Medical Xpress

Implant breakthrough helps paraplegic man stand, step with assistance, move legs voluntarily

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This 2010 photo provided by Rob Summers shows Summers, center, receiving intensive physical therapy in Louisville, Ky. Summers was paralyzed below the neck in a 2006 car accident and in 2009, doctors decided to implant an electrical stimulator onto his spinal cord to try waking up his damaged nervous system. Summers is now able to stand and move during therapy sessions with the stimulator turned on. (Courtesy of Rob Summers)

A team of scientists at the University of Louisville, UCLA and the California Institute of Technology has achieved a significant breakthrough in its initial work with a paralyzed male volunteer at

Louisville's Frazier Rehab Institute. It is the result of 30 years of research to find potential clinical therapies for paralysis.

The study is published today in the British medical journal *The Lancet.*

The man, Rob Summers, age 25, was completely paralyzed below the chest after being struck by a vehicle in a hit and run accident in July 2006. Today, he is able to reach a standing position, supplying the muscular push himself. He can remain standing, and bearing weight, for up to four minutes at a time (up to an hour with periodic assistance when he weakens). Aided by a harness support and some therapist assistance, he can make repeated stepping motions on a treadmill. He can also voluntarily move his toes, ankles, knees and hips on command.

These unprecedented results were achieved through continual direct epidural electrical stimulation of the subject's lower spinal cord, mimicking signals the brain normally transmits to initiate movement. Once that signal is given, the research shows, the spinal cord's own neural network combined with the sensory input derived from the legs to the spinal cord is able to direct the muscle and joint movements required to stand and step with assistance on a treadmill.

The other crucial component of the research was an extensive regime of Locomotor Training while the spinal cord was being stimulated and the subject suspended over the treadmill. Assisted by rehabilitation specialists, the individual's spinal cord neural networks were retrained to produce the muscle movements necessary to stand and to take assisted steps.

Leading researchers on the 11-member team are two prominent neuroscientists: Susan Harkema, Ph.D., of the University of Louisville's Department of Neurosurgery, Kentucky Spinal Cord Research Center and Frazier Rehab Institute, a service of Jewish Hospital & St. Mary's

HealthCare in Louisville; and V. Reggie Edgerton, Ph.D., of the Division of Life Sciences and David Geffen School of Medicine at UCLA.

Joel W. Burdick, Ph.D., Professor of Mechanical Engineering and Bioengineering at Caltech, developed new electromechanical technologies and computer algorithms to aid in locomotion recovery in spinal cord injury patients.

The research was funded by the Christopher & Dana Reeve Foundation and the National Institutes of Health. Dr. Harkema is Director of the Reeve Foundation's NeuroRecovery Network, which translates scientific advances into activity-based rehabilitation treatments. Dr. Edgerton is a member of the Reeve Foundation's Science Advisory Council and its International Research Consortium on Spinal Cord Injury.

Drs. Harkema, Edgerton and their colleagues envision a day when at least some individuals with complete spinal cord injuries will be able to use a portable stimulation unit and, with the assistance of a walker, stand independently, maintain balance and execute some effective stepping.

Relief from secondary complications of complete spinal cord injury – including impairment or loss of bladder control, sphincter control and sexual response – could prove to be even more significant.

"The spinal cord is smart," notes Dr. Edgerton, distinguished professor of integrative biology and physiology, and neurobiology at UCLA. "The neural networks in the lumbosacral spinal cord are capable of initiating full weight bearing and relatively coordinated stepping without any input from the brain. This is possible, in part, due to information that is sent back from the legs directly to the spinal cord." This sensory feedback from the feet and legs to the spinal cord facilitates the individual's potential to balance and step over a range of speeds, directions and level of weight bearing. The spinal cord can independently interpret these data and send movement instructions back to the legs – all without cortical involvement.

Dr. Harkema, Professor of Neurological Surgery at the University of Louisville, oversees the human research program there. She began her career as a postgraduate student in Dr. Edgerton's UCLA laboratory, where he pioneered the field of locomotion with extensive animal studies. The two have been close collaborators ever since.

"This is a breakthrough. It opens up a huge opportunity to improve the daily functioning of these individuals," concludes Dr. Harkema, lead author of today's Lancet article. "But we have a long road ahead."

"While these results are obviously encouraging," concurs Dr. Edgerton, "we need to be cautious. There is much work to be done."

To begin with, only one subject has been studied, and he was an athlete in extraordinary physical condition before his injury. (Five human subjects have been authorized by the Food and Drug Administration to be enrolled in the study.)

Additionally, the first subject, while completely paralyzed below the chest (C7/T1 vertebra spinal section), was rated "B" on the American Spinal Injury Association's classification system, since he did retain some feeling below the level of injury. It is not known how these interventions will work with "A"-level patients (no cognition of sensation below the injury). Yet another issue is the stimulation equipment itself. To date, researchers have only had access to standard off-the-shelf stimulation units designed for pain relief.

Finally, in earlier published animal studies, drug interventions further heightened the sensitivity and functioning of the spinal cord's neural network. The compounds used in animals, however, are not approved for human use; it is likely that a large investment in further pharmacological research will be required to bring such compounds to market.

More than five million Americans live with some form of paralysis, defined as a central nervous system disorder resulting in difficulty or inability to move the upper or lower extremities. More than 1.275 million are spinal cord injured, and of those many are completely paralyzed in the lower extremities.

Epidural stimulation, in the context of paralysis of the lower extremities, is the application of continuous electrical current, at varying frequencies and intensities to specific locations on the lumbosacral spinal cord corresponding to the dense neural bundles that largely control movement of the hips, knees, ankles and toes. The electrodes required for this stimulation were implanted at University of Louisville Hospital by Dr. Jonathan Hodes, chairman of the Department of Neurosurgery at the University of Louisville.

"Today's announcement clearly demonstrates proof of concept," said Susan Howley, Executive Vice President for Research at the Christopher & Dana Reeve Foundation (which, in addition to supporting this particular work, has underwritten basic research in the field for more nearly three decades). "It's an exciting development. Where it leads to from here is fundamentally a matter of time and money."

Adds research volunteer Rob Summers, "This procedure has completely changed my life. For someone who for four years was unable to even move a toe, to have the freedom and ability to stand on my own is the most amazing feeling. To be able to pick up my foot and step down again was unbelievable, but beyond all of that my sense of well-being has changed. My physique and muscle tone has improved greatly, so much that most people don't even believe I am paralyzed. I believe that epidural stimulation will get me out of this chair."