

Neuropsychological and MRI Assessment of Young Adults with Hemiplegic Cerebral Palsy

Makoto FUKAMACHI,¹ Tomitaro AKIYAMA,² Akira TSURU,¹ Minoru MORIKAWA,³ Yukiyoishi KAWAGUCHI,⁴ Hiroyuki MORIUCHI¹

¹Department of Pediatrics, Nagasaki University School of Medicine, Nagasaki, Japan

²Nagasaki Municipal Welfare Center for the Disabled, Nagasaki, Japan

³Department of Radiology, Nagasaki University School of Medicine, Nagasaki, Japan

⁴Nagasaki Prefectural Kodomo Iryou Hukushi Center (handicapped children's hospital), Isahaya, Japan

We assessed 12 young adults with hemiplegic cerebral palsy, aged from 14 to 33 years, by intellectual quotient (IQ) and magnetic resonance imaging (MRI), and obtained the following findings. First, the IQ scores were relatively lower than those predicted by their social activities. Second, there were two cases who seemed to have right or bilateral hemisphere representatives of language; their IQ scores were within normal range, while MRI demonstrated extensive brain damages including usual ones in language areas. Third, IQ scores and MRI findings were correlated to some extent; however, a case of limited brain damage on MRI had low IQ score, while five cases of brain damage located excluding their language areas had normal or high IQ scores.

The results of the present study indicate the necessity of follow-up MRI for prospective observation of the brain damage acquired at or around birth.

ACTA MEDICA NAGASAKIENSIA 49: 81–85, 2004

Keywords: Hemiplegic cerebral palsy; Young adult; IQ; MRI

Introduction

Cerebral palsy is a non-progressive, but not necessarily unchangeable, disorder of movement and posture caused by damage to developing brain at or around birth.¹ Cerebral palsy is not a single condition—cerebral palsies would be a more accurate description, since a wide spectrum of disorders is covered. Generally, cerebral palsy may be classified either by the type of movement problem or by the body parts involved. The former refers to the following five groups: spastic, athetoid, hypotonic, ataxic, and mixed, while the latter refers to the following five groups: monoplegia, hemiplegia, diplegia, triplegia, and quadriplegia. The term "hemiplegia" is defined as a condition in which spasticity or dyskinesia affects only one side of the body.²

Although hemiplegic cerebral palsy can be associated with a wide spectrum of difficulties, most patients with left hemiplegic cerebral palsy have no verbal impairment. On the other hand, patients with right hemiplegia, secondary to lesions in the left cerebral hemisphere, in which language areas are located, are likely to have verbal

impairment. However, there may exist a disputable problem between location of brain lesions and verbal abilities.

We assessed 12 young adults with hemiplegic cerebral palsy by intellectual quotient (IQ) scores and magnetic resonance imaging (MRI) findings to elucidate their present language function, their brain lesions and the relation between these two.

Materials and Methods

Subjects

In this study, cerebral palsy was defined as a condition caused by damage to the developing brain at or around birth or even beyond the neonatal period, whenever it is still developing. Among 100 young adults diagnosed hemiplegic cerebral palsy at Nagasaki University Hospital, we recruited 30 subjects for the present study and obtained informed consent from them. They were aged from 14 to 33 years. Despite such considerable impairment as hemiplegic spastic gait

Address correspondence: Makoto Fukamachi, M.D., Department of Pediatrics, Nagasaki University School of Medicine 1-7-1 Sakamoto, Nagasaki 852-8501 JAPAN

TEL: +81-(0)95-849-7298, FAX: +81-(0)95-849-7301, E-mail: d399036ystcc.Nagasaki-u.ac.jp

Received April 8, 2004; Accepted May 14, 2004

and/or unskilfulness of the lateral hand, they have few obstacles in their daily lives.

Of the 30 subjects, 12 have completed two examinations, the test of Wechsler Intelligence Scale for Children, 3rd edition (WISC-III) and MRI examination of the brain, and were further analyzed.

Neuropsychological method

The WISC-III test evaluates the verbal intelligence quotient (VIQ) and the performance intelligence quotient (PIQ) of examinees. The subjects underwent the test with the help of an experienced psychologist, and we estimated their intelligence from respective results of the test.

Radiological method

1) MRI

MRI was performed on a 1.5 T (Tesla) superconductive magnet (Sigma Horizon LX, GE Medical Systems, Milwaukee, WI) using a quadrature transmit/receive head coil. The initial conventional MRI of the brain included transverse T2-weighted fast spin-echo sequence (3000 ms/85 ms/2 = repetition time(TR)/echo time(TE)/number of acquisition (NEX)) using the following parameters: field of view--22 cm, section thickness--5 mm with 1 mm gap, and acquisition matrix--320×224. The coronal 3D spoiled gradient-echo sequence (50 ms/6 ms/45 degree/1 = TR/TE/Flip angle/NEX) was also obtained using the following parameters: field of view--24 cm, section thickness--3 mm with no gap, and acquisition matrix--256×192.

2) Characteristics and locations of the lesions

The MRI is expected to reveal subcortical or cortical lesions that have caused subjects' impairment. The characteristics and locations of these lesions were analyzed by neuroradiologists without any information on medical histories of the subjects.

We focused our attention on whether locations of the lesions are related to language area or not. We defined "language area" as Broca's area (left inferior frontal region), Wernicke's area (left superior and middle temporal region), supramarginal and angular gyri, and arcuate fasciculus.^{3,5}

Results

All subjects except for two had right hemiplegia as shown in Table 1; the Case 4 had left hemiplegia and the Case 1 had mild diplegia. We, however, did not exclude the Case 1 from the study subjects because the right side of his body was affected more seriously than the left side. With respect to their handedness, 11 were left-handed and one (Case 4) was right-handed naturally (Table 1).

Regarding the social activities, 4 were students, 6 were clerks and 2 had no occupation (Table 1).

The verbal intelligence quotient (VIQ) of the subjects assessed by the WISC-III test was as follows: 7 were normal (80-); 2 were borderline (70-79); 2 were mildly retarded (50-69); and 1 was moderately retarded (-49) (Table 1).

The brain lesions in the subjects revealed by MRI were as follows: encephalomalacia in 4 (Cases 2-4 and 12), volume loss of white matter or enlarged ipsilateral ventricle in 7 (Cases 2, 4-7, 10 and 11), atrophy of gray matter in 4 (Cases 1, 8, 9 and 11), and lateral

Table 1. Profile of young adults with hemiplegic cerebral palsy in the present study

Case No.	Sex ^a	Age ^b	Hemiplegia	Handedness	Etiology	Developmental delay	Complication	Occupation/Education	VIQ/PIQ
1	M	15	Right ^c	Left	Asphyxia	Psychomotor delay	No	Student	57/47
2	M	18	Right	Left	Unknown	Psychomotor delay	No	Student	74/73
3	M	21	Right	Left	Unknown	Motor delay	Epilepsy	Clerk/High school	81/65
4	M	22	Left	Right	Intracranial hemorrhage	No	No	Student	128/85
5	M	22	Right	Left	Unknown	No	No	Student	97/86
6	M	30	Right	Left	Asphyxia	No	No	Clerk/College	114/82
7	F	19	Right	Left	Unknown	Psychomotor delay	Epilepsy	No	48/51
8	F	22	Right	Left	Encephalitis	Psychomotor delay	Epilepsy	No	53/46
9	F	28	Right	Left	Asphyxia	Psychomotor delay	No	Clerk/High school	80/62
10	F	30	Right	Left	Immature	Psychomotor delay	No	Clerk/College	82/64
11	F	30	Right	Left	Unknown	Psychomotor delay	No	Clerk/High school	79/65
12	F	33	Right	Left	Asphyxia	Motor delay	Epilepsy	Clerk/High school	99/97

^aM=male, F=female.

^bAge (in years) at the time of the examination.

^cPredominantly right.

Table 2. MRI findings of young adults with hemiplegic cerebral palsy in the present study

Case No.	Brain lesion	Damage to language area			
		Broca	Wernicke	Arcuate fasciculus	Angular gyrus/Supramarginal gyrus
1	Atrophy of gray matter in bilateral precentral and postcentral gyri	No	No	No	No
2	Encephalomalacia in left middle cerebral artery territory; Brainstem atrophy; Volume loss of white matter of left thalamus and basal ganglia	No	No	No	No
3	Encephalomalacia in left middle cerebral artery territory	Yes	Yes	Yes	Yes
4	Encephalomalacia in right temporal, parietal and occipital lobes; Volume loss of right thalamus and basal ganglia	No	No	No	No
5	Volume loss of white matter in left thalamus and basal ganglia; Brainstem atrophy	No	No	No	No
6	Volume loss of white matter of left frontal and temporal lobes; Brainstem atrophy	No	No	No	No
7	Volume loss of white matter of left thalamus and basal ganglia; Brainstem atrophy	No	No	No	No
8	Atrophy of gray matter of left frontal, temporal and parietal lobes; Brainstem atrophy	No	No	No	No
9	Atrophy of gray matter of bilateral precentral and postcentral gyri	No	No	No	No
10	Volume loss of white matter in left anterior and middle cerebral arteries territories; Brainstem atrophy	Yes	No	Yes	Yes
11	Volume loss of white matter of left thalamus and basal ganglia; Brainstem atrophy; Atrophy of gray matter of left frontal and temporal lobes	Yes	Yes	Yes	Yes
12	Encephalomalacia in left anterior cerebral artery territory	No	No	No	No

atrophy of brainstem in 7 (Cases 2, 5-8, 10 and 11) (Table 2). Brain lesions in Cases 1, 5, 7 and 12 were confined to unilateral frontal lobe and other 8 cases had brain lesions extended to two or more lobes.

Damage to language area was observed in 3 cases (Cases 3, 10 and 11), while damage to motor area including pyramidal tract and basal ganglia was observed in all cases (Table 2).

While the VIQ score was low in one case (Case 7) of limited brain damage, it was normal or high in 5 cases (Case 3, 4, 6, 10 and 12) of extensive brain damage (Tables 1 and 2).

Discussion

The aim of the present study was to reassess young adults with hemiplegic cerebral palsy by neuropsychological and neuroimaging methods. Although similar studies have been reported, most of them were completed before MRI became widely available.⁶⁻⁸ As stated in Introduction, we examined their current abilities in social activity, language function and their brain lesions, and analyzed the correlation between the last two.

Discrepancy between ability in social activity and results of IQ assessment

In general, the ability of an individual in social activity is greatly influenced by his/her overall intelligence. The IQ assessment, therefore, can partly explain the ability in social activity.

The WISC test is one of the most frequently used IQ tests. We certainly have a possible risk to have assessed our subjects'

intelligence to a limited degree by adopting this test as the sole IQ test. Scientific evidence of WISC test, however, has been demonstrated by many researchers⁹ and is easily applicable to children and adolescents.

In the case of hemiplegia, VIQ is much better than PIQ as an indicator of overall intelligence since the performance items of the latter require normal manipulative ability;¹⁰ we therefore adopted VIQ as an indicator of our subjects' overall intelligence. The VIQ scores of our subjects were lower than those predicted by their social activities. The mean VIQ score was 83 in our subjects. Among 10 cases (Cases 1-6 and 9-12) who had little handicaps in their social activities, their VIQ scores indicated that 2 (Cases 2 and 11) were borderline and 1 (Case 1) was mildly retarded. There is a report¹¹ that in a group of children with hemiplegia, approximately two thirds of them had normal ability in social, while the mean IQ of the group was low as 81. Two explanations are possible for such discrepancy between VIQ score and ability in social activity. First, VIQ may not eventually be an ideal indicator of overall intelligence of patients with cerebral palsy, and even an individual with borderline VIQ score can be considered of normal intelligence. Second, education and rehabilitation can overcome low IQ, and even an individual with borderline VIQ score can perform social and school activity as comparably as can one with normal IQ. Further evaluation would be needed to decide which explanation is appropriate.

Relation between neurological findings and brain lesions indicated by MRI

Although MRI has been an indispensable method in neurological diagnosis for the last 20 years, most of our subjects had acquired

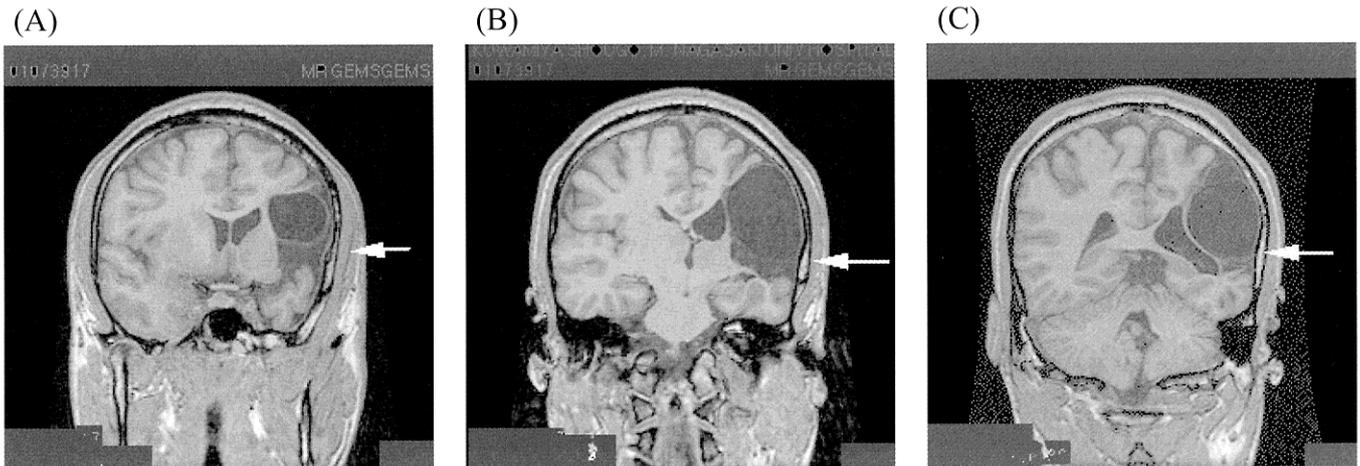


Figure 1. Case 3 with a normal VIQ score despite of severely damaged language areas. A series of coronal images (A, B and C) of T1-weighted MRI show a vast encephalomalacia including Broca's area (indicated by the arrow in A) and Wernicke's area (indicated by arrows in B and C).

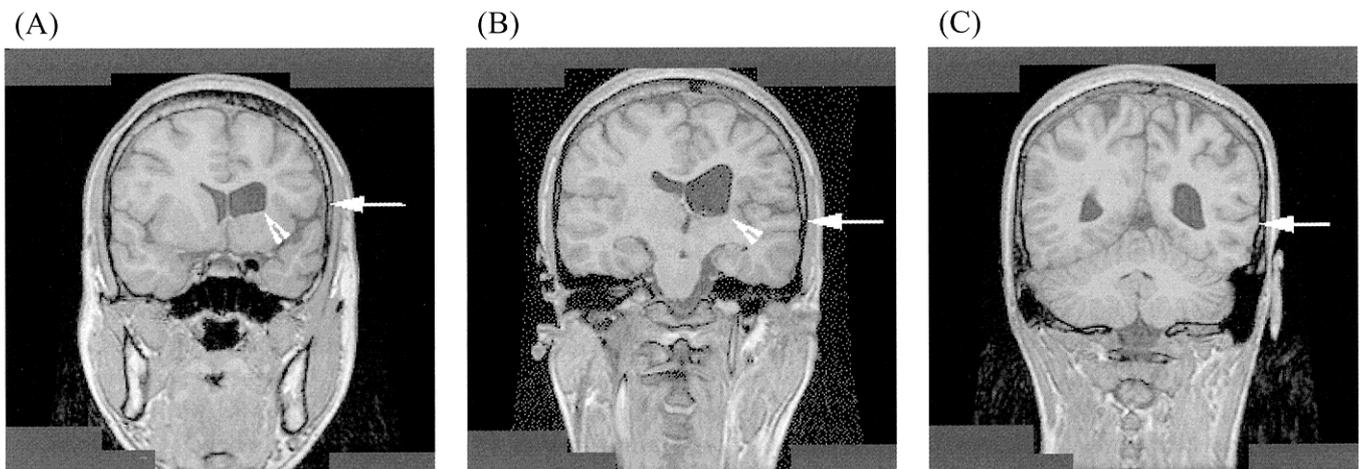


Figure 2. Case 7 with a low VIQ score despite of apparently intact language areas. A series of coronal images (A, B and C) of T1-weighted MRI do not show any damage to the language regions including Broca's area (indicated by the arrow in A) and Wernicke's area (indicated by arrows in B and C), but show the atrophic lesions on the left basal ganglia and thalamus (indicated by arrowheads in A and B).

brain lesions before it became available. We therefore used MRI to reassess their brain lesions. We adopted coronal images to analyze the brains of 12 subjects because they depict cortical lesions clearly.

Notably, at least two cases (Cases 3 and 10) could have lost neurological function more extensively than their present condition, if we postulate that the location of their lesions at or around birth is similar to that demonstrated by MRI at present. These cases could speak quite fluently and had normal VIQ scores, although MRI revealed that their language areas were severely damaged (see Figure 1). Possible explanation for such cases includes a functional specialization of the brain in which the right hemisphere become dominant for language or there is bilateral representation.¹²⁻¹⁴ As described by Luria and other authors about adult post stroke cases, there may be various pathways of functional compensation for damaged parts in developing brain.¹⁵⁻¹⁷ This statement requires further examinations by such strategies as functional MRI.¹⁸⁻²⁰

On the other hand, one case of our study (Case 7) had low VIQ scores, although she only had subtle lesions away from her language areas (see Figure 2). Such discrepancies suggest the existence of microstructural damage and the underdevelopment of brain, which are not detectable by MRI. The progress of radiological technology will prove this hypothesis.

In other five cases of our study (Cases 4-6, 9, and 12), their current language functions were compatible to their MRI findings.

This study, although the sample size was small, indicated a correlation between VIQ scores and MRI findings. It is unknown, however, whether the brain lesions at or around birth are compatible to those at present in our cases because the present study is retrospective. We emphasize the necessity of a prospective and large-scale MRI study^{21,22} for understanding how brain lesions at or around birth will change and relate with intellectual development in child.

Acknowledgements

We express sincere thanks to Miss Kaori Matsuo, an experienced psychologist, for her devoted work in administering WISC-III test to participants of the present study and the assessment of their IQ. We thank the participants of the present study for their cooperation.

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