Functional Magnetic Stimulation:
Emerging Technology Improves Respiration After Spinal Cord Injury  Page 6
Dear Colleague,

As the new Chair for the Department of Physical Medicine and Rehabilitation, I would first like to thank my predecessors, Dr. Frederick Frost and Dr. Vinod Sahgal, for their leadership and tireless efforts in making our department a center of excellence in rehabilitative care.

I am also pleased to inform you that our department has become part of Cleveland Clinic’s renowned Neurological Institute (NI), a family of premier clinical centers that includes the:

- Lou Ruvo Center for Brain Health
- Brain Tumor and Neuro-Oncology Center
- Cerebrovascular Center
- Epilepsy Center
- Mellen Center for Multiple Sclerosis
- Center for Neuroimaging
- Neurological Center for Pain
- Center for Neurological Restoration
- Neuromuscular Center
- Center for Pediatric Neurology and Neurosurgery
- Sleep Disorders Center
- Center for Spine Health

Altogether, more than 250 medical, surgical and research specialists in the NI see over 140,000 patients annually, perform 7,500 surgeries each year, and receive $18 million in annual funding for neurologically related research in collaboration with the Lerner Research Institute. Funding includes 91 NIH and 167 non-NIH grants.

Within our own department, we are committed to delivering world-class rehabilitation services. This entails providing superior physician and therapy services to our patients, and pursuing innovation in our clinical practice.

We will soon open a new inpatient unit on our main campus, and have hired a number of outstanding physicians and therapists to expand our services, which include cardiac rehabilitation, women’s rehabilitation, neuromuscular, and musculoskeletal rehabilitation.

We are also working with Cleveland Clinic’s Center for Allied Health and Department of Government Relations to form academic affiliations with local universities and to address the shortage of qualified therapy professionals. This will help us meet the workforce needs of a rehabilitation network that is rapidly changing and evolving.

In this issue of Frontiers in Rehabilitation, we will introduce you to:

- the pioneering work by Dr. Yu-Shang Lee in advancing the science of spinal cord regeneration through a combination of peripheral nerve grafts, growth factors and rehabilitation to promote locomotor and bladder function in a rat model
- the unique perspective of Dr. Steve Landers, Medical Director of Cleveland Clinic Home Care Services, on making “house calls” for the vulnerable elderly, in a summary of his January 2009 JAMA editorial
- the identification of functional magnetic resonance imaging by Dr. Janice Zimbelman and her colleagues as a potential imaging biomarker for the earliest stages of neural dysfunction prior to the onset of Huntington’s disease
- functional magnetic stimulation, a noninvasive method of neural stimulation, and its efficacy in improving inspiratory and expiratory function for patients with spinal cord injuries

We welcome your comments about this publication as well as your inquiries. We look forward to being partners with you and sharing knowledge so that, together, we may provide the best care possible to our patients.

Respectfully,

Vernon W.H. Lin, MD, PhD
Chairman, Department of Physical Medicine and Rehabilitation
216.445.7350 or linv@ccf.org
We believe that functional magnetic resonance imaging (fMRI) has the potential to serve as an imaging biomarker to identify the earliest stages of neural dysfunction in individuals before the onset of Huntington's disease (pre-HD).

Huntington's disease, an autosomal dominant disorder leading to selective degeneration of basal ganglia structures, is typically diagnosed with the onset of motor signs (manifest HD), although there is evidence that cognitive changes occur prior to this.

The estimated age of disease onset can be calculated using a regression equation based on the number of trinucleotide CAG repeats in the genetic coding for Huntington's disease along with current age.

Participants in two cross-sectional studies we conducted have demonstrated changes on fMRI – in the absence of neuropsychological, behavioral and structural measures – more than 12 years before the predicted onset of manifest HD.

We are now following this study population longitudinally with funding from the National Institutes of Health and the CHDI Foundation. If we are able to confirm the findings from our earlier studies, then fMRI results may be used in combination with CAG repeat length and current age to more accurately predict the onset of manifest HD. In addition, fMRI could potentially be used to monitor the progression of neural dysfunction and to assess treatment efficacy in clinical trials.

Dr. Zimbelman, of the Schey Center for Cognitive Neuroimaging at Cleveland Clinic, is affiliated with the Department of Physical Medicine and Rehabilitation. Physicians may reach her at 216.444.8666 or at zimbelj@ccf.org.

**Relevant Publications**


Vulnerable Elders:
Moving the “Medical Home” Where It Belongs

By Steven Landers, MD, MPH (Adapted from his commentary, “The Other Medical Home,” JAMA 2009 Jan 7;301(1):97-90.)

The growing population of older adults with multiple coexisting chronic conditions and functional limitations presents a significant challenge to the United States healthcare system. These vulnerable elders account for the majority of expenditures in the Medicare program, yet in spite of the high spending, they often suffer without the holistic, coordinated and integrated care that could address their complex health care needs.

Need for non-encounter-based care

Primary care physicians have traditionally been responsible for taking a whole-person approach to care integration and coordination. However, existing Medicare payment policies have pushed the typical office-based practice toward high volumes of brief encounters. These practices are often unable to provide the non-encounter-based care coordination needed by the highest-risk elders who frequently transition between different venues of care and multiple types of providers.

In light of these challenges, primary care organizations and policymakers, including the Medicare Payment Advisory Commission (Med-PAC), have embraced a reform called the “Medical Home.” If enacted, the Medical Home initiative would provide additional capitation reimbursement to primary care practices that are able to provide added accessibility, quality improvement, care coordination and self-management support for patients with chronic conditions.
Ironically missing from the “Medical Home” initiative as currently articulated is an emphasis on care provided in the actual homes of high-risk, low-mobility older patients. Many of the vulnerable elders driving the high costs at which the Med-PAC reforms are aimed have significant functional limitations, and they may not be regularly able to access office-based primary care.

The medical home initiative could be improved by adding elements that make the immobile patient’s home the main venue for primary care. Such reforms would empower informal caregivers, home health aides, social workers, home health and hospice field nurses, and home care therapists to provide ongoing direct care in the home under the leadership of primary care physicians.

**Strengthening home care/hospice benefits**

Home health providers and hospice agencies can bring a multidisciplinary team of clinicians into the patient’s home to partner with family caregivers. However, Medicare’s existing home health and hospice benefits limit the ability of these teams to take on a more prominent ongoing care role, and do not facilitate needed physician leadership and collaboration.

The home health and hospice benefits could be strengthened by:

- expanding home health episodes beyond 60-day periods for certain high-risk patients
- ensuring a loose interpretation of “homebound status”
- providing payment for “hospital at home” programs
- expanding access to personal home health aide care
- removing the requirement for a prognosis of six months or less for hospice care, and allowing those with end-stage illnesses and palliative goals to receive in-home hospice services
- revising the self-referral “Stark” laws, which apply to home health agencies
- mandating active medical directors for home health agencies
- improving reimbursement for in-home physician services
- providing physician reimbursement for multidisciplinary team meetings and geriatric assessment, and
- enhancing medical education initiatives to address geriatric issues.

Physicians who would like to comment or contact Dr. Landers, Medical Director of Cleveland Clinic Home Care Services, are encouraged to call him at 216. 636.7870 or email him at landers@ccf.org.

**Missing: care in the home**

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Studies have shown that an emerging technology pioneered by Department of Physical Medicine and Rehabilitation Chairman Vernon W.H. Lin, MD, PhD, can improve respiratory function, a major cause of mortality and morbidity in patients with spinal cord injury.

“Functional magnetic stimulation, or FMS, is a very promising technology that can be applied to patients with spinal cord injury and many other neurological diagnoses,” says Dr. Lin, whose team has worked on the technology for the past 20 years. “FMS has shown clinical efficacy in inspiratory/expiratory muscle training, ventilatory assistance and cough production.”

In FMS, an electromagnetic field generated from a round magnetic coil passes easily through structures such as skin, fat and bone to activate nerves and muscles.

“The beauty of FMS is that it is relatively noninvasive and can be applied outside the patient’s clothing,” explains Dr. Lin. “Placing the coil on someone’s back, we can produce a very effective cough, and if we move it up a little bit, we can also generate some inspiratory capacity by stimulating the phrenic nerves and the muscles contributing to inspiratory function.”

Useful in tetraplegia and paraplegia

FMS of the cervical and upper thoracic nerves generates significant inspiratory volume and pressure, of particular benefit to patients with high cervical (C3 - C5) quadriplegia who have both inspiratory and expiratory muscle dysfunction. FMS of the lower thoracic nerves has the potential to help patients with paraplegia by stimulating an effective cough and conditioning the expiratory muscles to improve coughing ability.

In a study published in the Archives of Physical Medicine & Rehabilitation, Dr. Lin’s team reported that training expiratory muscles for four weeks using FMS resulted in significant improvement over baseline in voluntary maximal expired pressure (116 percent), volume (173 percent) and flow rate (123 percent).

Improving quality of life

“When we are able to noninvasively stimulate the nerves and muscles below the level of injury, we hope to improve patients’ quality of life, and boost their medical health in order to prevent the complications of long-term disability,” says Dr. Lin. “Patients who partially regain some of the functions that they have lost can live to their best potential.”

FMS offers many advantages over functional electrical stimulation (FES) for patients with spinal cord injuries. It does not require surgery, electrode implantation or application of electrodes to the skin with gel. This avoids common complications like wire breakage, implant failures and skin infections. FMS is also less painful and better tolerated by patients.

“Unlike needle electrode stimulation, FMS is free of any traumatic risks due to the absence of contact with the stimulated structures,” says Dr. Lin. “No side effects have been reported with FMS. Risks of thermal injury from the heated magnetic coil in prolonged stimulation can be prevented by using a thermistor-controlled FMS unit and effective magnetic coil cooling system.

Contraindications to FMS include metal implants in the abdomen or spine, which are subject to mechanical forces exerted by the induced currents. Cardiac pacemakers are a possible contraindication, since a magnetic stimulator placed directly over the device could induce sufficient current and voltage to damage its internal electronics.
Testing a ‘racetrack’ coil

Cleveland Clinic’s FMS laboratory is collaborating with the Louis Stokes Cleveland VA Medical Center’s FMS Laboratory on a clinical efficacy trial of a modified FMS coil. Designed by our engineers, the “racetrack” coil will be tested in a six-week human trial. They will measure the coil’s effect on strengthening of inspiratory and expiratory muscles, compared with a standard respiratory muscle conditioning protocol.

Aiming for portability

Cleveland Clinic’s FMS Laboratory is working on improving the magnetic stimulator’s engineering and power supply to develop a small, portable FMS unit. “We are about five years away from developing a prototype for demonstration,” says Dr. Lin.

The current unit’s lack of portability and bulkiness are major drawbacks to use of this tool in patients’ homes and various clinical settings. “We can definitely take advantage of some of the more advanced battery technologies that are now available,” he adds.

Dr. Lin and colleagues remain excited about the application of FMS, not just in spinal cord injury, but also in other neurologic conditions. “FMS has demonstrated efficacy not only in improving inspiration and expiration, but also in improving bladder and bowel function, and preventing deep venous thrombosis,” he says. “We also have good reports from early animal studies on its potential for pain management. The future is bright.”

Dr. Vernon Lin is board-certified in Physical Medicine and Rehabilitation as well as Spinal Cord Injury Medicine, and serves as Editor-in-Chief of Spinal Cord Medicine: Principles and Practice. Physicians may reach him at 216.445.7350 or at linv@ccf.org.

Relevant Publications


Expiratory reserve volume (ERV) improvement. Changes in lung volume (L) throughout the conditioning protocol.

Maximum expired pressure (MEP) improvements at total lung capacity (TLC) and functional residual capacity (FRC). Changes in airway pressure (cmH2O) throughout the conditioning protocol. [ ], MEP-TLC; [ ], MEP-FRC. *Versus baseline, p < .05.

*Reprinted with permission from the Archives of Physical Medicine and Rehabilitation (Arch Phys Med Rehab Vol 82, February 2001).*
Spinal cord injury (SCI) is one of the most damaging, immobilizing and irreversible injuries that a human being can survive. Most individuals with SCI experience multi-organ dysfunction. In addition to motor and sensory deficits, they often experience neurogenic bladder and muscle atrophy that contribute to a tremendous burden of care, increased mortality and morbidity, and a compromised quality of life.

In Cleveland Clinic’s Neural Regeneration Laboratory, Yu-Shang Lee, PhD (above), and his team are laying the groundwork for the development of surgical treatments that will allow maximal recovery of spinal-cord-related functions.

CNS regeneration achievable

“Our research in experimental rodent models proves that nerve regeneration is achievable,” says Dr. Lee. “We have been able to stimulate the re-growth of nerve fibers damaged after SCI using surgical bridging techniques.”

The results offer promise for promoting reconstruction of the spinal cord. These methods have already shown success in improving motor function in animal models. “What is most promising is the potential for bridging techniques to improve autonomic function, such as bladder and bowel control,” says Dr. Lee. “These are among our greatest concerns for quality of life among SCI patients.”

Once deemed impossible, advances in regeneration of the spinal cord now offer hope for thousands of persons with SCI.
Bridging is key to recovery

He believes that bridging – use of peripheral nerve graft techniques accompanied by application of acidic fibroblast growth factor – is a promising interventional modality to promote functional recovery. “This approach encourages more axons to cross the damaged site and make proper connection with the target neurons,” explains Dr. Lee.

In his laboratory, he has achieved 30 percent restoration of supraspinal hindlimb control by reconnecting the sectioned spinal cord in rats. He has also demonstrated a reduction in hindlimb skeletal muscle atrophy following bridging surgery.

In the experiment, rehabilitative therapies were used alone or in combination with other interventions to gauge recovery of locomotor performance. A combination treadmill exercise protocol improved the animals’ kinematic features and coordination of electromyographic signals from hindlimb skeletal muscle.

Combined strategy for bladder control

Dr. Lee and his team have observed that bridging surgery promotes recovery of bladder function. He anticipates even greater success using the enzyme chondroitinase ABC (ChABC) together with peripheral nerve graft and acidic fibroblast growth factor to stimulate axon growth while removing glial scar inhibitors at the distal end of constructed bridges. “This particular combination strategy allows axons to grow rapidly, exit the bridge and reconnect the sectioned spinal cord.”

Dr. Lee plans to examine the safety and efficacy of the bridging techniques in higher-level mammals, as an important step toward application of these techniques in humans.

Physicians may reach Dr. Lee in the Neural Regeneration Laboratory in Cleveland Clinic’s Neuroscience Institute at 216.445.5040 or at leey2@ccf.org.

Relevant Publications


Publications by Physical Medicine & Rehabilitation and Related Faculty 2008-2009

Landers SH. The other medical home. JAMA 2009 Jan 7;301(1):97-99.
Cleveland Clinic
Physician Resource Guide

General Referrals to Cleveland Clinic
24/7 hospital transfers or physician consults
800.553.5056

Department of Physical Medicine and Rehabilitation
Referrals
216.445.7342 or 800.223.2273, ext. 57342

On the web at clevelandclinic.org/frontiers

Services for Physicians

Physician Directory
View all Cleveland Clinic staff online at clevelandclinic.org/staff.

Physician Liaison
Referring physicians have a direct and personal link to Cleveland Clinic with our Physician Liaison. For help with any interaction involving Cleveland Clinic, contact Physician Liaison Kate Kenny at clevelandclinic.org/ContactKate.

Improved Communication, Improved Care
Cleveland Clinic DrConnect is a complimentary service providing our referring physicians with secure, online access to the electronic medical record information related to a patient’s treatment progress. To receive your next patient report electronically, please log onto clevelandclinic.org/drconnect to establish your own DrConnect account.

Online Medical Second Opinions
Request a secure online medical second opinion from Cleveland Clinic specialists. For more information, visit clevelandclinic.org/myconsult.

Resources for Your Patients

Cleveland Clinic’s Department of Physical Medicine and Rehabilitation serves patients with mobility, self-care, communication, swallowing and cognitive impairments. Our more than 150 physiatrists, physical and occupational therapists, vocational rehabilitation counselors and rehabilitation nurses provide inpatient and outpatient rehabilitation after orthopaedic surgery, stroke, spinal cord injury or transplant, and for neurological disorders, cancer and pulmonary disorders. Special programs are targeted at driving rehabilitation, golfing with disabilities and other areas.

Appointments
Rehabilitation Physiatry: 216.445.7342
Physical/Occupational Therapy: Adults, 216.445.8000; Pediatrics, 216.444.6572
Return to Work Services/Vocational Rehabilitation: 216.444.WORK (9675)
Orthotics and Prosthetics Center/Wheelchair & Seating Clinic: 216.445.9000

Medical Concierge
Complimentary assistance for out-of-state patients and families:
800.223.2273, ext. 55580, or email medicalconcierge@ccf.org

Global Patient Services
Complimentary assistance for national and international patients and families:
001.216.444.8184 or visit clevelandclinic.org/gps

Frontiers in Rehabilitation, published by the Cleveland Clinic Department of Physical Medicine and Rehabilitation, provides updates on diagnostic and therapeutic techniques and current research for physiatrists, neurologists and neurosurgeons.

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The Department of Physical Medicine and Rehabilitation is part of the Neuroscience Institute, one of 26 institutes at Cleveland Clinic that group multiple specialties together to provide collaborative, patient-centered care. The department offers full cross-disciplinary rehabilitation for people with physical, psychosocial, cognitive and vocational impairments. Patients receive coordinated care across a continuum that spans inpatient rehabilitation, skilled nursing and outpatient therapy at Cleveland Clinic facilities throughout the region. Cleveland Clinic is a nonprofit, multispecialty academic medical center. Founded in 1921, it is dedicated to providing quality specialized care and includes an outpatient clinic, a hospital with more than 1,000 staffed beds, an education institute and a research institute.

Frontiers in Rehabilitation is written for physicians and should be relied upon for medical education purposes only. It does not provide a complete overview of the topics covered, and should not replace the independent judgment of a physician about the appropriateness or risks of a procedure for a given patient.

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Co-chairs: Vernon Lin, MD, PhD, and Frederick Frost, MD, Cleveland Clinic Department of Physical Medicine and Rehabilitation

Sept. 23, 2009
(Pre-Course to the Congress on Spinal Medicine and Rehabilitation in Dallas, Texas)

This one-day intensive review will feature an in-depth review of more than 20 essential spinal cord injury topics, including:

- Spinal cord anatomy, epidemiology, imaging and pathologies
- Neurocritical care, surgery and neurological assessment of acute SCI
- Management of neurogenic bladder and bowel, and sexual dysfunction
- Management of pain, spasticity and musculoskeletal dysfunction in SCI
- Cardiovascular, endocrine, metabolic and respiratory care in SCI
- Nutrition, immunological factors and pressure ulcer management
- Psychosocial adjustment and SCI rehabilitation
- Functional restoration of the upper limb in tetraplegia
- Nontraumatic myelopathies and dual diagnosis of SCI and brain injury
- Disorders affecting children and adolescents

To register for the pre-course, visit www.asia-ascip2009.org/registration_home.php.

Cleveland Clinic CME Opportunities: Live and Online
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