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

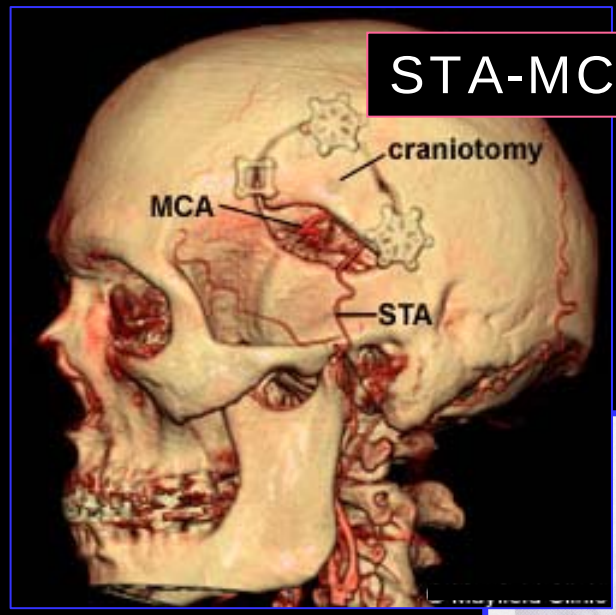
4D-flow MRI offers the visualization of the temporal evolution of complex flow and motion pattern in three dimensional volume.

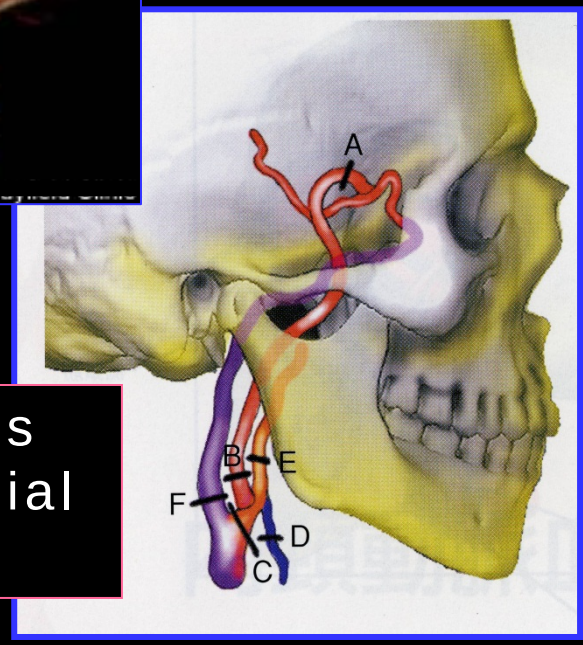
BACKGROUND : EC/IC bypass

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.

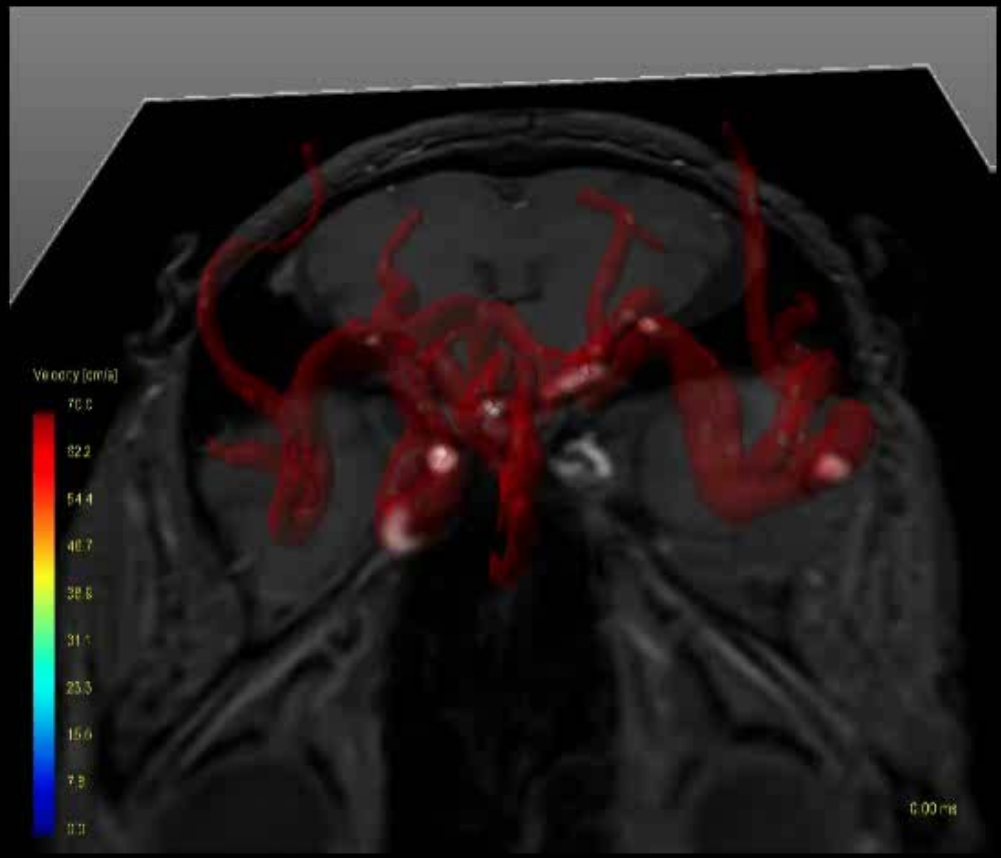
METHODS

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



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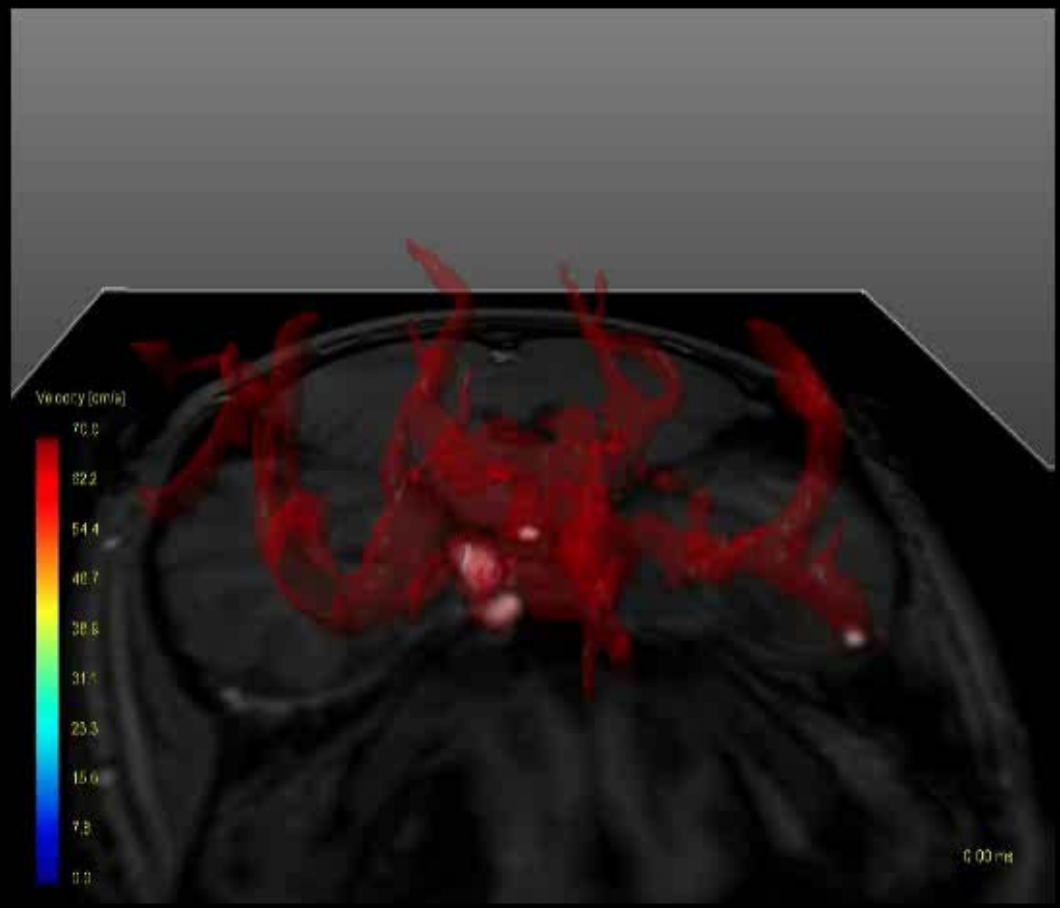
Case 2 48 y.o. Female, High flow graft post ligation of ICA due to giant ICA An.

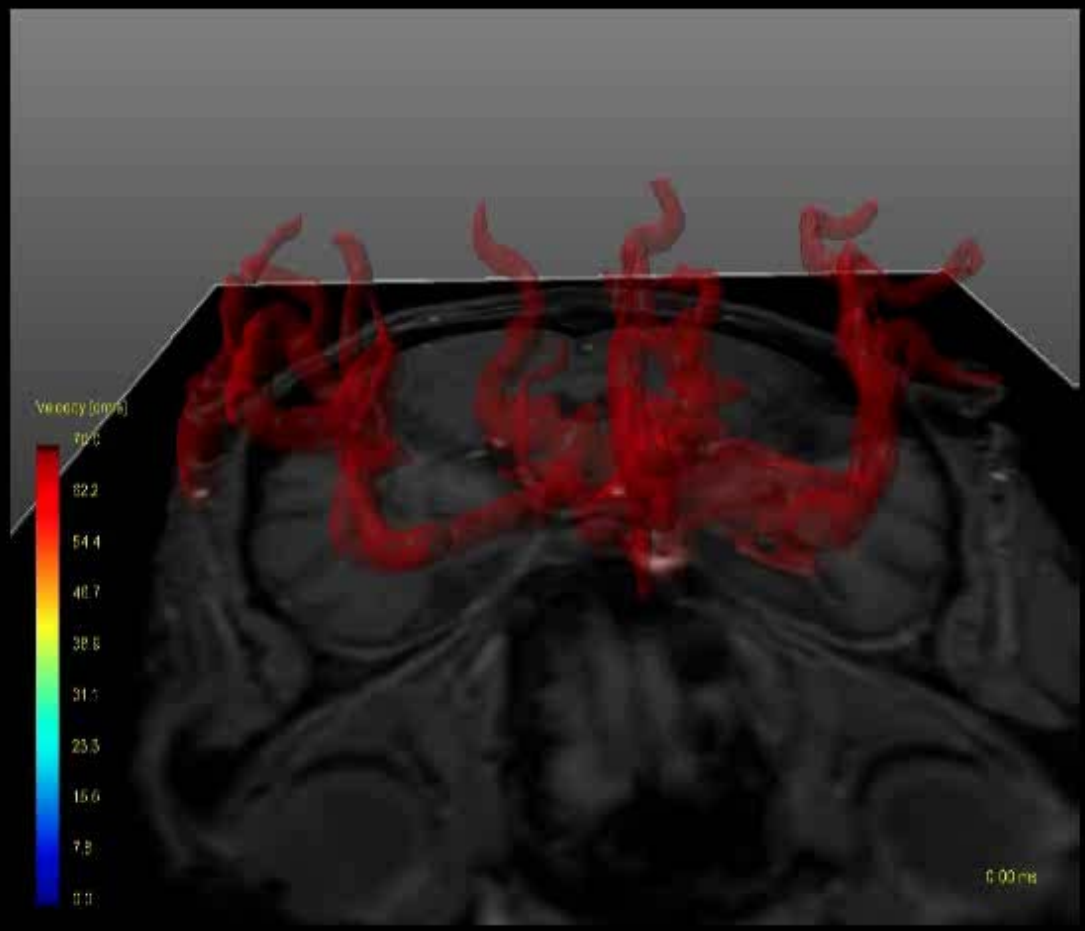
MCA flow : M1-M1/2 M2 : Antegrade flow



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

A: antegrade flow R: retrograde flow

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

RESULTS

CASE	Age	S
1	58	
2	72	
3	73	
4	44	
5	48	
6	79	
7	70	
8	73	
9	74	
10	58	
11	74	
12	64	

Flow average

M1
mean: 0.565
Min: 0.077 Max: 1.108

Bypass
mean: 2.065
Min; 0.223 Max: 3.395

M2
mean: 0.691
Min: 0.032 Max: 1.447

Flow average (ml/sec.)		
M1	bypass	M2
0.077	2.306	0.522
1.108	2.452	0.865
0.794	2.316	0.809
0.088	2.031	0.806
0.909	2.071	1.447
0.82	1.888	0.57
0.079	0.223	0.032
0.943	1.137	1.012
0.754	1.408	0.571
0.329	3.395	0.864
0.375	2.235	0.536
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