

# Deep brain stimulation could cause delayed and recurrent cerebral ischemia: a case report

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**Abstract** A 40-year-old male who had a severe tremor, bradykinesia, and rigidity for 6 years underwent bilateral subthalamic nucleus (STN) deep brain stimulation (DBS) at our hospital. The patient did not have any prior ischemia events or any risk factors in his medical history. Six and 9 months post-operation, this patient was admitted to the hospital twice for lower left limb involuntary twitching. Two magnetic resonance imaging (MRI) scans showed cerebral ischemia surrounding the implanted electrode. To our knowledge, this is the first case of recurrent cerebral ischemia associated with DBS. Reports in the literature of cerebral ischemia associated with DBS were reviewed, and the mechanism was discussed.

**Keywords** Deep brain stimulation · Parkinson's disease · Cerebral ischemia · Complications

## Introduction

In recent decades, deep brain stimulation (DBS) has been deemed as an effective and safe surgical method for Parkinson's disease (PD) [5, 11]. Compared to applying radio-frequency to the lesion, the advantages of DBS are as follows: it is reversible, less invasive, and an adjustable surgical mortality [13]. Although the benefits that patients with PD gain from DBS are enormous, the complications related to this surgery can also be significant. In the literature, the most

common complications include hemorrhage (2.7–5 %), infection (0–15.2 %), seizure (0.9–2.8 %), and death (0.4–1.8 %) [1, 12]. The reports of cerebral ischemia associated with DBS are very rare, but the consequence of this complication is serious. Although many explanations for the risk factors of cerebral ischemia associated with DBS are present in the literature, including patients with preexisting vascular disease [6], preexisting ischemia areas [5], unexplained micro electrode recording (MER) silence during the surgery [2], and electrode heating resulting from the magnetic field, the exact mechanism is still unknown. We report a case suffering from PD who underwent subthalamic nucleus (STN) stimulation and then twice had cerebral ischemia that was associated with DBS. To the best of our knowledge, this is the first report of recurrent cerebral ischemia resulting from DBS, and the clinical course and mechanism are worthy of being discussed.

## Case report

A 40-year-old male who had a severe tremor, bradykinesia, and rigidity for 6 years, predominantly on the left side, was treated with a daily dose of 750 mg of L-dopa. The symptoms were controlled inadequately because the efficacy of the drug gradually decreased. The patient was admitted to the hospital for DBS. UPDRS Part III cores were 48 in the medication-off condition and 26 in the medication-on condition. No prior ischemia events or any risk factors were present in the medical history. The pre-operative laboratory tests and imaging examination were normal (Fig. 1 A1–A3). With the aid of local anesthesia, a Leksell G frame (Elekta AB, Stockholm, Sweden) was used, and magnetic resonance imaging (MRI) was conducted for localization and surgery planning. The patient underwent awake bilateral STN DBS (the electrodes were Model 3389, the extensions were Model 37086 and the

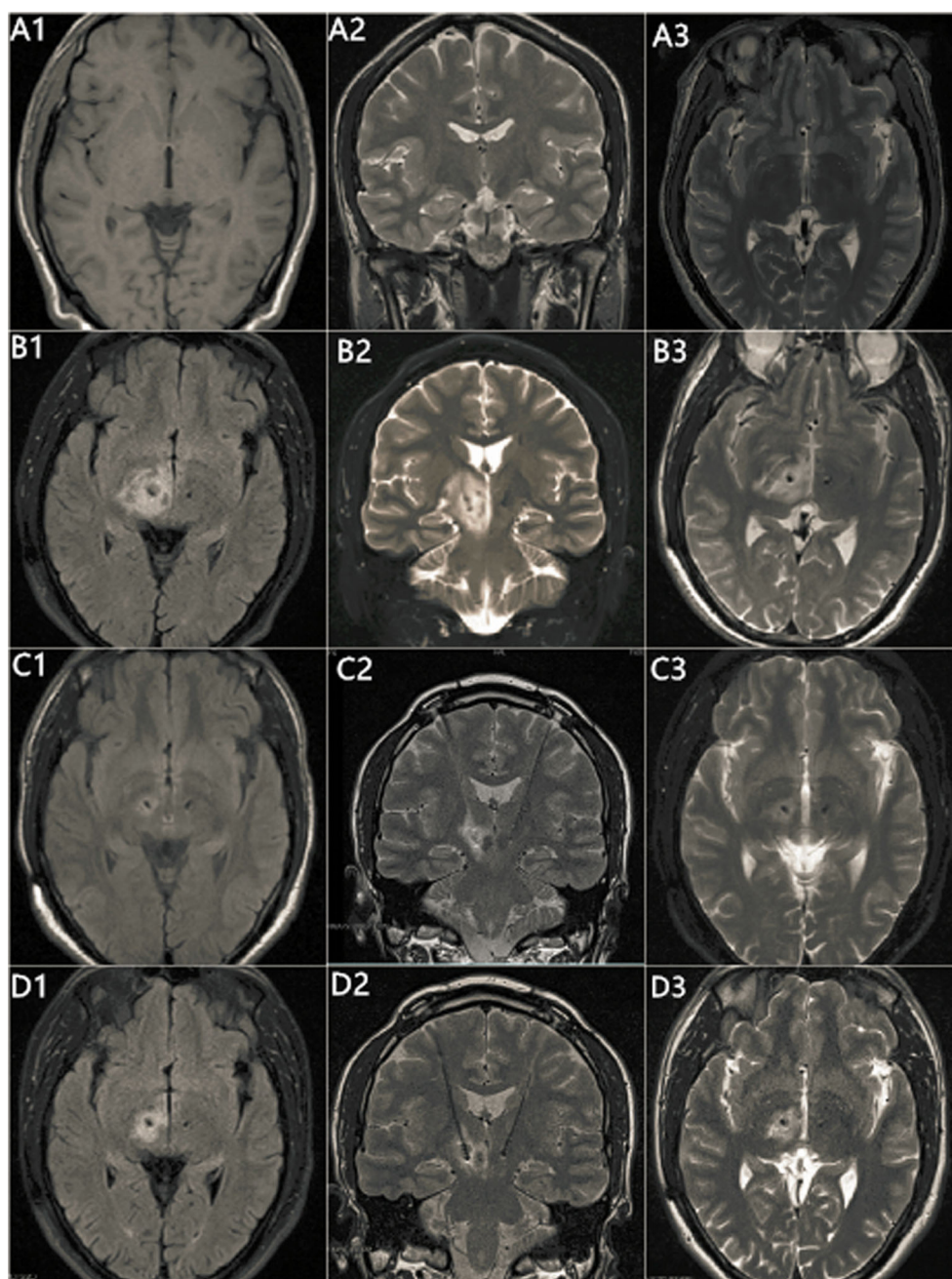
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**Fig. 1** MRI imaging was acquired from the same machine and using the same scanning parameters. *A1-A3* are the pre-operative MRI T1- and T2-weighted images. No signs of infraction or preexisting cerebral vascular disease were observed. *B1-B3* are the post-operative images 5 months later. *B1* is the FLAIR sequence. A large area of cerebral ischemia is observed on the right thalamus surrounding the implanted electrode. The area of edema is from the thalamus to the upper deutocerebrum and is approximately  $2.5 \times 2.5 \times 3$  cm. *C1-C3* are the images 9 days after treatment. *C1* is the FLAIR sequence. The area of edema is constricted. *D1-D3* are the second occurrence of ischemia. *D1* is the FLAIR sequence. The area of the edema is approximately  $1.0 \times 1.0 \times 2.0$  cm and is smaller than that of the first time



simulator was Model RC, Medtronic, Inc., Minneapolis, MN, USA) without micro-electrode recording. Temporary electrical stimulation during the operation indicated accurate localization. The surgical procedure was smooth. The immediate post-operative computed tomography (CT) did not show any signs of hemorrhage or ischemia. The implanted equipment was powered on 2 weeks after the surgery. Due to the symptoms predominantly on the left side, the left electrode was unused after the surgery. The stimulation parameters were set at C+, 1-, 3.5 V, 125 Hz, and 90  $\mu$ S for the right STN. The patient was discharged without any discomfort, and the UPDRS Part III cores were 20.

Six months later, however, the patient was admitted to our hospital again. He was sane and had normal speech and muscle strength. The patient's lower left limb involuntarily twitched for 15 days with hypermyotonia. The twitch was similar to typical static tremors. The patient increased the drug dose without any effect. After admission, the stimulation parameters were adjusted, but there was no symptom improvement. The MRI scanning using a spin-echo sequence showed a large area of cerebral ischemia on the right thalamus surrounding the implanted electrode (Fig. 1 B1-B3). The implanted equipment was powered off and the patient was treated by intravenous infusion of 250 ml of 20 % mannitol three

times a day for 7 days, 10 mg of dexamethasone twice a day for 5 days (in 500 ml of 10 % glucose), 60 mg of ganglioside twice a day for 9 days (in 250 ml of physiological saline), and 30 mg of fasudil twice a day for 7 days (in 100 ml of physiological saline). He was discharged 9 days later when the involuntary twitch symptom disappeared. The implanted equipment was powered on again 2 weeks after the patient was discharged, and the stimulation parameters were set at C+, 1-, 2.7 V, 120 Hz, and 90  $\mu$ S for the right STN.

Unfortunately, the patient was admitted to our hospital for a third time for the same reason 3 months later. The MRI showed the same location of the cerebral ischemia, but the cerebral ischemia area was smaller than it was the first time (Fig. 1 D1-D3). There was no significant difference between the two treatment times. The patient was discharged 7 days later without any overt symptoms. Currently, the patient's condition is maintained at the pre-operative level. The implanted equipment is still not powered on for the sake of safety. Throughout the whole course of treatment, the left electrode was unused, except for the temporary electrical stimulation during the operation. The patient had never been at any place where a strong magnetic field would cause a disturbance to the implanted equipment. All MRI imaging was acquired from the same machine using the same scanning parameters.

## Discussion

DBS is a relatively safe and effective surgical method for advanced-stage PD. The adverse events include infection, seizures, and device failure; in the literature, the most attention has been given to hemorrhages because of their serious consequences [10]. A few cases of cerebral ischemia related to DBS have been reported. To further investigate this rare complication, we reviewed reports in the literature. There were seven cases of cerebral ischemia associated with DBS. The electrode targets were the STN in four cases and Gpi in three cases. The onset time frames varied from intraoperation to 3 days after the operation. Most cases recovered well. The details of the cases are reported in Table 1. In these reports, many hypotheses were provided to explain the relationship between DBS and cerebral ischemia. However, not much is known about the exact frequency, risk factors, mechanism, or prognosis.

Lim et al. observed that there is a higher incidence of infarction in patients with preexisting vascular disease compared to that in patients with only risk factors for vascular disease [6]. Novak et al. theorized that preexisting small vessel disease or ischemia areas may be the risk factor for intraoperative infarction [8]. However, these hypotheses cannot explain our case appropriately. The patient was relatively young in our report, and the pre- and post-operation

**Table 1** Summary of cerebral ischemia cases after DBS in the literature

Reference	Age (years)/sex	Diagnosis	DBS target	Onset time	Symptom and location of ischemia	Suggested reason	Improvement time and prognosis
Nonako et al. [8], 2006	53/m	PD	STN	Intraoperation	Slurred speech, mild weakness; thalamus	Vessel constriction	6 weeks Persisted mild dysarthria
Kang et al. [4], 2011	67/m	PD	STN	3 days post-operation	Confusion, short-term memory loss, epileptiform attack; periventricular and subcortical white matter; thalamus	Small arteries compressed by edema area	9 months Short-term memory problems
Morishita et al. [7], 2013	34/m	CD	GPI	Intraoperation	Slurred speech, motor and facial weakness; internal capsule	Vasospasm deduced by microstimulation	3 months Almost full recovery
	67/f	PD	STN	1 day post-operation	Word-finding difficulties, confusion; superficial aspect of the DBS lead	Surface veins injury	Several days to weeks Full recovery
	50/m	PD	STN	1 day post-operation	Somnolent and confused; superficial aspect of the DBS lead		3 days Full recovery
	60/m	PD	GPI	1 day post-operation	Weakness, lethargy, confusion; superficial aspect of the DBS lead		Several days Full recovery
	58/m	PD	GPI	1 day post-operation	Word-finding difficulty, confusion; superficial aspect of the DBS lead		Four months Full recovery

DBS deep brain stimulation; PD Parkinson's disease; CD cervical dystonia; STN subthalamic nucleus; GPI internal globus pallidus

blood pressures were normal. No risk factors for infraction or preexisting cerebral vascular disease were present. The preoperative MRI was normal, and small vessel disease or ischemia areas were excluded.

Dietrich et al. hypothesized that unexplained microelectrode recording (MER) silence indicates ischemia during the surgery. The authors believe that if cellular activity suddenly disappears during MER mapping, ischemia must be suspected, even without the immediate appearance of clinical symptoms [2]. The MER was not applied in our case because of the increased risk of hemorrhage and the sometimes-unreliable MER silence [2]. Furthermore, the ischemia onset times were 6 and 9 months after the surgery in our report.

MRI scanning causing electrode heating and cerebral ischemia has also been reported in recent years [3, 9]. In our report, the MRI magnetic field was 1.5 T using a spin-echo sequence. The scanning parameter was set according to the manufacturer's instructions under FDA (Food and Drug Administration) regulation. Moreover, the patient had never been at any place that had or could cause a strong magnetic field that would cause a disturbance of the implanted equipment. A magnetic field causing electrode heating can be excluded.

Wan et al. described a case of cervical dystonia treated by globus pallidus internus (GPi) DBS that led to cerebral ischemia. They concluded that electrical stimulation may lead to small vessel vasospasm and result in ischemia [13]. This could be the only optional reason for our case. The stimulation parameters are suitable for most patients, but individual differences led to vessel vasospasm in this patient. The course of the vessel vasospasm caused by electrical stimulation may be chronic and could explain the reason for the delay of the cerebral ischemia after the stimulation and its recurrence. However, this hypothesis is without any experimental or pathological evidence. Furthermore, it cannot explain why the ischemia appeared unilaterally and why the ischemic area during the second time is smaller than the first time.

This patient is still under follow-up and is maintained by medicine to control the PD symptoms. The final outcome will be reported later.

## Conclusions

DBS is a relatively safe and effective surgical method for advanced-stage PD. The recurrence rate of cerebral ischemia associated with DBS is very low, but this complication deserves attention. Chronic vessel vasospasm caused by electrical stimulation could be the cause of the recurrent cerebral ischemia related to DBS, and the exact mechanism and prognosis require more exploration.

## Patient Consent

The patient has consented to the submission of this case report to the journal.

## Compliance with Ethical Standards

**Source(s) of support** None.

**Presentation at a meeting** None.

**Conflict of interest** None.

## References

- Bhatia S, Oh M, Whiting T, Quigley M, Whiting D (2008) Surgical complications of deep brain stimulation: a longitudinal single surgeon, single institution study. *Stereotact Funct Neurosurg* 86:367–372
- Dietrich HH, Dacey RG Jr (2000) Molecular keys to the problems of cerebral vasospasm. *Neurosurgery* 46:517–530
- Gupte AA, Shrivastava D, Spaniol MA, Abosch A (2011) MRI-related heating near deep brain stimulation electrodes: more data are needed. *Stereotact Funct Neurosurg* 89(3):131–40
- Kang DW, Kim HY, Chang JW (2011) Cerebral ischemia related to globus pallidus internus stimulation for cervical dystonia. *Stereotact Funct Neurosurg* 89(4):201–204
- Laitinen LV, Bergenheim AT, Hariz MI (1992) Leksell's posteroventral pallidotomy in the treatment of Parkinson's disease. *J Neurosurg* 76:53–61
- Lim JY, De Salles AA, Bronstein J, Masterman DL, Saver JL (1997) Delayed internal capsule infarctions following radiofrequency pallidotomy: report of three cases. *J Neurosurg* 87:955–960
- Morishita T, Okun MS, Burdick A, Jacobson CE, Foote KD (2013) Cerebral venous infarction: a potentially avoidable complication of deep brain stimulation surgery. *Neuromodulation* 16:407–413
- Novak KE, Nenonene EK, Bernstein LP, Vergenz S, Medalle G, Prager JM, Eller TW, Cozzens JW, Rezak M (2006) Two cases of ischemia associated with subthalamic nucleus stimulator implantation for advanced Parkinson's disease. *Mov Disord* 21:1477–1483
- Rezaei AR, Baker KB, Tkach JA, Phillips M, Hrdlicka G, Sharan AD et al (2005) Is magnetic resonance imaging safe for patients with neurostimulation systems used for deep brain stimulation? *Neurosurgery* 57(5):1056–62
- Sansur CA, Frysinger RC, Pouratian N, Fu KM, Bittl M, Oskouian RJ, Laws ER, Elias WJ (2007) Incidence of symptomatic hemorrhage after stereotactic electrode placement. *J Neurosurg* 107:998–1003
- Tong F, Ramirez-Zamora A, Gee L, Pilitsis J (2014) Unusual complications of deep brain stimulation. *Neurosurg Rev* 38(2):1–8
- Umehara A, Jaggi JL, Hurtig HI, Siderowf AD, Colcher A, Stern MB, Baltuch DH (2003) Deep brain stimulation for movement disorders: morbidity and mortality in 109 patients. *J Neurosurg* 98:779–784
- Wan KD, Hae Yu K, Woo CJ (2011) Cerebral ischemia related to globus pallidus internus stimulation for cervical dystonia. *Stereotact Funct Neurosurg* 89(4):201–204