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【 CASE REPORT 】

Delayed Hemiparkinsonism Associated with Kernohan's Notch in a Patient with a Ruptured Arteriovenous Malformation

Masayuki Ueda[1], Marie Tsunogae[1], Hiroshi Saito[2], Takeya Suzuki[2] and Takahiro Ota[2]

Abstract:
A 24-year-old female patient was admitted for a right frontal intracranial hematoma with an uncal herniation due to a ruptured arteriovenous malformation and therefore underwent emergency surgery. Neuroimaging revealed left-sided midbrain notching against the tentorium, indicating Kernohan's notch phenomenon. She denied experiencing any short-term neurological deficits but right-sided delayed hemiparkinsonism developed 18 months later. Dopamine transporter tracer uptake was severely reduced in the left striatum, suggesting nigrostriatal degeneration secondary to Kernohan's notch. Uncal herniations are potentially fatal, but surgery can save the patient's life and improve the functional outcomes. Clinicians should therefore be aware of delayed hemiparkinsonism as a rare complication of Kernohan's notch phenomenon.

Key words: hemiparkinsonism, Kernohan's notch phenomenon, uncal herniation, arteriovenous malformation, trihexyphenidyl

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Introduction

Kernohan's notch phenomenon is a unique form of intracranial space-occupying lesion resulting from contralateral midbrain notching against the tentorium associated with uncal herniation and is usually characterized by hemiparesis ipsilateral to the primary brain lesion (1). Although hemiparesis is an ordinary symptom of this phenomenon, parkinsonism secondary to Kernohan's notch phenomenon has rarely been reported (2, 3). We herein described a patient with delayed hemiparkinsonism associated with Kernohan's notch phenomenon following an acute intracranial hematoma caused by a ruptured arteriovenous malformation (AVM).

Case Report

A previously healthy, 24-year-old, female patient experienced headache and nausea followed by a seizure and a disturbance of consciousness. She was transported to our hospital by ambulance. On admission, she was comatose (Glasgow Coma Scale 3) and presented right mydriasis, but her blood pressure, heart rate, and body temperature were unremarkable. Cranial non-contrast computed tomography (CT) on admission revealed a right frontal intracerebral hematoma and adjacent subdural hematoma with a midline shift to the left together with a right frontal, oblong-shaped, cystic lesion (Figure A, B). An emergency decompressive craniotomy was performed, but a dilated red vein was observed when the subdural hematoma was removed, suggesting that it was the drainer of the ruptured AVM. Emergency cerebral angiography revealed a right frontal AVM with extravasation (Figure C). Embolization was carried out against two major feeding arteries. Thereafter, she underwent surgical resection of the AVM. A second angiography on day 2 showed a complete resolution of the AVM (Figure D). Her consciousness level recovered spectacularly to almost normal by day 7, but mild right hemiparesis was noted. Brain magnetic resonance imaging (MRI) on day 8 visualized a lesion in the

[1]Department of Neurology and Stroke Medicine, Tokyo Metropolitan Tama Medical Center, Japan and [2]Department of Neurosurgery, Tokyo Metropolitan Tama Medical Center, Japan
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Correspondence to Dr. Masayuki Ueda, ueda@nms.ac.jp

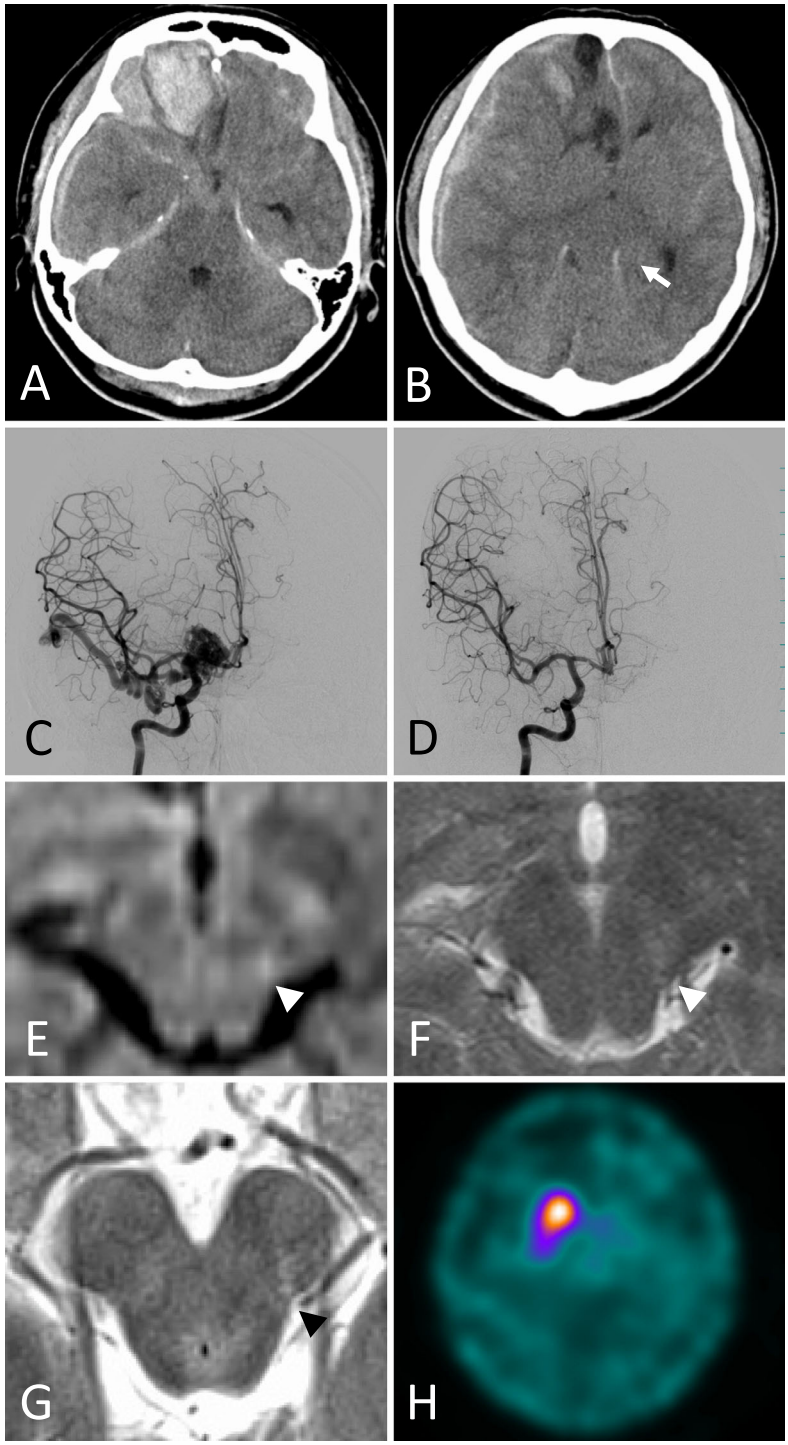

Figure. **A, B: Cranial non-contrast computed tomography on admission. Right frontal intracerebral hematoma and adjacent subdural hematoma with midline shift to the left, together with a right frontal oblong-shaped cystic lesion, can be seen. Note the uncal herniation and left-side midbrain notching against the tentorium (white arrow). C: Cerebral angiography on admission. Angiography of the right internal carotid artery revealed a right frontal arteriovenous malformation (AVM) with extravasation. D: Cerebral angiography on day 2. Angiography of the right internal carotid artery after surgical treatment demonstrated complete disappearance of the AVM. E, F: Brain magnetic resonance imaging on day 8. Diffusion-weighted imaging (D) and T2-weighted imaging (F) displayed a lesion on the left lateral surface of the midbrain (white arrow head) probably associated with Kernohan's notch phenomenon. G: Brain magnetic resonance imaging at two years after hemorrhage. T2-weighted imaging showed a lesion in the left midbrain (black arrow head). H: ^{123}I-ioflupane single photon emission computed tomography at two years after experiencing the hemorrhage. Note the extremely reduced dopamine transporter-specific tracer uptake in the left striatum.**

Table. Clinical Characteristics of Patients with Hemiparkinsonism Associated with Kernohan's Notch.

Reference	Age(yo)/Sex	GCS	Duration	Symptom	Neuroimaging	AI (%)	LD Efficacy
2	36/F	3	4W	Rt	Rt ICH/SDH/SAH, An	40.3*	Good
3	27/M	3	2W	Lt	Lt SDH, Head trauma	57.7**	Good
Present case	24/F	3	18M	Rt	Rt ICH/SDH, AVM	166.2**	Poor

AI=2×100×(ipsilateral binding ratio-contralateral binding ratio of the more affected side)/(ipsilateral binding ratio+contralateral binding ratio). * Examination by ^{18}F-dopa positron emission tomography. ** Examination by ^{123}I-ioflupane single photon emission tomography.

yo: years old, F: female, M: male, GCS: Glasgow Coma Scale, Duration: duration of parkinsonism onset from hemorrhage, Rt: right, Lt: left, ICH: intracerabral hemorrhage, SDH: subdural hemorrhage, SAH: subarchnoid hemorrhage, An: aneurysm, AVM: arteriovenous malformation, AI: asymmetry index, LD: L-dopa

left lateral surface of the midbrain (Figure E, F) indicating Kernohan's notch phenomenon. She was able to walk with assistance after three weeks and was transferred to a rehabilitation hospital at six weeks after admission due to slight, remaining, right hemiparesis. At nine weeks after onset, she was discharged from the rehabilitation hospital without any neurological deficits.

The patient thereafter visited our neurology department at 26 years years of age due to a slowly progressing right hand tremor which occurred 18 months after the onset of her previous symptoms. A neurological examination revealed right hemiparkinsonism presenting with a resting tremor in the right upper limb, cogwheel rigidity in the right upper and lower extremities, slowed right-sided movement, but no postural instability. Her Unified Parkinson's Disease Rating Scale (UPDRS) motor score was 17. Her deep reflexes and her pathologic reflexes were unremarkable, and the previously noted right hemiparesis was no longer observable. The patient had no family history of parkinsonism. A brain MRI at two years after onset showed post-operative changes in the right frontal lobe together with slight damage to the left midbrain (Figure G), but no abnormalities in the basal ganglia were noted. Single photon emission computed tomography (SPECT) using ^{123}I-ioflupane, a dopamine transporter-specific radioactive tracer, visualized extremely reduced uptake in the left striatum (Figure H); the specific binding ratio (SBR) in the right and left striatum was 4.21 and 0.44, respectively. The tracer uptake showed marked asymmetry as indicated by an asymmetry index (AI) of 162.2%. ^{123}I-metaiodobenzylguanidine myocardial scintigraphy showing the cardiac postganglionic sympathetic function indicated a normal uptake. The early and delayed heart and mediastinum ratio was 2.50 and 3.37, respectively. Based on these findings, hemiparkinsonism secondary to Kernohan's notch phenomenon associated with uncal herniation was diagnosed. L-dopa (LD) was initiated on 100 mg of LD/10 mg of carbidopa daily, but the patient responded poorly. However, after the temporary discontinuation of LD for several days, her tremors slightly deteriorated, suggesting that the LD therapy had some effect. Trihexyphenidyl (hydrochloride), an anticholinergic agent, was added to the LD therapy at a dosage of 2 mg/day. The patient responded favorably to this regimen, and the trihexyphenidyl was increased to 4 mg/day, resulting in further, marked improvement of her tremor and rigidity (UPDRS motor score 6).

Discussion

Stroke patients sometimes develop movement disorders. Alarcón et al. reviewed 1,500 acute stroke patients in a stroke registry and found 56 patients exhibiting extrapyramidal symptoms (4). In their study, post-stroke parkinsonism was observed in six patients, all of whom had an ischemic stroke. Parkinsonism after a hemorrhagic stroke may be rarer, but several patients exhibiting hemiparkinsonism following a contralateral midbrain hemorrhage, in which the substantia nigra was directly involved, have been reported (5-8). Besides the present patient, previous studies reported two patients with hemiparkinsonism following a large, ipsilateral, supratentorial hematoma, probably associated with Kernohan's notch phenomenon (2, 3). Turjanski et al. described a patient with right-sided, LD-responsive hemiparkinsonism following an ipsilateral temporal hematoma due to a ruptured aneurysm in the right middle cerebral artery, which developed four weeks after onset (2). Evans et al. reported a patient with left-sided, LD-responsive hemiparkinsonism following an ipsilateral, traumatic, subdural hematoma, which developed two weeks after a head injury (3). All three patients had symptoms in common, including a deep coma (Glasgow Coma Scale 3), dilated pupils on admission, and almost complete recovery from intracranial hemorrhage after surgical intervention. The present case was characterized by remarkably delayed onset of hemiparkinsonism and a poorer response to LD than that seen in the two previously reported cases. The clinical characteristics of the three patients are summarized in Table. In their review of the literature, Zhang et al. found 39 cases of Kernohan's notch phenomenon (1) where the main manifestation was hemiparesis; however, they found only one case of parkinsonism, which was also cited in the present report (3). Uncal herniations are generally fatal or can lead to a major disability if the patient survives. The present patient was rescued by prompt surgical intervention and she experienced no short-term neurological deficits, thus allowing the delayed parkinsonism to be detected. Her neurologically deficit-free period strongly indicated that the delayed parkin-

sonism probably resulted from nigrostriatal degeneration, such as pathological gliosis and delayed neuronal loss, secondary to midbrain notching against the tentorium but not from any direct damage to the substantia nigra. In addition, the transient hemiparesis observed in the present patient might have influenced the onset of delayed hemiparkinsonism, because of a potential relation between pyramidal tract damage and delayed ipsilateral nigro-striatal pathway (9).

The present patient showed a good therapeutic response to trihexyphenidyl but not to LD. Precisely, the relatively low dose of LD (100 mg/day) administered to the present patient did not necessarily indicate the ineffectiveness of LD. However, the therapeutic response to LD might have been poor in this patient, because LD therapy is usually associated with a drastic improvement of the motor symptoms for the first several years in the early stages of PD patients (10). The dopamine transporter binding capacity reportedly declines with disease duration in Parkinson's disease (PD) (11), indicating progressive nigrostriatal dopaminergic degeneration. This feature is a fundamental aspect of the pathogenesis of PD although the striatal dopamine receptors apparently remain unchanged regardless of the disease duration (12).

While there is a pharmacological basis for LD efficacy in PD, aromatic L-amino acid decarboxylase, a key enzyme for converting LD to dopamine, may decrease with nigrostriatal dopaminergic degeneration because dopaminergic neurons contain the enzyme (13). Thus, LD efficacy may decline with the disease duration, especially in advanced PD. ^{123}I-ioflupane SPECT in the present patient revealed severely reduced left striatal uptake (SBR 0.44) like that seen in advanced PD. The left-side tracer uptake was completely suppressed in the whole striatum including the head of caudate nucleus and the putamen, indicating severe damage in the inner and outer parts of the substantia nigra. The present patient exhibited some transient damage in the pyramidal tract, located in the middle part of the cerebral peduncle, thus suggesting that not only the outer side, but also the inner side of the midbrain was affected. Furthermore, the tracer uptake was markedly asymmetrical (AI 162.2%), thus indicating significant damage to the left-sided dopaminergic pathway. The AI was also calculated in each of the previously reported cases of LD-responsive hemiparkinsonism associated with Kernohan's notch phenomenon using the data described in the respective reports [AI=2×100×(ipsilateral binding ratio-contralateral binding ratio of the more affected side)/(ipsilateral binding ratio+contralateral binding ratio)]. The AI was 40.3% on the ^{18}F-dopa positron emission tomography study (2) and 57.7% in the ^{123}I-ioflupane SPECT study (3), suggesting that the damage to the nigrostriatal domapinergic pathway in the present patient was more severe than in the two previously reported patients. These discrepancies might explain the present patient's relatively poor response to LD. Furthermore, cholinergic denervation of the central nervous system is reportedly involved in PD pathology in addition to dopaminergic degeneration (14). The pathogenesis of the present patient's condition differed from that of ordinary PD, thus raising the possibility that the cholinergic system might not have been affected in our patient. Thus, cholinergic hyperactivity relative to the dopaminergic system likely explains the patient's excellent response to trihexyphenidyl.

Uncal herniations resulting from a supratentrial hematoma are usually fatal, but appropriate surgical intervention can improve the chances of survival and even improve functional outcomes. The present patient experienced hemiparkinsonism following a supratentrial hematoma and was unique in having a delayed onset of parkinsonism and a relatively poor response to LD. Clinicians should therefore be aware of delayed hemiparkinsonism as a rare complication of Kernohan's notch phenomenon.

The authors state that they have no Conflict of Interest (COI).

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