Spinal Cord Stimulation as a Perfect Walking Aid

Spinal Cord Stimulation Therapy at the Department of Neurosurgery, Hualien Tzu Chi Hospital

Spinal cord injuries result in paraplegia (paralysis of the lower limbs), while accidental brain injuries cause excessive muscle tension and insufficient muscle strength in the arms and legs, which in turn leads to loss or impairment of mobility and an unsteady gait. Spinal Cord Stimulation (SCS) represents an effective treatment for such patients. SCS requires the implantation of a neurostimulator at a suitable location of the spine. This stimulator delivers mild electronic stimulation to muscle groups controlled by nerves along the spinal column through electrodes.

SCS can also be applied to patients suffering from brain injury, a strike-induced coma, or extreme pain in the lower extremities caused by nerve damage. The goal of utilizing medical technologies and innovative therapies combined with a synthesis of Western and Chinese medicine and follow-up rehabilitation programs is to ensure ongoing patient progress, help patients wake from a coma and regain their mobility and balance, and ultimately improve their quality of life.

By Hana You, Chen Ping-Hung

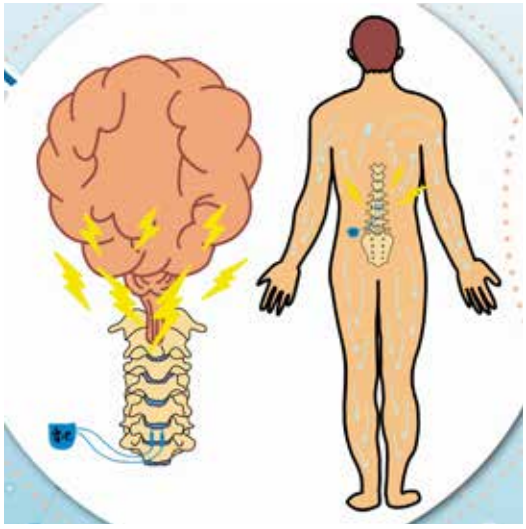
Mr. Cai often has a numb feeling in his legs and has had an unsteady gait for many years. Due to a worsening of symptoms, he has difficulty successfully crossing the road during the green light period. After seeking medical attention from numerous renowned doctors on the west coast with little effect, he proceeded to Hualien Tzu Chi Hospital for medical treatment by recommendation of a friend.

Implantation of a Chip into the Thoracic Spine to Electrically Stimulate Nerves and Thereby Control Muscle Groups

Mr. Cai, a middle-aged man who lives in Nantou County, states that he started to experience an odd sensation of weakness in his arms in 2013. Cervical decompression surgery brought no improvement and he continued to experience the same symptoms. Several years later, this sensation of numbness spread to his legs, resulting in an unsteady gait. Endogenous Stem Cell Therapy (G-CSF) administered by Lin Shinn-Zong, a neurosurgery expert and Superintendent of Hualien Tzu Chi Hospital, in 2020 finally restored his arm and leg functions.

In July 2021, Mr. Cai reappeared in the outpatient department of Hualien Tzu Chi Hospital to express the wish to continue his Endogenous Stem Cell Therapy to Superintendent Lin since the numb sensation had reemerged in his arms and legs one month earlier. He pointed out that in the past he only had to use a walking cane to prevent falls in the winter months. He had no problems walking in the summer albeit at a slightly slower pace. He was therefore taken aback when the numbness symptoms appeared in the summer months. This was a vexing issue for him since there seemed to be no suitable therapy. He therefore begged Superintendent Lin to devise a therapy for him.

After assessing the patient's condition, Superintendent Lin determined that the cause of his poor motor coordination was excessive muscle tension in both legs resulting in the patient's inability to



A neurostimulator has been implanted in the thoracic and lumbar spine of the patient to control relevant muscle groups and restore muscle strength through delivery of mild electronic stimulation to nerves along the spinal column

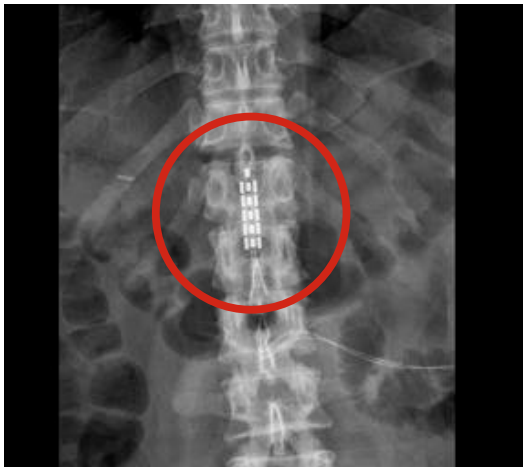
take normal steps when walking. He therefore recommended advanced Spinal Cord Stimulator implantation therapy and referred the patient to Dr. Tsai Sheng-Tzung, Director of the Department of Neurosurgery, for further assessment.

Upon evaluation by a medical team headed by Director Tsai, it was concluded that the muscle tension issue and resulting symptoms could be relieved and alleviated through implantation of a Spinal Cord Stimulator. Mr. Cai then decided to undergo treatment.

After his surgery, the patient received rehabilitation therapy based on a fusion of Chinese and Western medicine concepts. In addition to acupuncture and drug administration by a Chinese medicine doctor, Dr. Cheng Hung-Yu, Director of Rehabilitation, and his team of physical therapists designed a series of rehabilitation exercises tailored to the patient's symptoms and SCS therapy. It was evident that once the power supply was turned on and the chip started to send electric signals to the nerves, Mr. Cai regained the strength to take normal steps. His motor coordination when making turns also improved significantly.

In the course of his hospitalized therapy, the patient noticed ongoing progress in his legs after each rehabilitation session. His muscle tension had decreased significantly and the motor coordination in his legs had improved noticeably. His gait was steadier, and his walking pace had increased. Prior to his discharge, he told the medical team beamingly that he still had a lot of work to do in his home. In the past years, he could not accomplish anything since

Syringomyelia symptoms appeared after severe damage to the 3rd, 4th, and 5th vertebra of the cervical spine



The X-ray image taken after implantation surgery indicates the location of the chip between the 12th vertebra of the thoracic spine and the 1st vertebra of the lumbar spine.

he had no strength in his arms. He felt deeply disheartened and frustrated when he realized that he couldn't walk normally after his symptoms had finally taken a turn for the better last year. Now he could at last return to his hometown to make some money.

From Pain Control to Improved Mobility – SCS Therapy-based Interdepartmental Care

As a matter of fact, Spinal Cord Stimulation (SCS) technology dates back to 1975. Despite the successful development of elective surgery procedures, application of this technology was confined to pain treatment. Results of research on improved mobility in patients suffering from paralysis due to spinal cord damage conducted by medical professionals in the US and Switzerland were only published within the last two years. The Department of Neurosurgery at Hualien Tzu Chi Hospital adopted this therapeutic method in June 2019 to provide relief to patients with spinal cord injuries. SCS therapy requires the implantation of a neurostimulator at a location between the of 11th vertebra of

Dr. Tsai Sheng-Tzung, Director of the Department of Neurosurgery, applies Neurostimulator Implantation Surgery in patients with spinal cord injuries to restore their limb strength. The image shows Director Tsai (left) performing minimally invasive surgery in the operating room.

During a follow-up visit of a patient with an implanted Spinal Cord Stimulator, medical engineering research fellow Chen You-Qin (left) asks the patient Mr. Qiu to walk to test the effects of electrostimulation and make adjustments accordingly.

the thoracic spine and the 1st vertebra of the lumbar spine. This stimulator delivers mild electronic stimulation to muscle groups controlled by nerves along the spinal column through electrodes.

Director Tsai Sheng-Tzung points out that interdisciplinary SCS medical care teams must encompass members of the Departments of Neurosurgery, Rehabilitation, Pain Management, Chinese Medicine, and Nursing to ensure optimized treatment and care quality for patients. The treatment process involves surgery performed by neurosurgeons and anaesthetists, care provided by NPs and RNs in wards, and post-surgery personalized rehabilitation training delivered in a precise manner. Chinese medicine doctors administer acupuncture and drugs to stimulate and activate bodily functions, while physiatrists and physical therapist teams design rehabilitation exercises. Furthermore, information engineering experts are responsible for setting and adjustment of stimulator parameters and case managers provide professional care.

Electrostimulation Paired with Muscle Strength Training – Recovery of Strength Required for Walking and Driving

A horrific surfing accident due to a rogue wave left Mr. Qiu, a Taipei native, a quadriplegic as a result of severe damage to the 5th vertebra of his cervical spine. After undergoing decompression surgery

and ongoing rehabilitation therapy, he was finally able to walk with the aid of a walking cane. However, due to lack of strength in his left leg, he felt exhausted after walking for around 20 minutes on the same day and was forced to sit or lie down to take a rest.

Mr. Qiu, who is a 50-year-old senior executive, hasn't given up hope for a better recovery. When he visited relatives in Hualien in May 2020, he learned of a rehabilitation therapy at Hualien Tzu Chi Hospital which includes Endogenous Stem Cell Therapy (G-CSF), acupuncture, and rehabilitation robots based on a fusion of Chinese and Western medicine concepts. By relying on experience accumulated over many years, the hospital brings new hope to patients with brain and spinal cord injuries who are desperate to get up and walk again. He therefore made an appointment with Superintendent Lin in the outpatient department of Hualien Tzu Chi Hospital to seek medical treatment.

During this outpatient visit, Mr. Qiu revealed that he had suffered two successive fall accidents while walking with a cane at home prior to this appointment. He had returned to his post, but his legs felt swollen whenever he had to attend longer meetings due to the fact that he was unable to sit for extended periods. This tended to cause him great discomfort. He was therefore longing for relief in these two areas with ensuing

Therapies based on a fusion of Chinese and Western medicine concepts represent a unique characteristic of the Department of Neurosurgery at Hualien Tzu Chi Hospital. The goal is to utilize all available methods to restore patient health. The image shows Dr. Wang Chien-Hao of the Department of Chinese Medicine performing acupuncture for a patient after Spinal Cord Stimulation Surgery.

improvement of his life quality and work performance.

After undergoing Endogenous Stem Cell Therapy, he expressed the wish to receive more symptom-alleviating treatment. Consequently, Director Tsai Sheng-Tzung recommended the newly adopted Spinal Cord Stimulation Therapy (SCS). During an online search, he found medical research findings published in America on the application of this technology to alleviate neuropathic pain. Relevant studies also prove positive effects of this therapy in patients with spinal damage if it is combined with a rehabilitation program encompassing high-intensity arm and leg muscle strength, balance, and endurance training.

20 months have passed since Mr. Qiu underwent neurostimulator implantation surgery. He has made significant progress after completing his electrostimulation rehabilitation program. He is even able to work out in a gym and his leg strength has increased by 50%. During a follow-up visit three months ago, Mr. Qiu pointed out that he was now able to stand for 30 minutes without problems and his leg lift strength had increased by around 30%, which represents a miraculous improvement in view of the fact that he was only able to stand for five minutes with great difficulty prior to undergoing therapy. He further stated that he felt more confident to move around and drive his car to the company parking lot without assistance. In the past, he had no faith in his ability to walk. Now, he has no problems crossing a road during the green light period and climbing the stairs to his office.

Looking back on the period right after his return to work following his accident, Mr. Qiu recalled that his wife had to drive him back and forth to work, which is a one-hour commute each way and a total of four hours on the freeway each day. They had a very low life quality. “Now, I can commute to work by car without assistance and my wife can resume her life as a noble lady” he added with a chuckle.

Driving a car represents a major breakthrough for Mr. Qiu since he no longer feels like a patient. His wife is also no longer worried when he drives from Taipei to Hualien for his follow-up appointments. Although he has by no means regained full mobility, he can at least move freely. What’s most important is that he can work normally and is no longer afflicted with swollen legs after sitting for extended periods. In addition, he can receive clients as before his accident and his life quality and work performance are almost back to normal. Walking does not cause him any problems anymore. The neurostimulator helps him maintain his balance when standing and compensates for the impaired neural control of his left leg.

Persistence of Hope for Recovery - Muscle Strength Stabilization Through Electrostimulation

This innovative therapeutic method was initially adopted for the treatment of patients who have been afflicted with spinal cord injuries for more than a year. It was to be recommended after no significant improvement had been achieved with other available methods. Director Tsai Sheng-Tzung recalls a patient of the same age as Mr. Qiu who had an acute spinal cord injury and was transferred from a hospital in Taitung to Hualien Tzu Chi Hospital since his relatives wanted the patient to gain access to more treatment options.

This patient had severely damaged the 3rd to 6th vertebra of his cervical spine in a bicycle accident in April of last year. He expressed the wish to be transferred to Hualian Tzu Chi Hospital, but due to his unstable condition he had to undergo artificial disc replacement and decompression and fusion surgery in a local hospital. Due to the tense situation caused by a community outbreak of COVID-19, he had to wait until early March for his transfer. He was personally admitted by Director Tsai Sheng-Tzung.

Director Tsai points out that the patient was fully conscious when he arrived at the hospital, but he was unable to verbally express himself due to a tracheostomy. He had to be fed with a gastrostomy tube and was unable to move his four limbs. Consequently, he was fully reliant on caregivers. Despite the fact that healthcare professionals were initially pessimistic about his chances for improvement, his wife was not ready to give up. She contacted Superintendent Lin through a friend in Hualien. Since the medical team had successfully applied the Endogenous Stem Cell Therapy paired with a rehabilitation program based on a fusion of Chinese and Western medicine concepts in the treatment of patients with spinal cord damage in the past, it decided to make a determined effort to improve the patient's condition through this therapy.

After arrival of the patient, a spinal X-ray and MRI were arranged immediately. Endogenous Stem Cell Therapy combined with Chinese medicine concepts and physical rehabilitation therapy was initiated on the following day. Starting in July, the patient was able to slightly move his limbs although he still had tracheostomy, gastrostomy, and urinary catheters in place. Physical therapist Dai Chen-Yun states that the patient had undergone robotic arm rehabilitation training at his own expense in addition to the stimulation of extremity joint movement and prevention of ankylosis through a rehab drawer.

Dr. Tsai Sheng-Tzung, Director of the Department of Neurosurgery, Hualien Tzu Chi Hospital is deeply committed to bringing new hope to comatose and paralyzed patient by utilizing innovative therapies and medical technologies.

By the end of August, a chip had been successfully in his thoracic and lumbar spine. Director Tsai explains that leg lifting training initiated in September relied on a series of rehabilitation training exercises designed based on Spinal Cord Stimulation concepts. In spite of the positive effect of SCS, the team had to administer drugs and tilt the patient's bed to treat his postural hypertension during the initial one-month stage which is characterized by multiple changes in acute patients.

Prior to his discharge in November, it was evident that the patient was fully determined to improve his condition through rehabilitation training encompassing sitting, standing, and stepping training. Physical therapist Dai recalls that initially the patient had poor trunk control, a hunched sitting posture, and couldn't sit for extended periods. During standing and stepping training, he was unable to control his leg tension. Postdoctoral research fellow Chen You-Qin, a member of the medical team, points

Hualien Tzu Chi Hospital has achieved excellent results by applying therapies based on a fusion of Chinese and Western medicine concepts in the last two or three years. From left to right: Dr. Huang Chih-Kai of the Department of Chinese Medicine, Vice Superintendent Ho Tsung-Jung, Dr. Tsai Sheng-Tzung, Director of the Department of Neurosurgery, Dr. Chen Jhong-Kuei of the Department of Chinese Medicine.

out that a scissor-like posture would emerge during stepping training. The patient noticed a significant improvement in his muscle tension control as a result of electrostimulation. Chen further recalls that his right leg would shake uncontrollably when she first met him. The frequency of this leg shaking dropped significantly after application of SCS therapy.

This patient returned to the hospital for a follow-up visit in January 2022. During his one-month hospitalization, rehabilitation results were evaluated, and he underwent advanced training. Director Tsai states that he was able to stand without issues and his legs were no longer shaking. With the aid of a rehabilitation device, he was able to walk back and forth 10 meters in the ward hallway. The patient had noticeably improved trunk control and leg strength when the stimulator was turned on. When the

patient was discharged prior to Lunar New Year, the rehabilitation team provided him with a home rehabilitation program with recommended assistance by a physical therapist in a local hospital. The results of this program were to be reviewed during a follow-up visit at the end of March.

A Valid Alternative for Spinal Cord Damage and Brain Injury Patients – Restored Ability to Squat, Stand, and Walk

A total of eight patients with lower limb disabilities underwent this therapy last year. Seven of these patients were afflicted with spinal cord injuries. One of them was a young patient in a coma due to a severe brain injury sustained in a traffic accident in northern Taipei two years ago. One month after initiation of treatment, he was still bedfast and unable to verbally express himself. Upon his transfer to Hualien Tzu Chi Hospital and administration of Endogenous Stem Cell Therapy and a rehabilitation program based on a fusion of Chinese and Western medicine concepts for three months, he had regained his ability to walk and speak.

Upon his discharge, he progressed significantly after continuing stem cell therapy and the rehabilitation program for another year. However, due to the remaining strong tension in his upper and lower left extremities, his muscle strength was insufficient, and he still had a swaying gait. After implantation of a Spinal Cord Stimulator last year, his stride rate and distance increased noticeably due to relief of his excessive muscle tension. Director Tsai points out that the patient's walking posture and muscle strength have improved considerably despite that fact that his pace is still abnormal. In the past, he was unable to do one-legged squats on his left leg. Two weeks after his surgery he had regained the ability to do several one-legged squats in a row by relying on electrostimulation.

Neurostimulator implantation can also be applied in comatose patients who have suffered brain injuries or strokes. Director Tsai states that six patients underwent this therapy last year. Two of them have exhibited significant improvement in their communication and interaction abilities. The remaining four are still under observation since their surgeries have been completed only recently. The same therapy was applied in two patients with severe pain in the lower extremities caused by nerve injuries. Against the backdrop of ongoing advances in the field of medical technologies and innovative therapies, Hualien Tzu Chi Hospital is deeply committed to bringing new hope to comatose and paralyzed patients with the ultimate goal of restoring their ability to stand up and walk and thereby improve their quality of life.