

## Case report

**Swift improvement of prolonged motor deficit: cumulative effect of phototherapy in a survivor from hemorrhagic stroke**Tony Dong-Lun Hsieh<sup>1\*</sup>, Peiyuan Fuyuan Hsieh<sup>2</sup>, Hsin-Chen He<sup>3</sup>, Yuan-Yang Cheng<sup>4,5,6</sup>, Shin-Tsu Chang<sup>4,7,8\*</sup><sup>1</sup>Department of Medical Education, Taichung Veterans General Hospital, Taichung, Taiwan<sup>2</sup>Division of Epilepsy, Department of Neurology, Taichung Veterans General Hospital, Taichung, Taiwan<sup>3</sup>Department of Physical Medicine and Rehabilitation, Taichung Veterans General Hospital, Taichung, Taiwan<sup>4</sup>Department of Physical Medicine and Rehabilitation, Taichung Veterans General Hospital, Taichung, Taiwan<sup>5</sup>Center for Geriatrics and Gerontology, Taichung Veterans General Hospital, Taichung, Taiwan<sup>6</sup>School of Medicine Yangming Campus (Taipei), National Yang Ming Chiao Tung University, Hsinchu, Taiwan<sup>7</sup>Department of Physical Medicine and Rehabilitation, Kaohsiung Veterans General Hospital, Kaohsiung, Taiwan<sup>8</sup>Department of Physical Medicine and Rehabilitation, Tri-Service General Hospital, School of Medicine, National Defense Medical Center Taipei, Taiwan**Corresponding author**

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**Abstract**

Improved post-stroke crossed cerebellar diaschisis (CCD) and motor function was reported in the setting of intravascular laser irradiation of blood (ILIB) in subacute phase after ischemic stroke. However, there is no article before mentioning the effects of ILIB on post-stroke CCD and motor function in chronic post-stroke phase. In this article we describe the effect on a 52-year-old retired martial artist, who was diagnosed with hemorrhagic stroke accompanied by crossed cerebellar diaschisis. This patient had undergone physical and occupational therapy for 3 years before receiving ILIB therapy in our hospital. We evaluated the changes in brain perfusion scan, and the extent of recovery from hemiplegia with Brunnstrom Approach. Before ILIB, CCD was detected affecting left cerebellar hemisphere, and the patient's upper left extremity was in stage 3 of stroke recovery. After ILIB, the perfusion of the left cerebellar hemisphere has greatly increased, and the left upper extremity has improved to be in stage 4. In summary, therapeutic ILIB preceded a partial restoration of the cerebellar perfusion of affected by CCD, and a partial yet rapid recovery in this presented case, even performed years after stroke.

**Keywords:** case report, chronic phase, crossed cerebellar diaschisis, intravascular laser irradiation therapy, stroke**Introduction**

Crossed cerebellar diaschisis (CCD) refers to a depression in metabolism and blood flow in a cerebellar hemisphere induced by a contralateral supratentorial cerebrum lesion. CCD is detected in patients with stroke [1], stated to be correlated with crossed cerebellar atrophy [2], and detection of CCD after stroke may indicate poor prognosis [3]. Therefore, to diminish or to correct CCD might be beneficial to the patient.

Intravascular laser irradiation of blood (ILIB) can mitigate oxidative damage, modify mitochondria dysfunction, and increase the activity of blood cells [4]. ILIB is used in stroke, metabolic diseases, cardiovascular diseases in Taiwan. One case report endorsed that ILIB may improve the

patient's physical performance and help eliminate CCD [5]; the improvement, however, was established in subacute post-stroke phase. Additionally, CCD is observed to be reversible in weeks without special intervention after occlusion of middle cerebral artery in an animal research [6].

Before our case, no article was published regarding the effects of the ILIB in the chronic phase. We herein present a case diagnosed with hemorrhagic stroke, accompanied by CCD, who received ILIB therapy after 3 years of post-stroke rehabilitation. Postprocedural imaging study and Brunnstrom stages of stroke recovery revealed that therapeutic ILIB sessions performed in chronic post-stroke phase was effective in improvement in both CCD and stroke recovery.

## Case report

A 52-year-old retired martial artist was healthy before 2016. He was diagnosed with intraparenchymal hemorrhage (IPH) and subarachnoid hemorrhage (SAH) secondary to ruptured right middle cerebral artery (MCA) aneurysm in 2016/08 and had undergone craniotomy followed by post-stroke rehabilitation for 3 years.

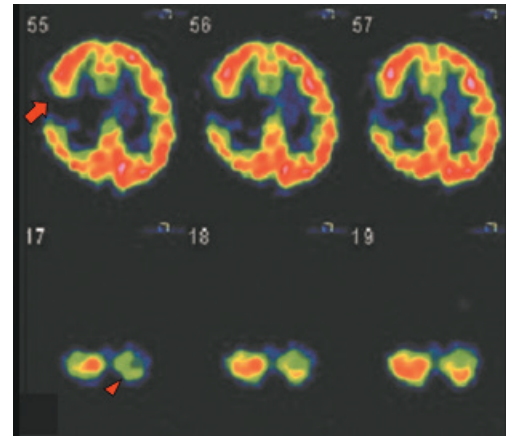
This patient started post-stroke rehabilitation in subacute phase, with intact consciousness, partial dependency in ADLs, and Brunnstrom stage 1 of recovery from stroke in the left upper extremity, stage 1 in left hand, and stage 3 in the left lower extremity recorded just before rehabilitation. After 6 months of subacute rehabilitation, he became totally independent in ADLs, and the stages improved to be 3 in left upper extremity, 3 in left hand, and 3 in the lower left extremity. However, little improvement had been noticed since he moved into the chronic phase of stroke.

This patient thus sought for further recovery from stroke at our hospital. We did a computer tomography (CT) for him, and a hypodense ischemic area was located in the right precentral gyrus, Fig. 1. We also did a single-photon emission computed tomography (SPECT) for him and found metabolic depression in right MCA territory and in left cerebellar hemisphere, which established the detection of CCD, Fig. 2. After initial image studies, we recruited ILIB as a therapy.



**Figure 1.** Brain CT of our case. There is a hypodense ischemic area located

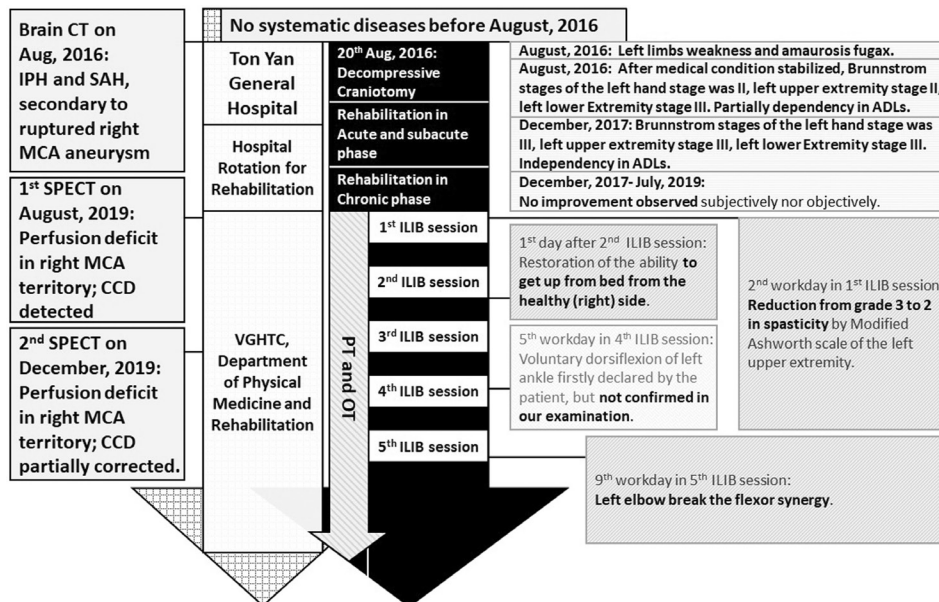
in the right precentral gyrus. A cavus septum pellicidum is found. CT = computer tomography.



**Figure 2.** Regional perfusion SPECT before and after therapeutic ILIB session. The perfusion of white to red area is higher, green to blue lower. (A) The first SPECT (before ILIB) shows perfusion deficit at the right lateral precentral gyrus (red arrow), and decreased perfusion on the left cerebellar hemisphere (red arrow head), establishing the detection of CCD. (B) The second SPECT (after the third ILIB session) still demonstrates same deficit in the right cerebrum (white arrow), but more blood flow in the left cerebellar hemisphere (white arrow head). CCD = crossed cerebellar diaschisis, ILIB = intravascular laser irradiation of blood, SPECT = single-photon emission computed tomography.

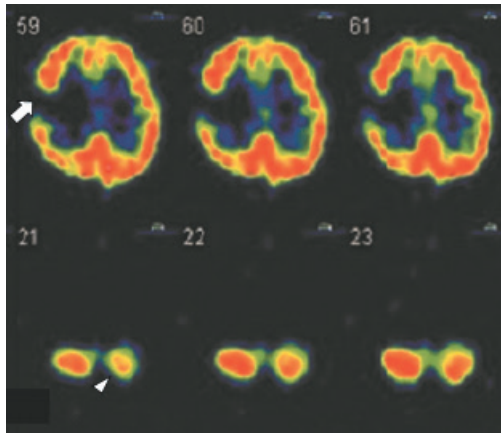
The parameter we adopted for ILIB in our case was similar to that in our previous study.<sup>5</sup> The power output of laser is up titrated on the basis of the patient's adaptability.

We evaluated the patient's recovery from stroke with Brunnstrom Approach before and after every ILIB session and did a series of SPECT additionally after 3 ILIB sessions to compare cerebral and cerebellar perfusion with that before ILIB. The patient's medical history was chronologically listed in the timeline, Fig. 3.



**Figure 3.** Timeline. The chronological timeline contains the interventions, image reports, and clinical evaluation of the patient we presented. CCD = crossed cerebellar diaschisis, CT = computer tomography, IPH = intraparenchymal hemorrhage, MCA = middle cerebral artery, OT = occupational therapy, PT = physical therapy, SAH = subarachnoid hemorrhage, VGHTC = Taichung Veterans General Hospital.

Three months after the first day ILIB performed, the follow-up SPECT, Fig. 4, demonstrated that the blood perfusion in the left cerebellar hemisphere showed greater resemblance to the right cerebellar hemisphere than that in the first SPECT image series. Aside from improved CCD, this patient made progress in stages of recovery after ILIB: his left upper extremity improved to stage 4. In summary, the application of ILIB on this patient may attribute to the improvement on CCD and stroke recovery.



**Figure 4.** Regional perfusion SPECT after therapeutic ILIB session. The perfusion of white to red area is higher, green to blue lower. The SPECT (after the third ILIB session) still demonstrates same deficit in the right cerebrum (white arrow), but more blood flow in the left cerebellar hemisphere (white arrowhead). CCD = crossed cerebellar diaschisis, ILIB = intravascular laser irradiation of blood, SPECT = single-photon emission computed tomography.

## Discussion

This is the first case report describing the application and the possible benefit of ILIB therapy in a patient with CCD in chronic post-stroke phase. In addition, this is also the first article that denotes the possible cumulative effect of ILIB in treatment of motor function.

There are two notable findings in the study of this patient. Firstly, the perfusion in the affected cerebellar hemisphere by the CCD has increased. This remarkable increase is region-limited, suggesting that ILIB therapy may have a tendency toward the correction of CCD. Secondly, this patient made clinical progress, according to his Brunnstrom stage. Generally speaking, the effectiveness of traditional rehabilitation diminishes by time. Thus, after three years of rehabilitation without subjective improvement, the relatively rapid improvement in motor function during our treatment suggests that the patient benefited from ILIB therapy.

A previous article stated that a significant number of patients with CCD would develop crossed cerebellar atrophy that can be detected with MRI [2]. Another article stated that CCD in subacute post-stroke phase indicates poor outcome [7]. CCD can be caused by anterograde degeneration of fronto-ponto-cerebellar tract or retrograde degeneration of dentate-rubro-thalamo-cortical tract [8], and postural asymmetry can be demonstrated in the left side [9]. Based on information above, we hypothesized that the increase in the metabolic activity of cerebellum might balance the hypometabolism caused by CCD and facilitates the rehabilitation in restoration of the patient's motor function.

ILIB is a kind of low-level laser therapy (LLLT) and may share some common features of LLLT. Studies have shown that LLLT is effective in restoring neurologic impairment. Launching infrared laser therapy in early acute phase is associated with better neurologic outcome after rehabilitation [10]. Regeneration of neuronal cells and migrating cells are detect-

ed in an experiment conducted with transcranial laser therapy [11]. One well-studied and commonly accepted mechanism of LLLT is that photon stimulates photoacceptors, facilitates adenosine triphosphate production, and enhances the respiratory chain in mitochondria [12]. Based on this mechanism, ILIB might promote the metabolism in the affected cerebellar hemisphere and synergy with physical and occupational therapy in patients found with CCD, even performed in chronic post-stroke phase. ILIB has been used in our hospital and it showed some improvement in selected cases with cognitive dysfunction [13-15] motor function [16], and CCD after acute stroke [5].

With respect to the pace of clinical improvement in motor deficit, all the motor functional improvements are discovered during or right after an ILIB session, and no motor functional regression after the therapy is observed. We speculated that the effect of ILIB therapy on motor function is cumulative, and that the after-benefiting duration of each ILIB session is short. The effect of ILIB on the affected cerebellar perfusion by CCD might also observe this feature.

There are some limitations of this case report. The first is the lack of a discrete comparison case, which is difficult to find for a single case. Secondly, this amateur martial artist developed a young stroke, has high ability of movement imagination, and participates sanguinely in rehabilitation programs. These are factors related to good outcome in stroke. However, the three-year cessation of clinical improvement makes these factors less likely the keystones of a sudden clinical improvement. Thirdly, we weakly confirm the hypothesis of cumulative effect of ILIB on the improvement of CCD and motor function, due to lack of discrete study and comparison, despite all our evaluations of this patient is consistent with this hypothesis. The findings and hypothesis in this case report need further examination.

In conclusion, we observed sudden improvements in motor function and in perfusion after ILIB therapy in a patient with CCD, and that improvements are noted either in or right after a session of ILIB therapy; thus, we think cumulative effect might be an explanation of these observed findings. More studies are needed on the therapeutic effect of ILIB in stroke patients with CCD.

## Abbreviations

- ADLs = activities of daily living,
- CCD = crossed cerebellar diaschisis,
- CT = computer tomography,
- HeNe = helium-neon,
- ILIB = intravascular laser irradiation of blood,
- IPH = intraparenchymal hemorrhage,
- MCA = middle cerebral artery,
- LLLT = low-level laser therapy,
- SAH = subarachnoid hemorrhage,
- SPECT = single-photon emission computed tomography.

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