The Relation between Crossed Cerebellar Blood Flow and Severities of Hemiplegia: A Technetium-^{99m} Hexamethylpropylene Amine Oxine SPECT Study Using Patlak Plot Method

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WATANABE, H., NIWA, N., KANAI, M. and SASAKI, S. *The Relation between Crossed Cerebellar Blood Flow and Severities of Hemiplegia: A Technetium-^{99m} Hexamethylpropylene Amine Oxine SPECT Study Using Patlak Plot Method.* Tohoku J. Exp. Med., 1996, **179** (3), 177-181 — Crossed cerebellar diaschisis (CCD), decrease in crossed cerebellar blood flow (CCBF) (ml/100 g/min), is often observed in the cerebral blood flow imaging of hemiplegic patients. We studied the relations between severities of hemiplegia and degrees of CCD. Severities of hemiplegia were evaluated by Brunnstrom stages (Br. stage) of lower limbs. Degree of CCD was evaluated as CCBF and asymmetry index (ASI) (%) of CCBF, which were calculated from technetium-^{99m} hexamethylpropylene amine oxine (^{99m}Tc HMPAO) SPECT study using Patlak plot method (Matsuda et al. 1992, 1993). We have studied twenty consecutive patients. The CCBF was significantly different between Br. stage II and IV ($p=0.0357$), III and IV ($p<0.001$) and III and V ($p<0.001$). ASI was significantly different between II and IV ($p=0.0357$), III and IV ($p<0.001$) and III and VI ($p=0.0238$). Both of CCBF and ASI of the group of II and III were significantly lower than those of the group of IV, V and VI ($p=0.0033$ for CCBF and $p=0.0087$ for ASI). We conclude that this study indicate a close correlation between the severities of hemiplegia and the degrees of CCD. — hemiplegia; crossed cerebellar diaschisis (CCD); Brunnstrom stage; ^{99m}Tc HMPAO; Patlak plot

Crossed cerebellar diaschisis (CCD), i.e., decrease of crossed cerebellar blood flow (CCBF), is often observed in the cerebral blood flow imaging of patients with hemiplegia due to supratentorial lesions (Baron et al. 1980; Pantano et al. 1986; Fulham et al. 1992). However the correlation between severities of hemiplegia and the degrees of CCD is still in controversial. We have performed quantitative SPECT study of CCD of 20 stroke patients to clarify this issue.

PATIENTS AND METHODS

Twenty Consecutive patients (14 men and 6 women), aged 43 to 82 (mean 63) were studied. They were treated in our hospital for hemiplegia between October 1993 and June 1995. Causes of hemiplegia were cerebral infarction in 14 patients and intracerebral hemorrhage in 6 patients. Severities of hemiplegia were evaluated by Brunnstrom stage (Br. stage) of lower limbs (Brunnstrom 1970). There were 3 patients in Br. stage II, 3 in III, 5 in IV, 3 in V and 6 in VI, respectively. Degrees of CCD were quantitatively evaluated as CCBF (ml/100 g/min) and asymmetry index (ASI) (%) of CCBF. CCBF was calculated from technetium-^{99m}hexamethylpropylene amine oxine (^{99m}Tc HMPAO) SPECT using Patlak plot method according to Matsuda et al. (1992, 1993). The intervals between those stroke events and the SPECT studies ranged 36 to 396 days (mean 120). Each patient received 760 MBq of ^{99m}Tc HMPAO i.v. injection. SNC-

TABLE 1. *Data of patients*

Pt/age/sex	Side/nature/ topography	Br. stage	Days to SPECT (days)	CCBF (ml/ 100 g/min)	ICBF (ml/ 100 g/min)	ASI (%)
1/51/M	L/H/Pu	II	134	42.4	50.4	-15.8
2/53/M	L/I/MCA	II	63	50.6	66.4	-23.8
3/71/M	L/I/MCA	II	217	54.7	99.1	-44.8
4/62/M	L/I/MCA	III	87	46.9	64.5	-27.3
5/82/M	R/I/Th	III	150	47.7	62.3	-23.5
6/59/M	R/H/Pu, Th	III	112	48.0	69.9	-31.4
7/51/M	L/I/Ic	IV	70	53.3	43.1	23.7
8/63/M	R/I/Pu	IV	60	58.3	66.8	-12.7
9/57/F	R/H/Pu	IV	82	63.5	65.2	-2.7
10/56/M	R/H/Pu	IV	46	66.9	85.2	-21.5
11/72/F	L/I/Pu	IV	76	68.1	79.9	-14.7
12/64/M	L/I/MCA	V	264	50.5	72.6	-30.5
13/64/F	R/I/MCA	V	396	55.8	70.4	-20.7
14/60/M	L/I/MCA	V	136	67.6	82.9	-18.5
15/74/F	L/I/Th	VI	134	46.9	52.3	-10.4
16/71/F	R/I/MCA	VI	94	52.5	65.6	-20.0
17/81/M	L/I/MCA	VI	116	55.5	70.4	-21.2
18/60/F	L/I/Ic	VI	74	56.8	66.7	-14.8
19/43/M	L/H/Pu	VI	56	57.6	76.5	-24.7
20/69/M	L/I/Ic	VI	36	85.9	88.4	-2.8

Pt, patient; M, male; F, female; R, right; L, left; H, hemorrhage; I, infarction; Ic, internal capsule; Th, thalamus; Pu, putamen; Br., Brunnstrom; MCA, territory of hemispherical branches of middle cerebral artery; CBF, crossed cerebellar blood flow; ICBF, ipsilateral cerebellar blood flow; ASI, asymmetry index.

500R system (Shimazu, Kyoto) was used. The each SPECT scan was performed by 60 projections (15 sec/projection, 6° steps, 360° rotation and 64×64 matrix) using a high resolution parallel hole collimator. Regions of interest (ROIs, 3.5 mm squares) were positioned in crossed cerebellar hemisphere of blood flow images. Each patient's CCBF was calculated as a mean of about 10 ROIs. Each patient's ipsilateral cerebellar blood flow (ICBF) was calculated as same as CCBF, then the ASI ((CCBF-ICBF)×100/ICBF) was calculated. The statistical analyses of the data were performed by Wilcoxon's rank sum test.

TABLE 2. *CCBF comparison between Br. stages*

Stage (mean±S.D.)	III	IV	V	VI
II (49.2±6.3)	0.4000	0.0357	0.2000	0.0972
III (47.5±0.6)		<0.0001	<0.0001	0.0952
IV (62.0±6.2)			0.3929	0.2468
V (58.0±8.8)				0.9048
VI (59.2±13.7)				

Abbreviations are common with Table 1.
Numbers in cells are *p*-values.

TABLE 3. *ICBF comparison between Br. stages*

Stage (mean±S.D.)	III	IV	V	VI
II (72.0±24.8)	0.7000	1.0000	0.4000	0.7143
III (65.6±3.9)		0.3929	<0.0001	0.2619
IV (68.0±16.3)			0.5714	0.7922
V (75.3±6.8)				0.5476
VI (70.0±12.0)				

Abbreviations are common with Table 1.
Numbers in cells are *p*-values.

TABLE 4. *ASI comparison between Br. stages*

Stage (mean±S.D.)	III	IV	V	VI
II (-28.1±14.9)	0.7000	0.0357	0.7000	0.1667
III (-27.4±3.9)		<0.0001	0.2000	0.0238
IV (-5.6±17)			0.0714	0.4286
V (-23.2±6.1)				0.2619
VI (-15.6±8.1)				

Abbreviations are common with Table 1.
Numbers in cells are *p*-values.

TABLE 5. *Comparison between the group of II and III and the group of IV, V and VI*

	CCBF	ICBF	ASI
Mean $\pm$ S.D. of II, III	48.4 $\pm$ 4.1	68.8 $\pm$ 16.3	-27.8 $\pm$ 9.8
Mean $\pm$ S.D. of IV, V and VI	59.9 $\pm$ 9.9	70.4 $\pm$ 12.3	-13.6 $\pm$ 13.2
<i>p</i> -Value	0.0033	0.2740	0.0087

Abbreviations are common with Table 1.

RESULTS

The individual clinical and cerebellar blood flow data are shown in Table 1. The statistical analyses are reported in Tables 2, 3, 4 and 5. The CCBF was significantly different between II and IV ($p=0.0357$), III and IV ($p<0.0001$), III and V ($p<0.001$) (Table 2). The CCBF was significantly different between IV and V (Table 3). The ASI was significantly different between II and IV ($p=0.0357$), III and IV ($p<0.001$) and III and VI ($p=0.0238$) (Table 4). From these results, we speculated that the CCBF and the ASI were significantly different between the group of II and III and the group of IV, V and VI. The CCBF and the ASI of the former group were significantly lower than those of the latter group ($p=0.0033$ and $p=0.0087$, respectively) (Table 5).

DISCUSSION

The relations between hemiplegia and CCD have already been discussed in some reports. Kim et al. (1992) reported that severely hemiplegic patients showed higher frequency of CCD. Flores et al. (1995) reported that CCD was associated with the presence of motor impairment but not related to its severity. In our study, we used CCBF and ASI to evaluate CCD quantitatively, and Br. stage to evaluate the severities of hemiplegia. We found that the CCBF and the ASI of the group of stages II and III were significantly lower than that of the group of stages IV, V and VI. The ratio of patients who can become ambulant to all patients was significantly lower in and under III than in and above IV (Niki 1982). We are interested in these similar results in classifying Br. stages and we think CCD may have clinical usefulness.

The hypothesis that CCD is a result of interruption of corticopontocerebellar system is widely accepted (Pantano et al. 1986; Fulham et al. 1992). Br. stages are speculated to correlate with disruption of corticospinal tracts (Brunnstrom 1970; Watanabe and Tashiro 1992). The results of this study indicate a close correlation between Br. stages of hemiplegia and degrees of CCD. So, Br. stages may have correlations with not only corticospinal tracts but also corticopontocerebellar pathways.

The mean ASI of IV was remarkably high. This was due to the ASI of

patient 7. In this patient, CCBF was higher than ICBF and visual CCD was not seen. There might be any cerebellar arterial abnormality, but we did not perform angiography.

In this study, there was no significant ICBF difference other than between III and V. Therefore, we think that ASI could evaluate degrees of CCD as CCBF. However, ICBF may be lower than the normal cerebellar blood flow due to contralateral cerebral hypometabolism of stroke patients, and ASI could be blunted compared with CCBF (Pappata et al. 1989).

Acknowledgment

We thank Kazuo Kubota M.D. of the Institute of Development, Aging and Cancer of Tohoku University for help in the preparation of this manuscript.

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