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## Frontiers in Rehabilitation



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# Using a Precision Medicine Approach to Improve Rehabilitative Care in Stroke

By Ela Plow, PhD, PT; Yin-Liang Lin, PhD; Kelsey Potter-Baker, PhD; Vishwanath Sankarasubramanian, PhD; David Cunningham, PhD; and Andre Machado, MD, PhD

The National Institutes of Health (NIH) launched its Precision Medicine Initiative in 2015 based on the idea that the likelihood and extent of recovery vary among individuals, with individual characteristics dictating how much recovery can be achieved with therapies. A greater emphasis is thus placed on customizing interventions to individual characteristics.

Our group at Cleveland Clinic has embraced the founding premise of the Precision Medicine Initiative to develop targeted rehabilitative therapies for individuals suffering from stroke. As survival rates after stroke continue to improve, more patients live longer lives facing chronic impairments. One of the most debilitating is weakness of the upper extremity, with up to 70 percent of affected patients experiencing lifelong difficulties in activities of daily living.

Improving the effectiveness of rehabilitation appears to be central to any solution. Pairing additional therapies within the limited time allotted for rehabilitation can supplement benefits without adding to stroke's cost burden. One such promising adjunct involves stimulation of the brain. Delivering electrical stimulation to residual, surviving areas in the lesioned hemisphere is believed to enhance mechanisms of plasticity — i.e., restorative processes that contribute to recovery. Stimulation has become even more popular since the advent of noninvasive techniques applying currents from atop the scalp/skull without requiring surgery.

## **Targeting Stimulation for Efficacy Regardless of Severity**

Although several hundred studies have claimed that stimulation can dramatically enhance outcomes of the weak upper extremity in stroke survivors, this therapy is not yet accepted for use in outpatient clinics. Stimulation-associated improvements vary across individuals. Those who are mildly affected are able to experience substantial outcome gains, but more-disadvantaged patients remain compromised in use of their paretic upper limb.



Our contribution has been to develop targeted brain stimulation techniques that can dramatically enhance rehabilitation outcomes in patients with minimal as well as serious disability. Our approach to developing tailored techniques has been unique in that, before predicting a priori who should receive which type of stimulation, we adopt a data-driven, post hoc empirical strategy.

Over the past few years, our findings and those of others led us to realize that traditional stimulation fails to affect outcomes because it relies on the potential of residual networks, which are substantially damaged in severely affected patients. These patients cannot rely on residual networks in the lesioned hemisphere and must depend on helpful changes or plasticity occurring in the intact hemisphere. Yet the intact hemisphere can reroute alternate

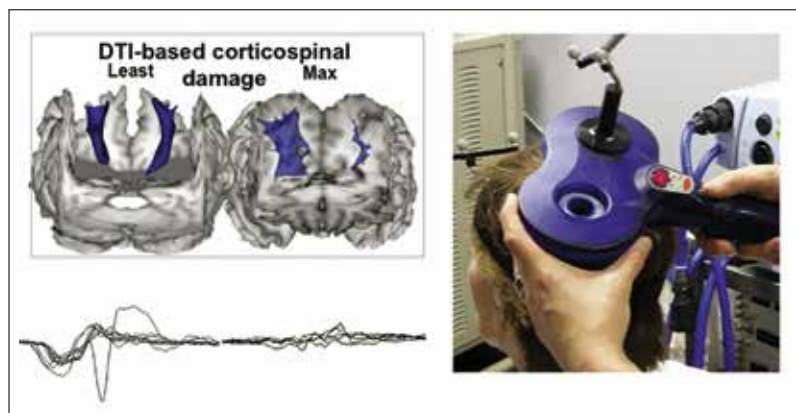


Figure 1. Damage in our study was measured using diffusion tensor imaging (DTI) (left), and the physiologic condition of pathways was assessed using transcranial magnetic stimulation (right).

pathways to move the ipsilateral paretic limb. Moreover, the intact hemisphere can influence activity of the lesioned hemisphere via the corpus callosum to enhance its ability to drive movement of the severely affected limb.

Given how patients with minimal damage can exploit the potential for plasticity available within residual networks of the lesioned hemisphere, as well as how patients with severe damage rely on plasticity offered by the intact hemisphere, we've proposed that targeted stimulation in stroke should involve offering traditional stimulation to patients with mild functional disability and stimulation of the alternate, intact hemisphere to those with severe disability.

### Insights for Stratifying Patients to Stimulation Type

Yet the biggest roadblock is lack of understanding of what constitutes severe disability. At what level of damage and deficit do patients fail to rely on residual areas in the lesioned hemisphere and need to rely on the intact hemisphere? How does one stratify patients for one or the other type of stimulation therapy? Our empirical, data-driven approach has offered the first solution, as indicated by findings presented at the 2015 annual meeting of the Society for Neuroscience.<sup>1,2</sup>

Using a crossover study design, we enrolled stroke patients across the spectrum of severity of upper limb impairment to receive stimulation to traditional targets in the lesioned hemisphere and, on a separate day, stimulation to the intact hemisphere. Ours is the first group to stimulate activity of the intact hemisphere on the assumption that it serves as a critical resource for recovery in severely disabled patients.

We allotted an adequate gap between sessions so the effects of stimulating one region did not influence effects of stimulating the other. We documented patients' stroke-related damage and impairment at baseline and then measured improvements in their ability to move their paretic limb. Damage was measured using diffusion-weighted MRI, which depicts damage to the structure of pathways (Figure 1). The physiologic condition of pathways was assessed using transcranial magnetic stimulation (TMS), which can study conduction of emergent pathways by delivering brief currents to motor areas in the brain. Conduction is indexed on the basis of movement potentials evoked with TMS in muscles of the paretic limb.

Our findings reveal that functional improvements associated with traditional stimulation and stimulation of the intact hemisphere share an inverse relationship. Whereas functional improvements associated with traditional stimulation are reduced with greater degrees of damage and impairment, improvements associated with stimulation of the intact hemisphere increase. Overall, as anticipated, mildly affected patients recovered the most with traditional stimulation while severely affected patients recovered with stimulation of the intact hemisphere.

### First Attempt to Develop Targeted Stimulation for Stroke

The unique aspect of our findings is that we've established that the relationship between improvements associated with alternate forms of stimulation is inverse. We are thus able to identify the intersection, or cutoff level, of damage and impairment at which to stratify candidates



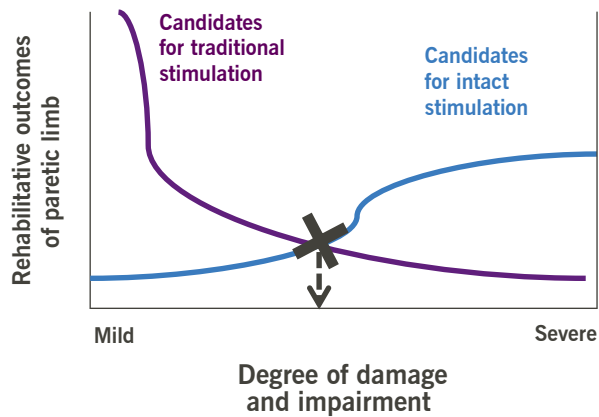


Figure 2. Our research establishing the inverse relationship between outcomes associated with alternate forms of stimulation can serve to stratify patients to therapy according to the severity of their functional impairment.

for traditional stimulation versus stimulation of the intact hemisphere (Figure 2).

This represents what we believe is the first attempt to develop targeted brain stimulation therapy for stroke. Not only can mildly affected patients achieve gains of greater than 30 percent in upper limb outcomes with traditional stimulation, but for the first time severely affected patients are likewise able to achieve greater than 30 percent gains with stimulation of the intact hemisphere.

In this way, our premise and findings are highly aligned with NIH's Precision Medicine Initiative. By accounting for an individual's damage and impairment following stroke, we can stratify that patient a priori for tailored stimulation so that all types of patients have an equal opportunity for fuller recovery. ■

*This work has been funded by the NIH, the American Heart Association and the American Stroke Association.*

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1. Sankarasubramanian V, Varnerin N, Cunningham D, et al. Employing patients' individual characteristics to derive personalized brain stimulation therapies. Poster 228.24/135 at the annual meeting of the Society for Neuroscience; Oct. 18, 2015; Chicago.
2. Plow EB, Varnerin N, Sankarasubramanian V, et al. Re-thinking brain stimulation in stroke rehabilitation: Why higher-motor areas might be better alternatives for patients with greater disability. Presentation 560.06 at the Society for Neuroscience Nanosymposium; Oct. 20, 2015; Chicago.

#### KEY POINTS

Traditional electrical stimulation of the brain fails to affect rehabilitative outcomes in stroke patients because it relies on the potential of residual networks, which are substantially damaged in severely affected patients.

Our group has shown that stimulating activity of the intact hemisphere in severely disabled stroke patients can yield substantial functional outcome gains, supporting our hypothesis that the intact hemisphere serves as a critical resource for recovery in such patients.

Our study represents what we believe is the first attempt to develop targeted brain stimulation therapy for stroke. It suggests that patients can be stratified a priori for tailored stimulation to optimize opportunity for recovery.

# Can Low Back Pain Be Tamed at the Population Level?

## Program pairs PTs with pain psychologists to curb disability.

For a person with chronic low back pain, a spine surgeon's office is not the ideal point of entry to the healthcare system. Neither is a spine imaging suite or the office of a pain specialist with a predilection for prescribing opioids. But those are places where far too many Americans with persistent back pain have surfaced at early stages of their disease in recent years. The result has been needless numbers of mutilating spine surgeries, premature imaging studies and avoidable opioid addictions — all without improved patient outcomes to show for it.

Cleveland Clinic's Neurological Institute has devised an unprecedented pilot population health initiative for chronic low back pain aimed at helping patients recover and become active again. The initiative, which launched in August 2016, promotes functional outcomes rather than procedure-based care and focuses on rehabilitation, relying primarily on a combination of physical therapy and behavioral medicine. It targets patients at high risk for extended disability.



"If we do a better job with people at risk for prolonged disability — if we treat them a bit differently — maybe they won't keep cycling through the system like they have been," says Mary Stilphen, PT, DPT, Senior Director of Rehabilitation and Sports Therapy at Cleveland Clinic.

### A Collaboration of PTs, Pain Psychologists, Physiatrists

The program's name, Back On Trek, alludes to its mission of **T**ransforming, **R**estoring and **E**mpowering patients — as well as providing them **K**nowledge. Achieving this goal requires a multidisciplinary approach. A team of physical therapists (PTs), behavioral medicine specialists and physiatrists treats participants in the 12-week pilot program at Cleveland Clinic's Lutheran Hospital on Cleveland's west side.

"Literature supports a collaborative approach," explains Stilphen. "If we combine cognitive behavioral therapy and physical therapy and focus on educating our patients about the neuroscience and neurophysiology behind their pain, we may achieve a better outcome."

### Multiple Entry Points

Eligible patients have typically experienced several months of chronic spine pain and screen negative for red flags suggestive of a possible medically dangerous pathology, as specified by Cleveland Clinic's Spine Care Path.

Patients who meet those criteria may self-refer to the program through the telephone contact center or be referred by a Cleveland Clinic physiatrist or medical spine physician. Additionally, patients may access the program through an initial assessment by a PT at any of Cleveland Clinic's 47 outpatient therapy locations. At that assessment, PTs use the Keele STarT Back Screening Tool; if the tool indicates a high risk for prolonged disability, the patient may be referred to the program.

Referred patients meet first with a behavioral medicine clinician who has special expertise in pain to gain an understanding of the biopsychosocial contributors to their pain, which helps the team focus their intervention appropriately.

“This program identifies patients who are likely to have psychosocial stressors, which can certainly impact recovery,” says Ian Stephens, PT, DPT, OCS, Physical Therapy Clinical Rehabilitation Manager at Cleveland Clinic. “It puts them in the setting to best address those issues and enables us to adjust our approach as indicated.”

### The Role of Physical Therapy

The program has two key components: individual therapy sessions and group conditioning sessions.

Individual therapy sessions involve meeting once a week with a PT who provides conventional interventions, such as manual therapy and corrective exercise, and also offers pain neuroscience education.

“The physical therapy management strategy relies heavily on patient education,” says Stephens. “The goal is to reduce fear of pain by helping patients understand more about pain. Fear of pain is often more disabling than actually experiencing pain. That knowledge brings empowerment, as patients learn strategies to better manage or control their pain.” Pain neuroscience education is the primary strategy used by PTs to reduce fear of movement.

During the group sessions, four to six participants meet for aerobic conditioning — twice weekly at the beginning, then once a week. Each patient is given a goal and positive feedback when it’s achieved. Patients also have weekly group sessions with a behavioral medicine specialist. “We’re hopeful the group dynamic will prove to support and motivate patients,” says Stephens.

Physicians add support to the program, reinforcing the messages from the PTs and behavioral medicine specialists. “Some patients tend to do better when they know there’s a collaborative team overseeing their care,” Stilphen explains. All team members meet weekly to discuss patients’ progress.



### Educating the Educators

Three to four outpatient PTs who specialize in treating people with spine pain are partaking in the pilot program. They will receive ongoing education on the cognitive behavioral approach to treating patients with chronic pain and on methods for talking to patients about the neuroscience of spine pain.

“Education needs to be delivered in a way that patients can process, so we’re using images, metaphors and stories instead of anatomical models and medical jargon,” says Stephens. “But providing this kind of education may not be a skill set that every PT has. It requires refinement, like anything else a PT offers when managing patients.”

To that end, core training based on the textbook *Therapeutic Neuroscience Education: Teaching Patients About Pain* is offered to the program’s PTs, physiatrists and other participating clinicians so they speak the same language — in service of the shared goal of improving patient outcomes.

“We know our low back pain patients get better with therapy, but those at high risk for disability don’t typically get to the same level as somebody at low risk,” says Stilphen. “We want to see if we can make an impact on the high-risk group and get them back to a manageable baseline.” ■

Contact Stilphen at [stilphm@ccf.org](mailto:stilphm@ccf.org) and Stephens at [stephei2@ccf.org](mailto:stephei2@ccf.org).



## Training Program Takeoff

**New PM&R residency makes the most of multidisciplinary resources.**

At a time when other U.S. institutions are closing or scaling back residency programs in physical medicine and rehabilitation, Cleveland Clinic has done just the opposite: In July 2016, it welcomed the first two residents (see sidebar) into its new three-year PM&R residency program.

“The launch of this residency program, along with Cleveland Clinic’s new and expanding joint venture with Select Medical to operate inpatient rehabilitation hospitals, signals the commitment our health system has made to PM&R,” says Frederick S. Frost, MD, Chairman of the Department of Physical Medicine and Rehabilitation. “As more and more baby boomers enter and approach their 70s, physiatry’s importance as a specialty is only increasing. Cleveland Clinic gets that and is responding to train the expert clinicians needed to meet the demand.”

### **Bringing Big-System Benefits to Bear**

The new ACGME-accredited residency program derives some distinctive benefits from being offered at Cleveland Clinic, according to PM&R Residency Program Director John Lee, MD:

**Exposure to a diverse mix of highly complex cases.** As a tertiary and quaternary referral center, Cleveland Clinic draws patients from around the world for highly specialized care for the most challenging conditions. “Our residents encounter an incredible array of patients and rehabilitative needs,” says Dr. Lee (pictured above with the two residents and a patient). He notes that they’ll care for patients with neurological conditions ranging from stroke to Parkinson disease to spinal cord injuries as well as patients recovering from complex surgeries like multiorgan transplants or requiring rehab for heart failure or the effects of cancer therapy.

### **Extensive interactions with specialists outside PM&R.**

While certainly not unique to Cleveland Clinic, opportunities for such interactions are more abundant at large institutions



like this one. “Take our program’s geriatrics rotation,” says Dr. Lee. “It involves patients that physiatrists often care for, but residents are rotating directly with geriatricians, not physiatrists, so they see the care of these patients from a different — and potentially invaluable — perspective.”

The rotation in Cleveland Clinic’s renowned Chronic Pain Rehabilitation Program is another case in point. “Because this program is run by psychiatrists, our PM&R residents are exposed to how psychiatry deals with chronic pain issues from a multidisciplinary perspective,” Dr. Lee notes.

Other outpatient rotations offer further opportunities for multidisciplinary exposure, and additional rotations are being planned for direct training with more specialties, including neurosurgery, orthopaedics, family practice and others. “These will grow over time,” says Dr. Lee.

**Abundant practice settings.** Residents, who are in PGYs 2-4, train across a diversity of clinical settings, including three Cleveland Clinic inpatient rehabilitation hospitals for adults, Cleveland Clinic Children’s Hospital for Rehabilitation, multiple family health centers, the Cleveland VA Medical Center (for amputee care) and the MetroHealth Rehabilitation Institute of Ohio (for spinal cord injury and traumatic brain injury care).

#### **New Means Nimble**

Dr. Lee sees additional strengths stemming directly from the program’s newness. “Because we just started, we’re able to build the program as it grows and be fairly flexible and innovative,” he says. He cites the fact that residents can consider a broad range of topics and mentors — including many multidisciplinary opportunities — for their research project as they discover areas of interest while proceeding through the program.

“Also, because we currently have only two residents, we can tailor the rotations according to residents’ interests,” he points out. “So within the confines of ACGME requirements, we have the flexibility to create rotations that appeal to an individual’s interest in a given clinical area.”

He adds that the number of residents will grow over time to better match Cleveland Clinic’s large patient volumes and clinical breadth.

#### **Takeaway Advice: Know Your Resources Well**

Dr. Lee notes that the new residency program was developed over three years and with input from 44 Cleveland Clinic PM&R clinicians and researchers.

Reflecting on that experience, he offers this advice to other institutions looking to start or refresh a PM&R residency: “Knowing your institution’s resources very well is important from the standpoint of clinical volumes and the other specialties you can tap into. Because PM&R works closely with so many other specialties, take full advantage of all the learning opportunities your nonphysiatrist colleagues can offer your residents.” ■

Contact Dr. Lee at [leej4@ccf.org](mailto:leej4@ccf.org) and Dr. Frost at [frostf@ccf.org](mailto:frostf@ccf.org).

#### **Meet the Program’s Inaugural Residents**



##### **Sharareh Izadi, MD**

**Medical degree:** Azad University of Najaf Abad, Iran

**Previous training:** Medicine residency at Lincoln Hospital, New York City; ENT training in Malaysia; service at a rehabilitation center in Iran

**In her own words:** “I believe PM&R is the combination of surgery, medicine and neurology and that my skills in those areas made PM&R a good fit for me.”



##### **Irfan Elahi, DO**

**Medical degree:** Kansas City University of Medicine and Biosciences

**Previous training:** Internship at Nassau University Medical Center, East Meadow, New York

**In his own words:** “At Cleveland Clinic, you are exposed to patients with the rarest of pathologies who come from all walks of life. It’s a remarkable place and a cultural melting pot that cannot be experienced anywhere else.”

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## A Growing Inpatient Rehab Footprint

Cleveland Clinic has been working in a joint venture with rehabilitation services provider Select Medical to offer a system of rehabilitation hospitals across Northeast Ohio. A 60-bed hospital opened 20 miles west of Cleveland in December 2015, and two new hospitals are under construction east and south of the city. Since its opening, the west side rehabilitation hospital has seen a diverse mix of stroke, brain injury, spinal cord injury, orthopaedic, neurologic and general rehab admissions.





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In 2016, Cleveland Clinic was ranked the No. 2 hospital in America in *U.S. News & World Report's* "Best Hospitals" survey. The survey ranks Cleveland Clinic among the nation's top 10 hospitals in 13 specialty areas, and the top hospital in heart care for the 22nd consecutive year.

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