Clinical Case Report

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Bidirectionality of the dentato-rubro-thalamo-cortical tract allows concurrent hypoperfusion in ipsilateral cerebellum and contralateral cerebral hemisphere

A case report

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Abstract

Rationale The brain circulation of the dentato-rubro-thalamo-cortical tract (DRTT) has been reported for decade, but is rarely observed using nuclear medicine imaging tools, to analyze a patient with midbrain hemiatrophy syndrome. We present a case that revealed notable interruption in the middle of the DRTT. Finding out whether the superior cerebellar peduncle of the midbrain was injured was a decisive element for developing bidirectional effect of DRTT.

Patient concerns A 34-year-old right-handed female presented with progressive weakness and bradykinesia in the left-sided limbs for about 6 months. She had difficulty with hand dexterity for activities of daily life and general tasks. She reported poor balance during walking and sitting. Muscle strength was 3 in the left hand and 4 in the foot due to atrophy of left limbs. The circumference of 10 cm proximally/distally from the lateral epicondyle of the humerus was 25.7/23.8 cm at right and 24.2/20.8 cm at left in the upper limbs, and 15 cm proximally/distally from the lateral joint space was 42.1/35.0 cm at right and 43/30.8 cm at left in the lower limbs. The brain magnetic resonance imaging study revealed a small-sized right midbrain.

Diagnosis Based on the distinct features of limbs atrophy and the locations of the lesions on the magnetic resonance (MR) imaging, the patient was diagnosed with midbrain hemiatrophy syndrome.

Interventions The patient was only willing to accept physical and occupational training programs at our outpatient clinic.

Outcomes We utilized serial anatomic and functional neuroimaging of the brain to survey the neurologic deficit. Brain perfusion single-photon emission computed tomography (SPECT) showed hypoperfusion over the left fronto-parietal regions, left anterior temporal region, and left occipital region, and also the left striatum and right cerebellum. Symptoms were gradually recovered with rehabilitation, and he was transferred to a rehabilitation facility on hospital day 40.

Lessons This is the first report to demonstrate concurrent hypoperfusion of ipsilateral cerebellum and contralateral cerebral hemisphere observed on SPECT images in a case of midbrain hemiatrophy syndrome. In our case, with midbrain hemiatrophy syndrome could be explained as mutual direction effect of DRTT.

Abbreviations: CCD = crossed cerebellar diaschisis, DRTT = dentato-rubro-thalamo-cortical tract, HPHA = hemiparkinson-hemiatrophy, MR = magnetic resonance, SPECT = single-photon emission computed tomography.

Keywords: case report, dentato-rubro-thalamo-cortical tract, midbrain hemiatrophy syndrome, single-photon emission computed tomography

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Informed written consent was obtained from the patient for publication of this case report and accompanying images.

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1. Introduction

The dentato-rubro-thalamo-cortical tract (DRTT) was first described by Chung in 1985. Damage to the ascending cerebellar fibers can lead to retrograde cerebellar alteration.[1] The greater part of the fibers run via the superior cerebellar peduncle and midbrain crossing the midline to the contralateral motor and nonmotor areas, which include regions of the prefrontal and posterior parietal cortex.[2] It predominantly influences neuronal activity, metabolism, and structures.[3] It is rare to observe brain circulation using single-photon emission computed tomography (SPECT). We herein describe a case of midbrain hemiatrophy syndrome, in which SPECT showed hypoperfusion of the ipsilateral cerebellum and contralateral cerebral hemisphere owing to the bidirectional nature of DRTT.

2. Case presentation

A 34-year-old right-handed female, born through natural labor without congenital problems, had no past history of head injury, operation, medication, prolonged or substantial exposure to toxic environmental agents, smoking, or other probable causes of movement disorders. She presented with progressive weakness of left-sided limbs since its onset 6 months ago.

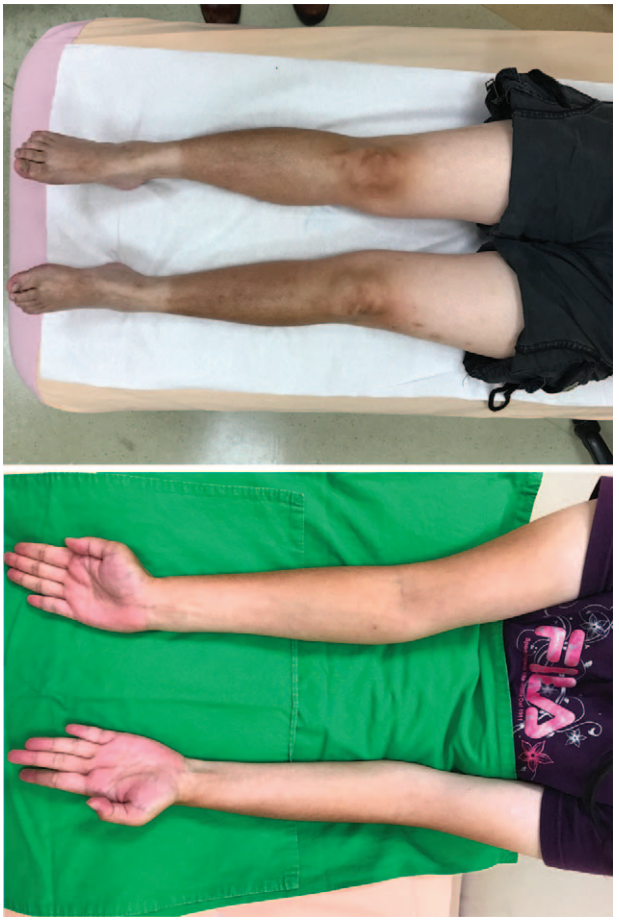

Figure 1. Images of patient measurements. Measurement of limb circumference: a point 10 cm proximally/distally from lateral epicondyle of the humerus and 15 cm proximally/distally from the lateral joint space of both knees yielded circumference of 25.7/23.8 cm at right and 24.2/20.8 cm at left in the upper limbs, and 42.1/35.0 cm at right and 43/30.8 cm at left in the lower limbs.

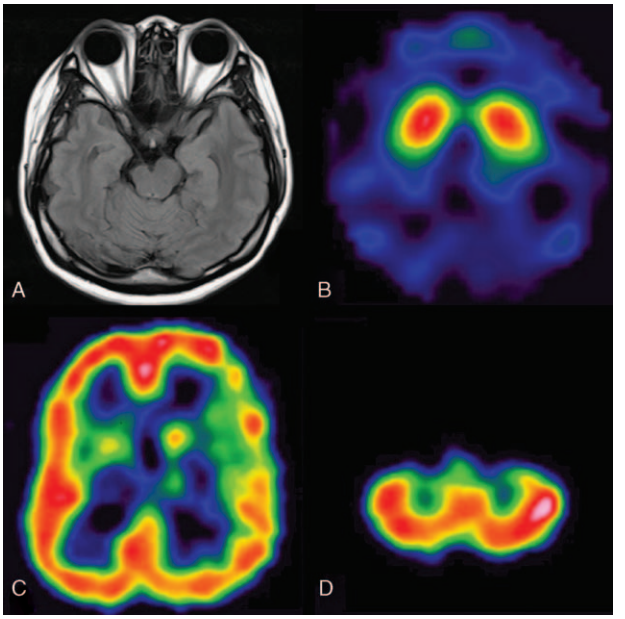

Figure 2. Various images of the patient. Axial brain fluid-attenuated inversion recovery MRI shows small size of the right midbrain (A). Axial 99mTc TRODAT-1 brain scan shows no obvious secondary reduction in the expression of dopamine transporter of the caudate nucleus and putamen (B). Axial brain perfusion SPECT with 99mTc-ECD revealed hypometabolic change over the left fronto-parietal regions, left anterior temporal region, and left occipital, left striatum and right cerebellum in the serial images (C, D). 99mTc TRODAT-1 = Technetium-99m-labeled tropanes as dopamine transporter imaging agents, ECD = ethylene cysteine diethyl ester, MRI = magnetic resonance imaging, SPECT = single-photon emission computed tomography.

An exaggerated motion of left upper limb was evoked by the movement of the contralateral limb. Bradykinesia was also noted in the left limbs. The patient had difficulty with hand dexterity for activities of daily life and general tasks. Furthermore, she reported poor balance during walking or sitting, which seemed to have worsened over time. Muscle strength was weak in the left hand and foot due to atrophy of left limbs. She visited our OPD, where she exhibited mild dysarthria and hypotonia, especially in the left-sided limbs. In addition, muscle strength was 3 in the left hand and 4 in the foot due to atrophy of left limbs plus left hemiatrophy and leg length discrepancy, that is, shorter on the left side. We measured a point 10 cm proximally/distally from the lateral epicondyle of the humerus and 15 cm proximally/distally from the lateral joint space of both knees, which revealed circumference of 25.7/23.8 cm at right and 24.2/20.8 cm at left in the upper limbs, and 42.1/35.0 cm at right and 43/30.8 cm at left in the lower limbs (Fig. 1). Deep tendon reflexes were generally brisk. There were no autonomic tribulations such as easy sweating and urinary incontinence. Her psychological and cognitive status, and also other general and neurological examinations were usual. The informed consent of the patient was obtained after we explained the purpose, benefits, and risks of these examinations to the patient. The brain magnetic resonance (MR) imaging revealed cortical thickening and nodular pattern in the right frontal lobe, small size of the right midbrain, and multiple small subcortical hyperintensity spots on parieto-occipital lobes (Fig. 2A). Tc-99m TRODAT-1 brain SPECT study revealed normal dopamine transporter uptake in the caudate nucleus and putamen (Fig. 2B). A brain perfusion

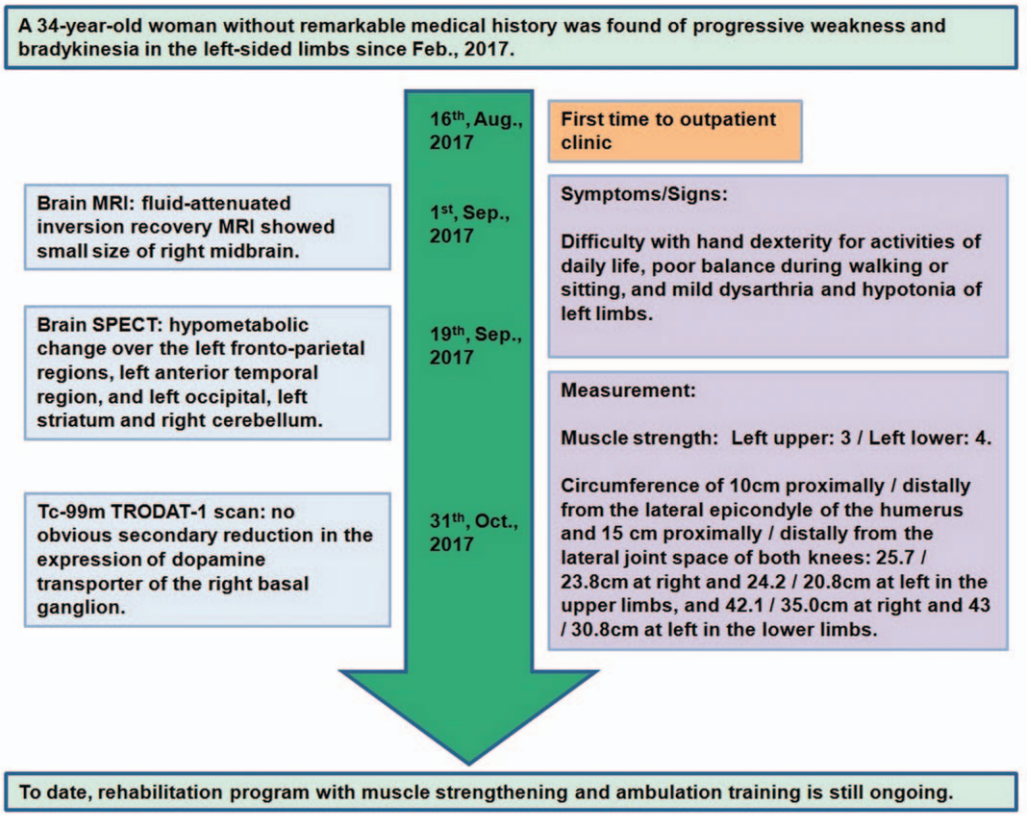

Figure 3. Timeline. The main symptoms and images provide the time course of the patient reported in this article.

SPECT study showed uneven hypoperfusion over the left fronto-parietal regions, left anterior temporal region, and left occipital region (Fig. 2C), and hypoperfusion in the left striatum and right cerebellum (Fig. 2D)—a phenomenon termed "crossed cerebellar diaschisis (CCD)." Associated laboratory data were unremarkable. We summarized the patient's condition in the timeline (Fig. 3). To date, rehabilitation program with muscle strengthening and ambulation training is still ongoing.

3. Discussion

With respect to the mechanism of this concurrent phenomenon, it is plausible that CCD may be involved. In 1981, Baron et al[4] reported that CCD is characterized by loss of functional activity and metabolism in the cerebellum contralateral to the supratentorial lesion. This phenomenon has been observed in many diseases, and appears to be the result of interruption of the cortico-ponto-cerebellar pathway. Moreover, cerebellar fibers of DRTT[5] ascend via the superior cerebellar peduncle and midbrain to the contralateral motor and nonmotor areas such as the primary motor cortex and the ventral premotor cortex.[5] The 2 distinct pathways cross the midline via different parts of cerebellar peduncles and midbrain. DRTT lesion can lead to retrograde changes in cerebellar neuronal activity, metabolism, and structure.[3] DRTT injury has been reported to cause obvious hand tremor[6] and serious ataxia after cerebellar infarct.[7] We hypothesize that the bidirectionality of DRTT, if damaged, can contribute to interruption of the DRTT pathway at the right midbrain and superior cerebellar peduncle due to atrophy. This may explain why hypoperfusion over the left fronto-parietal regions, left anterior temporal region, and right cerebellum could be observed on the brain SPECT in our case. We also have a schematic of the patient's DRTT (Fig. 4). This phenomenon cannot be attributed to the cortico-ponto-cerebellar pathway, because the left cerebral hemisphere and left pons were intact, as evidenced by the absence of any signs of hypoperfusion in the right cerebrum and left cerebellum.

There appears to be a relationship between hemiatrophy and hemiparkinson-hemiatrophy (HPHA) syndrome. HPHA was initially considered as a possible diagnosis in our case. Klawans[8] was the first to describe this rare disease in 1981. The main clinical picture of HPHA includes atrophy of 1 side of the body and unilateral hemiparkinsonism. Its symptoms are focal dystonia and tremor, which are only observed in about 70% HPHA patients. MR images of HPHA patients' brains typically reveal atrophy of cortex and the basal ganglia in focal or diffused forms, dilitation of the lateral ventricle, and/or with cortical and subcortical volume reduction on the affected side, with changes appearing in only 30% of patients.[9] [18F]-fluorodeoxyglucose PET may demonstrate cortical or ventricular brain asymmetry and focal hypometabolism of basal ganglia and frontal cortex contralaterally.[10] However, our case did not have rigidity and tremor, and the MR imaging study did not reveal any evidence of homolateral rarefaction of the substantia nigra. Furthermore, the TRODAT image did not show any abnormalities (Fig. 2B). A recent case report provided imaging evidence of a case of HPHA associated with contralateral midbrain hemiatrophy and nigral rarefaction.[10] However, the results were not consistent with our

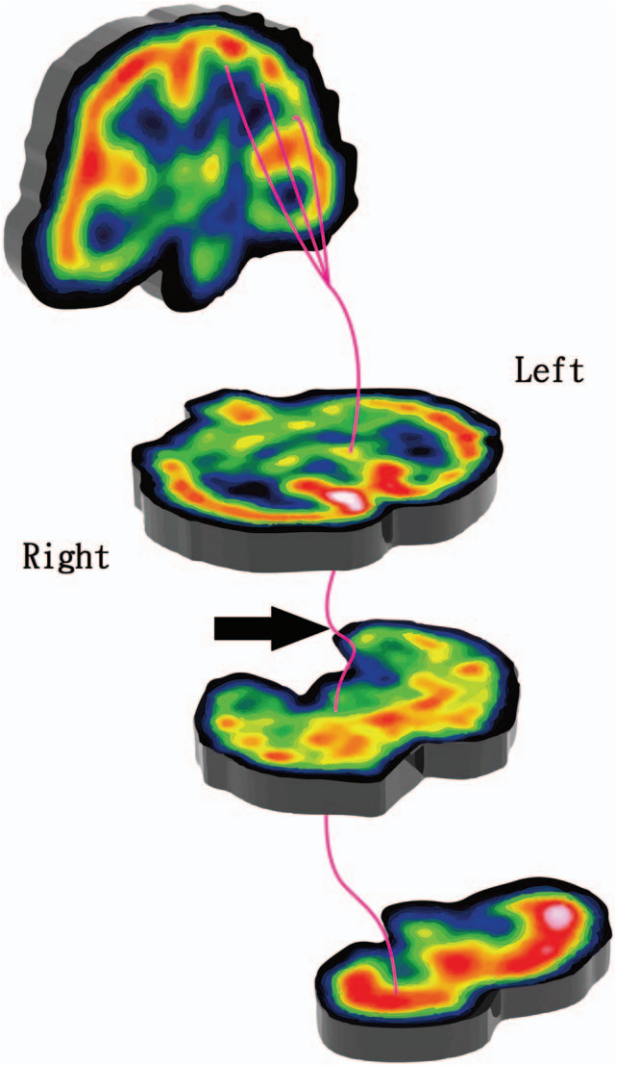

Figure 4. Schematic of dentato-rubro-thalamo-cortical tract. Schematics of proposed mechanism of concurrent hypoperfusion in the ipsilateral cerebellum and contralateral cerebral hemisphere due to the bidirectional property of the dentato-rubro-thalamo-cortical tract in our case of midbrain hemiatrophy syndrome. Black arrow: lesion site.

findings. Therefore, we ruled out a diagnosis of HPHA syndrome in our case.

To our knowledge, this is the first report to demonstrate concurrent hypoperfusion of ipsilateral cerebellum and contralateral cerebral hemisphere observed on SPECT images in a case of midbrain hemiatrophy syndrome. In our case, with midbrain hemiatrophy syndrome could be explained as mutual direction effect of DRTT. The use of brain perfusion SPECT to observe DRTT could be helpful for further evaluation. Several limitations should be considered. First, this study was a case report without a control group. Second, we did not employ tractography for direction-finding to determine the influence of DRTT. Therefore, further studies including a larger number of patients and the use of fiber tractography are required.

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Author contributions

Chun-Sheng Hsu performed and interpreted the SPECT studies.
Hsin-Chen He examined the patient and drafted the manuscript.
Investigation: Chun-Sheng Hsu.
Ming-Chun Hsu evaluated the patient and helped to format the manuscript.
Resources: Ming-Chun Hsu.
Shin-Tsu Chang reviewed the manuscript for intellectual content. All authors read and approved the final manuscript.
Validation: Yuan-Yang Cheng.
Writing – original draft: Hsin-Chen He.
Writing – review & editing: Shin-Tsu Chang.
Yuan – Yang Cheng created the artwork.

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