow & STA-MCA ICA occlusion due to arteriosclerosis

M1 : Antegrade M1/2 : Retrograde M2 : Antegrade



RESULTS

CASE	Age	Sex	Flow direction			Flow average (ml/sec.)		
			M1	M1/2 bifurcation	M2	M1	bypass	M2
1	58	M	R	R	A	0.077	2.306	0.522
2	72	F	R	R	A	1.108	2.452	0.865
3	73	F	A	A	A	0.794	2.316	0.809
4	44	M	A	A	A	0.088	2.031	0.806
5	48	F	A	A	A	0.909	2.071	1.447
6	79	F	R	R	A	0.82	1.888	0.57
7	70	F	A	A	A	0.079	0.223	0.032
8	73	M	A	R	A	0.943	1.137	1.012
9	74	F	R	R	A	0.754	1.408	0.571
10	58	F	R	R	A	0.329	3.395	0.864
11	74	F	A	R	A	0.375	2.235	0.536
12	64	F	A	A	A	0.452	0.689	0.255

A: antegrade flow R: retrograde flow

RESULTS

CASE	Age	Sex	Flow direction		
			M1	M1/2 bifurcation	M2
1	58	M	R	R	A
2	72	F	R	R	A
3	73	F	A	A	A
4	44	M	A	A	A
5	48	F	A	A	A
6	79	F	R	R	A
7	70	F	A	A	A
8	73	M	A	R	A
9	74	F	R	R	A
10	58	F	R	R	A
11	74	F	A	R	A
12	64	F	A	A	A

Three types of MCA flow direction

Type 1: 5 pts

RRA: from the graft to M1

Type 2: 5 pts

AAA: Antegrade flow of MCA

Type 3: 2pts

ARA: Comlicated flow

From the graft to M1/2, interflow M1 and M2

A: antegrade flow R: retrograde flow

RESULTS

CASE	Age	S	Flow average	Flow average (ml/sec.)		
				M1	bypass	M2
1	58		M1	0.077	2.306	0.522
2	72		mean: 0.565	1.108	2.452	0.865
3	73		Min: 0.077 Max: 1.108	0.794	2.316	0.809
4	44			0.088	2.031	0.806
5	48		Bypass	0.909	2.071	1.447
6	79		mean: 2.065	0.82	1.888	0.57
7	70		Min; 0.223 Max: 3.395	0.079	0.223	0.032
8	73			0.943	1.137	1.012
9	74		M2	0.754	1.408	0.571
10	58		mean: 0.691	0.329	3.395	0.864
11	74		Min: 0.032 Max: 1.447	0.375	2.235	0.536
12	64			0.452	0.689	0.255

A: antegrade flow R: retrograde flow

RESULTS

Comparison of MCA flow:
pre and post bypass surgery

CASE	IC oc	Bypass	M1		M2			
			Pre	post	pre	post		
8	SC	HFB & STA-MCA	1.7	>	0.94	0.28	<	1.01
10	AN.	HFB & STA-MCA	1.84	>	0.33	0.32	<	0.86
11	AN.	HFB & STA-MCA	3.43	>	0.38	0.67	>	0.54
12	SC.	STA-MCA	0.59	>	0.45	0.09	<	0.26

SC:ARTERIOSCLEROSIS AN; LIGATION OF IC AN. HFB: High Flow Bypass

DISCUSSION

- **Advantages of 4D-flow MRI:**
 - Non-invasive
 - Reproducibility
 - Quantitative analysis using 3D volume data
- **Subjects of future investigation:**
 - Scan time & analysis time
 - Reliability of the flow ratio

CONCLUSION

4D-flow MRI is a promising tool that visualizes the intracranial arterial hemodynamics in patients after EC/IC bypass surgery.



THANK YOU