Brunnstrom Stages and Wallerian Degenerations : A Study Using MRI

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WATANABE, H. and TASHIRO, K. *Brunnstrom Stages and Wallerian Degenerations : A Study Using MRI*. Tohoku J. Exp. Med., 1992, **166** (4), 471-473 — We studied the relationship between the Brunnstrom stages obtained after rehabilitations and Wallerian degenerations detected by magnetic resonance imaging (MRI). Forty-nine hemiplegic patients were retrospectively studied. The patients were grouped into a low stage group (30 patients) demonstrating Brunnstrom stages I~IV and a high stage group (19 patients) demonstrating stages V~VI. MRI detected Wallerian degenerations as changes of signal intensity in corticospinal tracts on T2-weighted images. The signals were hypointense or hyperintense compared to the normal side according to the intervals between the MRI examinations and the ictuses. MRI showed Wallerian degenerations in 27 of 30 patients in the low stage group and 5 of 19 patients in the high stage group. The difference between the two groups was significant ($p < 0.005$). ——— Brunnstrom stage ; Wallerian degeneration ; MRI

There are several measures to evaluate functional recovery states of hemiplegia (Arsenault et al. 1988). Although the Brunnstrom staging (Brunnstrom 1970) is believed to be one of the most useful measures, pathological and physiological explanations of the measures are still incomplete. Magnetic resonance imaging (MRI) is useful in the imaging of central nervous diseases and can be used to detect Wallerian degenerations following strokes (Matthew et al. 1988, 1989). This report focuses on a retrospective study of the relationship between the Brunnstrom stages obtained following rehabilitations and Wallerian degenerations evaluated by MRI.

MATERIALS AND METHODS

Seventy-three hemiplegic patients were admitted and received MRI examinations between October 1990 and June 1991 in Nanasawa Rehabilitation Hospital. Forty-nine hemiplegic patients (29 men, 20 women) were selected according to the following conditions of the Brunnstrom staging and of MRI examinations. The age of the patients was 58.0 ± 10.1 (mean $\pm$ s.d.).

Little neurological improvements occur after 12 weeks of the ictuses (Newmann 1972). Hence, in this study, Brunnstrom stages I~IV were determined after the 90th day of the ictuses. Brunnstrom stagings were performed for arms, fingers and legs of each patient, thus each patient has three Brunnstrom stages, namely the stages of the arm, the fingers and the leg. Then those patients were grouped into a low stage group (stages I~IV) and a high stage group (V~VI) in the analysis of the data of this study. Cases were selected so that all the three stages of those patients in the low stage group consisted of stage I~IV, while

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Fig. 1.

Fig. 2.

Fig. 1. A case of Wallerian degeneration with hypointense signals (71-year-old male with left cerebral infarction).

MRI (a~d) performed on the 50th day of the ictus revealed the hypointense signals (arrows) in the corticospinal tract at the pons, the cerebral peduncle and the internal capsule.

Fig. 2. A case of Wallerian degeneration with hyperintense signals (69-year-old male with right putaminal hemorrhage).

MRI (a~c) examined on the 215th day of the ictus revealed hyperintense signals (arrows) in the corticospinal tract at the pons.

all the three stages of those patients in the high stage group consisted of stages V~VI.

MRI was performed using 0.5-T unit. T2-weighted (employing a spin-echo technique with a repetition time of 2,000 ms and an echo time of 100 ms) axial images from the medulla oblongata to the parietal lobe were obtained in all cases, and those images were then used in this study. The slice thickness was 7 mm and the gap between the slices was 3 mm. 12 slices were obtained at one time. The changes in signal intensity in the ipsilateral corticospinal tracts on T2-weighted images were considered to represent Wallerian degenerations according to Matthew et al. (1988, 1989). Both hypointense and hyperintense signals compared to contralateral normal sides were considered to represent Wallerian degenerations (Fig. 1, 2). In this study, changes in signal intensity considered to represent Wallerian degenerations were longitudinally continuous at least 2 cm to exclude focal white matter lesions. As a general rule, MRI was performed after the 30th day of the ictuses considering possible delays of appearances of Wallerian degenerations (Matthew et al. 1989). However, two patients which demonstrated changes of signal intensity in MRI performed prior to the 30th day of the ictuses (on the 15th day and 22nd day respectively) were included in this study.

The statistical analysis of the data was performed by χ^2 test with Yates correction.

RESULTS

We grouped the patients into a low stage group (Brunnstrom stages I~IV) and a high stage group (V~VI). MRI detected changes of signal intensities considered to represent Wallerian degenerations in 27 of 30 patients in the low stage group, and in 5 of 19 patients in the high stage group. There was a significant difference between the two groups ($p < 0.005$).

DISCUSSION

Pathological and physiological explanations concerning the basis of the Brunnstrom staging are not complete. The Brunnstrom staging is based on synergies and spasticities of hemiplegic patients. One hypothesis suggests that these phenomena are due to spinal or brain stem reflexes, and that they are inhibited by neurons at higher positions than brain stem in normal subjects (Ueda 1982). And these phenomena appear by disinhibitions in hemiplegic patients (Ueda 1982). We speculated that the inhibitory neurons mentioned in the above hypothesis existed in corticospinal tracts and that disinhibitions might possibly be related to Wallerian degenerations.

Computed tomography can detect Wallerian degenerations as brain stem atrophies after several years of ictuses (Jorgan and Leonides 1982). MRI can detect Wallerian degenerations as changes of signal intensity in the corticospinal tract during acute and subacute stages of ictuses. On T2-weighted images, hypointense signals appear at about 4 weeks of ictuses, after which signals become hyperintense at 10~14 weeks (Matthew et al. 1989). During the early stages of Wallerian degenerations, myelin proteins degenerate and myelin lipids remain intact, while in the late stages, myelin lipids degenerate (Daniel and Strich 1969). So it can be assumed that at the early stages the high lipid-protein ratio make the tissue hydrophobic and hypointense signals on T2-weighted images, and at late stages lipid degenerations make the tissue hydrophilic and hyperintense signals on T2-weighted images (Matthew et al. 1989). In this study, both hypointense and hyperintense signals were considered to represent Wallerian degenerations.

The intervals between MRI examinations and ictuses were not constant in this study. In three cases who were examined twice on different days, despite the detection of hypointense signals at the time of the first examinations, there were no definite abnormalities at the time of the second examinations. At present, it is uncertain as to the existence of isointense stage, and or whether hyperintense signals will appear in these three cases. As such, these cases were excluded from this study.

Synergies and spasticities appear at the Brunnstrom stage II, and disappear or diminish at the stage V (Brunnstrom 1970). In this study, the patients were grouped into a low stage group (stages I~IV) and a high stage group (V~VI). The results of this study indicated that the detection rate by MRI of Wallerian degenerations was significantly higher in the low stage group than in the high stage group. It is believed that this result supports our speculation that inhibitory neurons of synergies and spasticities exist in corticospinal tracts and that disinhibitions might be related to Wallerian degenerations. It was also suggested that detections of Wallerian degenerations by MRI in hemiplegic patients in acute or subacute stage may result in prognoses in stages I~IV.

Thus, we conclude that the MRI detection rate of Wallerian degenerations of hemiplegic patients is significantly higher in the low stage group (Brunnstrom stages I~IV) than in the high stage group (V~VI).

References

- 1) Arsenault, A.B., Dulti, E., Lambert, J., Corriveau, H., Guarna, F. & Drouin, G. (1988) An evaluation of the hemiplegic subject based on the Bobath approach-part III. A validation study. *Scand. J. Rehabil. Med.*, **20**, 13-16.
- 2) Brunnstrom, S. (1970) Recovery stages and evaluation procedures. In: *Movement Therapy in Hemiplegia: A Neurological Approach*, Harper & Row, New York, pp. 34-55.
- 3) Daniel, P.M. & Strich, S.J. (1969) Histopathological observations on Wallerian degeneration in the spinal cord of the baboon, *Papio papio*. *Acta Neuropathol.*, **12**, 314-328.
- 4) Jorgan, S. & Leonides, T. (1982) Wallerian degeneration of the corticospinal tract region of the brain stem-demonstrated by computed tomography. *Radiology*, **149**, 717-720.
- 5) Matthew, J.K., Keith, A.J. & Kenneth, R.D. (1988) Wallerian degeneration-evaluation with MR imaging. *Radiology*, **168**, 199-202.
- 6) Matthew, J.K., David, J.M., David, M.A., Barry, E.K., Kenneth, R.D. & Juan, M.T. (1989) Wallerian degeneration after cerebral infarction-evaluation with sequential MR imaging. *Radiology*, **172**, 178-182.
- 7) Newmann, M. (1972) The process of recovery after hemiplegia. *Stroke*, **3**, 702-710.
- 8) Ueda, S. (1982) Pathophysiology and prognosis of hemiplegia. *Sogo Rehabilitation*, **10**, 66-77. (in Japanese)