Symptomatic Middle Cerebral Artery Stenosis Treated by Percutaneous Transluminal Angioplasty: Improvement of Cerebrovascular Reserves

A. ABE[1,2], T. UEDA[1,3], M. UEDA[2], S. NOGOSHI[1,3], Y. NISHIYAMA[2], Y. KATAYAMA[2]

[1] Department of Strokology, Yokohama Brain and Stroke Center; Kanagawa, Japan
[2] Divisions of Neurology, Nephrology and Rheumatology, Department of Internal Medicine, Nippon Medical School; Tokyo, Japan
[3] Department of Neurosurgery, St. Marianna University School of Medicine; Kanagawa, Japan

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Summary

This study evaluated the recoveries of cerebrovascular reserves (CVR) after applying percutaneous transluminal angioplasty (PTA) to patients with symptomatic middle cerebral artery (MCA) stenosis of varying severity. The patients were submitted to single photon emission computed tomography (SPECT) to obtain their regional cerebral blood flows at resting stage ($rCBF_{rest}$) and acetazolamide-challenged CBF in five regions of interest (ROIs), including the MCA, on the ipsilateral and contralateral sides of the hemisphere. rCVR values were then calculated from these CBF data to evaluate the CVR recoveries after PTA treatment. When the PTA effects were statistically analyzed of the patients dichotomized into more severe (n=9) and less severe (n=5) groups, distinctly significant ROI-specific PTA effectiveness was observed for CVR rather than CBF values in the patients of the severer group.

Introduction

The occurrence of middle cerebral artery (MCA) stenosis as a risk factor of stroke is more frequent in eastern than western countries. Common stroke mechanisms in patients with MCA stenosis are haemodynamic infarction and/or artery-to-artery embolism with impaired clearance of emboli that produces multiple small cerebral infarcts along the borderzone region. For treatment of MCA stenosis, administration of warfarin and aspirin as well as application of angioplasty are useful. While percutaneous transluminal angioplasty (PTA) is an effective treatment modality in coronary and peripheral arterial diseases, its effectiveness for intracranial atherosclerotic stenosis has not yet been well defined.

Atherosclerotic intracranial artery stenosis occurs most frequently in the MCA region. The MCA stenosis causes brain infarction and is also a risk factor of recurrent stroke [5]. Reportedly, stenosis of higher than 70% grade, represented as >70% stenosis, results in a yearly recurrence rate of 23% [6]. A recent paper [7] reported that an aggressive medical treatment like dual antiplatelet therapy with clopidogrel (75 mg/day) and aspirin (325 mg/day) as well as the management of brain infarction risk factors including hypertension and hyperlipidemia are better than PTA with stenting (PTAS) because the outcome of death and brain infarction recurrence from the former vs. the latter treatment is 5.8% vs. 14.7% in 30 day prognosis and 12.7% vs. 20.0% in one year prognosis. On the other hand, a pivotal value of PTA has been emphasized by Kim et al. [8] and Yoon et al. [9] Uncertainty thus remains of the effectiveness of PTA especially in the case that TIA and recurrent brain infarction despite a similar aggressive medical treatment.

Against this backdrop, we undertook a pilot study to evaluate the utility of PTA by a small-scale examination using consecutive 14 patients with symptomatic stenosis in the MCA region. The evaluation was conducted using acetazolamide (Acz)-challenged single photon emission computed tomography (SPECT) to obtain cerebral blood flows (CBFs) and cerebrovascular reserves (CVRs) in the MCA and another four regions of interest (ROIs). The present study is an attempt to apply PTA for treatment of severe symptomatic MCA stenosis for the purpose of adding value to this method for the potential ischemic stroke risk reduction through improvement of cerebral haemodynamics. The present paper is a sequel to our preceding report on CVR recoveries by carotid artery stenting (CAS) [10].

Materials and Methods

Subjects

Patients with symptomatic MCA disease, admitted consecutively to the Yokohama Brain and Stroke Center between January 2003 and September 2005, were recruited as subjects. We selected 17 subjects (Table 1) and submitted 14 of them to PTA treatment because, even after antiplatelet medication, transient ischemic attack (TIA) or brain infarction was found to recur. The other three patients were removed from the following investigation as they could not receive SPECT because of belonging to the case of acute phase PTA treatment. The 14 subjects had TIA or brain infarction resulting from clinically significant atherosclerotic stenosis in MCA M1 segment, and all of them also had ≧70% grade of artery stenosis in MCA region (Table 1).

For antiplatelet medication, we used once or twice daily administration of aspirin (100 mg/day), ticlopidine (200 mg/day), cilostazol (200 mg/day) and dipyridamole (200 mg/day) in addition to statin therapy. Even after maximum antiplatelet treatment according to a regimen of administrating aspirin at 100-200 mg/day and ticlopidine at 200 mg/day, three of the 14 subjects suffered from TIA many times. The other 11 still had nondisabled acute-phase ischemic stroke. None of the 14 subjects had serious complications such as vessel rupture or acute

Table 1 **Characteristics of patients as subjects.**

					Stenosis(%)							
No.	**Name**	**Age**	**Sex**	**Lesion**	**Before**	**After**	**Risk Factor**	**Diagnosis**	**Infarction**	**Medication**	**Complications**	**Duration (days)**
1	E. T	56	F	Lp	90	30	DL,DM,Alc	CI	ABZ	ASA		9
2	K. T.	68	F	Rd	85	30	HT,DL	CI	LSA/PBZ	TIC		14
3	H. Y.	70	M	Lp	80	30	HT,S,Alc	CI	ABZ	ASA		9
4	E. K.	46	F	Rd	90	40	HT,S,DL	CI	LSA	ASA TIC		9
5	K. M.	62	M	Ld	70	40	HT,DL,Alc	TIA	none	ASA DIP	Asym.CI	11
6	T. K.	43	M	Ld	90	40	DL,S,Alc,HU	–	–	ASA TIC	Restenosis	5
7	M. K.	47	M	Rd	90	30	HT,DL,S,Alc	CI	ABZ	ASA TIC		9
8	E. T.	58	F	Lp	80	20	DL,DM,Alc	–	–	ASA DIP	Restenosis	9
9	M. K.	65	M	Ld	90	10	HT,DL,DM	CI	LSA	ASA TIC		10
10	K. I.	40	F	Lp	90	0	DL,S,Alc,HU	CI	LSA ABZ	ASA TIC		20
11	H. O.	42	F	Ld	90	30	HT,UC,Alc	CI	MCA	ASA DIP		11
12	Y. M.	74	M	Rd	80	50	HT,S	CI	MCA	ASA TIC		20
13	S. Y.	46	M	Rp	80	40	HT,HU,T,Alc	CI	MCA	ASA CIL		10
14	I. K.	68	M	Ld	80	10	HT	CI	MCA	ASA TIC		13
15	K. J.*	43	M	Rp	90	0	DL,Alc	TIA	none	ASA CIL	Asym. dissection	17
16	S. S.*	67	F	Ld	80	20	HT,S	CI	LSA	ASA CIL	Asym. dissection	8
17	T. K.*	43	M	Ld	90	20	DL,S,Alc,HU	CI	LSA PBZ	ASA TIC	Asym. dissection	16

** Removed from examinations*
Symbols: Ld, *left distal;* Lp, *left proximal;* Rd, *right distal;* Rp, *right proximal;* HT, *hypertension;* DL, *dyslipidemia;* DM, *diabetes melitus;* S, *smoking;* Alc, *alcohol consumption;* HU, *hyperuremia;* CI, *cerebral infarction;* TIP, *ticlopidine;* ASA, *aspirin;* CIL, *cilostazol;* DIP, *dipyridamole*

thrombosis, and their PTA treatments were successfully performed, without recurrence of stroke during the subsequent following-up for six months.

PTA treatment

Prior to PTA treatment, all the subjects underwent magnetic resonance imaging (MRI) photographying to assign the positions of infarcts in MCA and other four major regions of interest (ROIs) according to Damasio et al. [11] and Wong et al. [12]. We thus selected the representative ROIs, anterior cerebral artery (ACA), anterior border zone (ABZ), posterior border zone (PBZ), and lateral striate artery (LSA) as well as MCA. PTA was performed with a microballoon, 2.0-2.5 mm in diameter and 10-13 mm in length, without insertion of stent. PTA with a Gateway PTA balloon catheter (Boston Scientific Corporation) was used for only one or two trials for dilatation. Shortly after, we evaluated the possible occurrence of restenosis, which was defined as < 50% stenosis (Table 1) on follow-up conventional angiogram or increased M1 flow velocity and also on follow-up transcranial Doppler up to the baseline level.

SPECT study

The study was performed as described in our previous paper[10]. In brief, resting-stage and Acz-challenged SPECT studies were carried out as usual to take quantitative CBF images (ml/100g/min) by Patlak plot analysis. All rCBF data were determined using automated three-dimensional ROI analysis software (3D-SRT) which permitted automatic computation of 318 ROIs in each hemisphere within several minutes to avoid biases depending on individual differences. We took data on the five representative ROIs mentioned above. The CVR was evaluated on both ipsilateral and contralateral hemispheric sides by calculating its percent values as follows:

$$CVR(\%)=[(\text{Acz-challenged CBF}-CBF_{rest})/CBF_{rest}]\times 100$$

where the suffix "rest" stands for "resting stage". Incidentally, the normal CBF value we observed was in a range of 40-45 ml/100 g/min. rCBFs were obtained within five to 20 days after PTA operation, where the suffix "r" means "regional".

This study was approved by the Institutional Review Boards of the Yokohama Brain and Stroke Center. In addition, written informed consent was obtained from the subjects or their families.

Statistical Analysis

Differences in CBFrest and Acz-challenged rCBF values as well as in rCVR values before- and after- PTA treatments were analyzed by Wilcoxon's signed-rank test to detect statistical significance at $P < 0.05$.

Results

Of the 17 subjects (Table 1) to be submitted to the present study, 14 were clinically found qualified for SPECT examinations to measure their rCBF values. Statistical analysis was first carried out with $rCBF_{rest}$ data as a whole and then with these data of two groups, severe and less severe groups, after dichotomization by MCA r CBF_{rest} value of larger or smaller than 30 ml/100g/min according to the criterion proposed by Mizumura et al. [13]. The resulting data are shown in Table 2. It was statistically found that, in any of the five ROIs on the ipsilateral or contralateral hemispheric sides, the PTA treatment gave no significant effect on $rCBF_{rest}$ data as a whole (n=14). In addition, no significant difference was found in data on each of the two stratified parts. Analyzing the Acz-rCBF data shown in Table 3, we failed to find any significant difference in whole or in part. These results suggest that CBF itself cannot be improved to any significant measure by treatment with PTA.

We then analyzed the rCVR data calculated from Acz-CBF and CBF_{rest} values by subtraction, with the result illustrated in Figure 1. Though there appeared no significant difference in CVR recovery as a whole (n=14) (data not shown), clear PTA effects ($P<0.05$) were observed for the CVR recovery in ACA and LSA as well as MCA on either of the ipsilateral and even contralateral sides, while no significant difference was detected in the data of the less severe group (n=5) probably because of a large bias in standard deviation. These results show that application of PTA is effective in improving CVR rather than CBF values in MCA and some other ROIs on ipsilateral and contralateral hemispheric sides of the subjects with severer symptomatic MCA stenosis as in the case of our previous study suggesting the utility of CAS [10].

Clinically, we observed small brain infarcts, recurrence of stenosis and dissection in one, two and three subjects, respectively, but these cases were non-symptomatic. Thus, the PTA operation was all conducted safely.

Discussion

In our previous study, we revealed that CAS is a better alternative to carotid endarterectomy (CEA) applied to improving the CVR recovery after stenting for severe stenosis particularly when this is the case with contralateral stenosis [10]. Though in recent years PTAS has been recognized as more useful than PTA, we thought it important to reconsider the utility of PTA without stenting. Suh et al. [14] applied PTA to nine patients with symptomatic MCA M1 stenosis and, after ten months follow-up, did not find any recurrence of brain infarction and MCA stenosis, with the result that the CVF values of two of them who had low CBF values were effectively improved. Lee et al. [15] used PTA for symptomatic MCA M1 stenosis and found that, after following-up nine cases for 34.6 months on average, six of the nine patients with medically intractable TIA had recovered, with their TIA symptoms lost almost completely. Kim et al. [8] reported that PTA was technically successful in 37 of the 40 included patients; 32 of the 37 patients were followed up at regular intervals of one to six months in the outpatient clinic of our institution for at least 42 months. Restenosis occurred in three of the 32 patients (9.4%) within two years after PTA, and no restenosis was identified thereafter. In addition, two of the three patients with restenosis had asymptomatic complications such as dissection and vasospasm during the intervention. The ischemic area was in the treated vessel for one of the 32 patients and in other vessels for three of the 32 patients (9.4%). However, no information is available regarding how ROI-specific CVR values significantly improved after PTA treatment.

In the present study, we undertook investigations aimed at finding out how the use of PTA was effective in improving CBFs of 14 patients with symptomatic MCA stenosis. As a result, no significant CBF and CVR improvement was observed in the 14 cases as a whole (Table 2). However, for the more severe patients (n=9) among them, we found a significant improvement in their CVR rather than CBF values in ACA, ABZ and LSA as well as MCA regions on the ipsilateral side, while no such CVR improvement resulted in the less-severe patients (n=5) (Figure 1). The result suggests that PTA is effective not only in inhibiting artery-to-artery embolism but also in inhibiting ischemia due to improved hemodynamics. Our observation also showed that CVR recoveries were significantly improved even in contralateral ACA and MCA regions of nine severe patients (Figure 1). The possibility thus exists that, in case of some intracranial stenosis, if any, the CVR values are reduced not only in the stenotic artery-dominant area but also in the healthy artery-dominant area for compensation of the neural network on the impaired hemispheric side. In our investigations, every case was found to have A-com and, therefore, there may be a cross flow from the impaired-side ACA and MCA regions. It is thus conjectured that PTA treatment can remove a burden of the impaired-side ACA region of each patient to reduce the necessity for rescue of this regions, with the result that CVR recoveries in the healthy-side ACA and MCA regions are ameliorated.

Since the result of intracranial artery stenosis treatment by PTAS with a Wingspan stent system is not better than that of medical treatment [7], the use of PTA without stenting should be reconsidered for its merits. Although PTA may have benefits over the Wingspan system, none has been compared with medical management. Progression of stenosis may occur overtime to result in stroke due to distal embolism or hypoperfusion [16,17]. We found a severe MCA rCVR decrease in nine out of 14 cases in which TIA or stroke recurred despite the combination of dual antiplatelet therapy and statin medication, although the distal embolism was not confirmed by echocardiography. Our result thus suggests the possibility that hypoperfusion as well as distal embolism plays an important part in the case of recurrent brain infarction by MCA stenosis.

In conclusion, the use of PTA for patients with severely decreased rCVR values is effective for amelioration of their ROI-specific CVR recoveries, with no recurrence of TIA and brain infarction during follow-up for at least six months. Thus, this indicates that PTA without stenting is a safe method for treatment of a severe degree of symptomatic middle cerebral artery stenosis.

Table 2 **Resting stage cerebral blood flow (CBF_{rest}) values in 5 regions of interest (ROIs) on ipsilateral and contralateral sides of more and less-severe subject groups before and after percutaneous transluminal angioplasty (PTA) treatment.**

	Ipsilateral ROI										**Contralateral ROI**									
	ACA		ABZ		MCA		PBZ		LSA		ACA		ABZ		MCA		PBZ		LSA	
	P=0.18		P=0.35		P=0.79		P=0.92		P=0.47		P=0.13		P=0.25		P=0.28		P=0.53		P=0.72	
Subject	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
more and less severe group																				
E. T	44.03	38.79	40.83	34.74	48.12	42.01	49.93	46.19	53.99	44.72	44.73	39.49	45.33	36.91	45.45	43.01	50.09	48.31	54.14	46.60
K. T.	41.44	40.81	40.08	39.04	43.67	41.62	46.26	46.38	48.09	42.97	42.23	41.82	40.29	42.36	45.05	44.23	48.57	47.44	46.94	47.03
H. Y.	37.38	38.03	39.04	40.59	39.44	41.54	38.27	42.06	46.63	49.10	39.03	39.58	35.38	39.13	41.84	41.32	46.93	45.48	47.93	50.19
E. K.	34.33	32.32	27.20	27.04	36.89	35.49	43.22	39.21	38.36	37.76	34.63	33.44	30.84	28.99	37.57	35.09	43.97	40.87	41.51	37.46
K. M.	39.70	38.55	41.94	40.88	40.97	42.28	42.08	45.51	42.46	43.28	39.54	38.44	40.50	39.64	41.06	40.97	47.08	47.45	46.45	47.45
H. O.	39.27	27.60	38.77	25.34	37.80	24.57	32.22	21.45	44.20	32.49	39.79	26.20	40.76	16.18	40.29	25.82	42.27	28.33	45.26	33.19
T. K.	34.96	30.61	28.61	27.71	35.27	31.79	34.02	32.76	34.82	30.63	38.26	33.64	37.72	32.60	42.59	38.03	42.97	41.20	46.91	39.30
M. K.	38.82	35.09	37.07	33.06	36.56	36.53	42.34	38.18	40.20	36.97	42.58	38.67	47.91	41.51	43.24	41.38	47.87	49.71	35.51	41.79
E. T.	40.08	40.37	36.39	37.18	41.01	42.51	44.73	48.67	43.81	48.81	40.76	40.97	38.30	37.21	42.54	42.61	48.19	47.12	47.73	48.15
Mean	38.89	35.80	36.66	33.95	39.97	37.59	41.45	40.05	43.62	40.75	40.17	36.92	39.67	34.95	42.18	39.16	46.44	43.99	45.82	43.46
±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±
S.D.	3.034	4.667	5.264	6.027	4.036	6.188	5.708	8.580	5.647	6.667	2.902	4.967	5.054	8.214	2.413	5.713	2.719	6.616	5.066	5.783
	P=1.00		P=0.68		P=0.68		P=0.84		P=1.00		P=1.00		P=0.53		P=0.83		P=0.83		P=0.53	
	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
more and less severe group																				
M. K.	35.47	37.68	31.16	28.21	40.74	41.38	38.96	40.92	34.26	37.59	35.34	37.53	28.46	28.62	39.01	42.93	40.06	40.92	37.34	40.08
K. I.	32.46	39.64	28.03	34.53	34.27	41.13	41.99	54.68	35.51	44.07	35.13	43.91	28.95	37.72	39.60	50.53	42.57	56.32	40.20	55.64
Y. M.	33.08	28.27	26.38	23.95	34.65	29.58	32.19	26.47	38.98	32.06	34.65	30.28	31.62	29.42	35.72	31.24	41.07	35.40	34.68	35.90
S. Y.	42.77	43.82	41.46	43.99	44.57	45.67	47.87	49.11	45.50	47.49	44.25	43.95	40.40	44.32	46.73	47.14	50.28	51.87	47.21	49.92
I. K.	31.76	31.87	29.14	28.21	32.66	30.24	36.83	30.53	39.41	40.65	34.16	33.96	31.77	33.64	37.27	35.41	42.76	36.03	43.24	41.76
Mean	35.11	36.26	31.24	31.78	37.38	37.60	39.57	40.34	38.73	40.38	36.71	37.92	32.24	34.75	39.67	41.45	43.35	44.11	40.53	44.66
±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±
S.D.	4.505	6.200	5.975	7.802	5.058	7.250	5.856	11.953	4.378	5.943	4.239	6.051	4.804	6.472	4.232	8.026	4.033	9.495	4.913	7.974

Table 3 **Acetazolamide (Acz) - challenged cerebral blood flow (Acz-CBF) values in 5 regions of interest (ROIs) on ipsilateral and contralateral sides of more and less-severe subject groups before and after percutaneous transluminal angioplasty (PTA) treatment**

	Ipsilateral ROI										Contralateral ROI									
	ACA		ABZ		MCA		PBZ		LSA		ACA		ABZ		MCA		PBZ		LSA	
	P=0.01		P=0.027		P=0.008		P=0.004		P=0.013		P=0.006		P=0.027		P=0.047		P=0.37		P=0.11	
Subject	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
more and less severe group																				
E. T	23.5	48.2	16.8	32.7	–0.6	40.2	–0.5	54.1	6.9	44.1	25.0	47.3	15.6	43.3	28.7	53.3	21.2	61.9	12.2	56.2
K. T.	14.9	20.0	–5.9	5.2	6.0	12.6	6.4	13.9	–1.1	31.0	14.7	26.2	20.1	27.7	19.4	27.5	23.1	33.2	22.7	15.7
H. Y.	14.5	41.5	10.6	68.0	8.3	26.9	13.2	55.9	1.1	24.2	16.3	44.6	47.9	77.8	24.8	48.8	37.2	2.2	31.2	52.3
E. K.	24.6	13.6	8.2	–30.0	9.4	9.6	9.1	14.8	23.7	7.3	24.8	11.2	17.3	–20.3	27.0	30.7	26.8	25.6	31.2	29.9
K. M.	10.8	43.7	–0.0	49.3	17.5	39.8	24.7	44.4	13.0	49.4	9.6	49.2	–1.6	45.9	15.4	45.3	21.5	43.1	10.2	29.4
H. O.	6.1	26.4	6.7	36.9	12.0	51.2	6.6	73.3	–1.7	28.8	–11.7	35.8	–41.5	117.4	4.8	37.7	9.4	28.4	15.7	27.4
T. K.	14.9	25.7	–6.9	20.0	19.4	23.5	22.9	22.9	14.2	15.8	14.2	26.4	–11.1	26.0	17.8	23.4	30.9	19.3	15.2	49.9
M. K.	10.9	45.3	8.9	33.6	19.8	41.7	14.5	47.0	30.6	59.4	14.3	45.1	22.2	37.3	19.5	43.7	35.7	28.1	55.9	39.2
E. T.	32.0	52.5	11.0	23.6	25.9	53.4	17.7	41.4	30.0	62.1	32.9	58.7	31.1	49.0	39.0	64.7	28.1	66.0	42.0	71.0
Mean	16.9	35.2	5.5	26.6	13.1	33.2	12.7	40.9	13.0	35.8	15.6	38.3	11.1	44.9	21.8	41.7	26.0	34.2	26.3	41.2
±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±
S.D.	8.2	13.9	8.0	27.7	8.3	15.9	8.2	20.1	12.8	19.1	12.5	14.7	26.1	37.6	9.6	13.2	8.5	20.1	15.3	17.4
	P=0.02		P=0.02		P=0.29		P=0.29		P=0.53		P=0.06		P=0.09		P=0.21		P=0.40		P=1.00	
	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
more and less severe group																				
M. K.	25.4	79.2	15.9	72.0	24.3	32.8	22.1	24.4	45.4	25.6	20.0	72.6	40.7	104.7	22.9	52.1	–2.9	24.8	36.9	13.5
K. I.	71.8	52.0	58.3	66.9	78.5	42.8	89.3	48.6	69.2	42.7	84.5	54.6	84.1	83.8	93.8	43.0	100.5	46.5	108.4	47.0
Y. M.	39.8	72.3	68.3	68.4	37.4	59.2	27.7	45.3	26.8	66.6	27.8	68.8	30.1	38.0	36.3	73.8	29.7	63.5	89.9	68.8
S. Y.	28.1	90.3	31.3	114.7	32.6	71.5	43.0	71.3	37.3	100.1	19.9	93.6	27.8	131.9	30.4	77.6	30.8	72.8	33.4	88.6
I. K.	44.7	102.0	37.2	97.5	44.1	96.3	41.6	115.1	58.8	86.5	43.2	97.4	60.8	95.5	54.6	101.0	49.2	124.9	35.1	93.8
Mean	42.0	79.2	42.2	83.9	43.4	60.5	44.7	61.0	47.5	64.3	39.1	77.4	48.7	90.8	47.6	69.5	41.4	66.5	60.7	62.3
±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±	±
S.D.	18.5	18.9	21.1	21.2	20.9	24.9	26.5	34.5	16.8	30.6	27.1	17.9	23.7	34.4	28.4	22.8	38.0	37.4	35.7	32.9

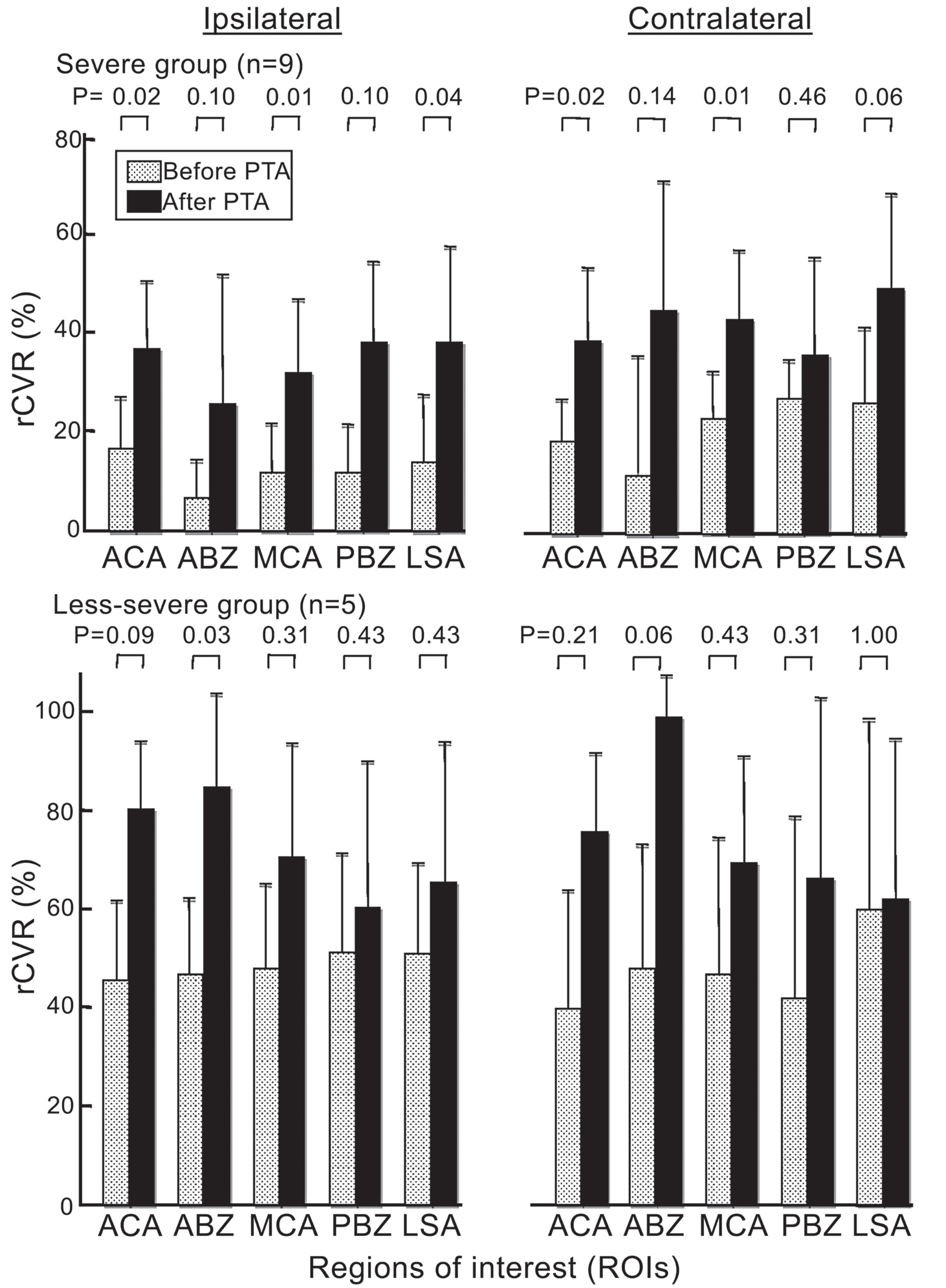

Figure 1 Regional cerebrovascular reserves (rCVRs) in 5 regions of interest (ROIs) on hemispheric ipsilateral and contralateral sides of sever and less-severe subject groups before and after percutaneous transluminal angioplasty (PTA) treatment. Each column represent a mean + standard deviation.

Nowadays, medical treatments for patients with >50% stenosis in cranial arteries may be followed by a recurrence rate of 20-25% / year. While stenting such as Wingspan is currently used as a predominant alternative to PTA, our present investigation is a ROI-specific and quantitative insight in the PTA surgical method, emphasizing the need to reconsider its importance.

More widescale investigations would justify the use of CVR in routine clinical practice against MCA stenosis, but the present study may help to stratify the risk in MCA stenosis patients for selection of PTA.

Conclusion

PTA without stenting applied to patients with severe MCA stenosis is effective to improve their ROI-specific CVR rather than CBF values on the ipsilateral and contralateral hemispheric sides. It may also help to removing the potential risk of recurrent TIA and stroke.

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Arata Abe, MD, PhD
Divisions of Neurology
Nephrology and Rheumatology
Department of Internal Medicine
Nippon Medical School
Tokyo 113-8602 Japan
Tel.: +81 3 3822 2131
Fax: +81 3 3822 4865
E-mail: abe@nms.ac.jp