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# NEUROSCIENCE
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Spring 2007

## Essential Tremor: Misunderstood But Common

Elan D. Louis, MD, MSc, has been studying essential tremor (ET) for more than 15 years. ET occurs in all human populations that have been examined to date. "There is no group of humans that is spared. People with ET live in all regions of the world, ranging from a remote area in Papua New Guinea to our urban Washington Heights [New York City] community," said Dr. Louis. In fact, ET is 20 times more prevalent than Parkinson's disease. It is one of the most common neurologic disorders.

During the past several years, Dr. Louis has conducted several large-scale epidemiologic studies of ET. He and Okan Dogu, MD, of Mersin University, Mersin, Turkey, used a unique method in which they went from door to door and examined several thousand people, finding that ET affects as many as 7% of people age 70 years or older. With Julian Benito-Leon, MD, of Mostoles General Hospital, Madrid, Spain, he carried out the first truly population-based analysis of the incidence of this disease; the researchers found that new cases of ET arise frequently (616 per 100,000 person-years).

Dr. Louis began his epidemiologic investigations of ET in Washington Heights in the 1990s. At the time, the prevailing view was that ET was a genetic disorder. In a 5-year familial aggregation study, Dr. Louis was surprised to find that ET seemed to be far less "familial" than had been suspected. This led him to begin to think about other factors, perhaps in

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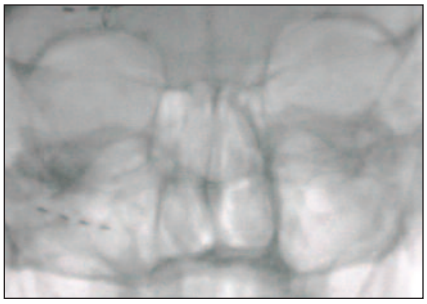
## New Treatment Approaches to Peripheral Nerve Problems

Significant advances in surgical technology have resulted in improved outcomes following peripheral nerve surgery, effectively expanding the types of nerve repair that can be performed and increasing the potential application in patients with a number of diseases and conditions.

Peripheral nerve problems typically develop as a result of diabetic peripheral neuropathy, and persistent pain following surgical procedures such as total knee replacement, reconstructive musculoskeletal surgeries, or spinal surgery. Columbia and Weill Cornell neurosurgeons at NewYork-Presbyterian Hospital are leading efforts to expand the uses of peripheral nerve surgery in new ways.

One strategy, nerve transfer surgery, is used to treat complex brachial plexus injuries. This technique involves isolating healthy (donor) nerves uninvolved



*Anteroposterior skull X-ray showing subcutaneous peripheral nerve stimulator electrodes used to treat trigeminal neuropathic pain.*

in injury, separating them from their target muscles, and reattaching them to the damaged (recipient) nerves. As they heal, nerve fibers from the healthy donor nerves grow into the damaged recipient nerves, and eventually into the denervated muscles, restoring function. Using this technique, Christopher Winfree, MD, has been repairing brachial plexus injuries.

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UPDATES

Paroxysmal Disorders: Differential Diagnosis of Seizures CME
September 29, 2007
CME credits: 4.5
Weill Cornell Medical College, New York, NY

Brain Attack and Cerebrovascular Disease Update 2007 CME
November 9, 2007
CME credits: 8
Grand Hyatt Hotel, New York, NY

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NewYork-Presbyterian
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# Innovations in Pediatric Neurosurgery Offer Improved Outcomes for Children

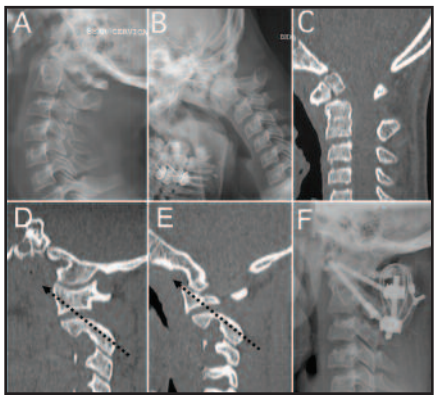
A child with epilepsy undergoes safer surgery thanks to sophisticated neuroimaging and monitoring. A toddler with craniovertebral instability avoids the discomfort of external fixation through a novel, transarticular fixation procedure. Ongoing research promises that children with inoperable brain tumors may receive high concentrations of therapeutic molecules directly to the tumor.

These advances are a reality for pediatric neurosurgeons at NewYork-Presbyterian Hospital/Weill Cornell Medical Center and NewYork-Presbyterian Hospital/Columbia University Medical Center. The procedures they perform improve quality of life and prognosis for some of the sickest pediatric patients.

Pediatric epilepsy surgery is a field in the midst of sweeping change, according to Columbia's Saadi Ghatan, MD. Up to 30% of people with epilepsy cannot become seizure-free with medication. Surgery to the brain may be an effective option, especially for children, who are more likely than adults to have focal symptomatic or cryptogenic epilepsy that is medically intractable but surgically treatable.

"Safety is always a concern in pediatric epilepsy surgery," said Dr. Ghatan. "Advances in neuroimaging help the surgeon target epileptogenic zones while sparing functionally important areas of the brain."

To improve surgical targeting, Dr. Ghatan uses functional magnetic resonance imaging (MRI) and invasive intra- and extraoperative intracranial monitoring, in addition to video electroencephalography (EEG) and positron emission tomography (PET). Functional MRI gives live feedback on the brain locations of vital functions such as language, movement, feeling, vision, and hearing. Intracranial monitoring pinpoints epileptogenic zones with high accuracy.




*Complex spinal instrumentation helps avoid the need for prolonged post-op halo bracing.*

"Classical scalp EEG localizes an epileptogenic lesion, but the output is clouded by artifacts from the skull, dura, and scalp," noted Dr. Ghatan.

In contrast, invasive intracranial monitoring is the best means to locate the epileptogenic zone in relation to functional cortical areas. Furthermore, the use of adjunctive functional MRI "avoids artifacts, shows a discrete lesion, and visualizes functional sites in the brain that are activated when a child taps a finger, feels a scratch on the palm, does a task, or experiences any of a number of stimuli," noted Dr. Ghatan. Brain mapping provided by functional MRI facilitates the surgeon's ability to remove brain tissue or place an electrode for neurostimulation, while safely navigating away from functional tissue that must remain patent. Functional MRI has an additional, nonsurgical role: It identifies brain areas linked to the anxiety, depression, and behavioral problems that may be debilitating for children with epilepsy.

By reducing risk in pediatric epilepsy surgery, functional MRI allays the fears of parents and community health professionals. As Dr. Ghatan noted, however, "not all centers can offer the advanced neuroimaging that improves surgery. It takes a great team and great radiologists. Then, the results are uplifting." Dr. Ghatan described an adolescent he treated surgically, who experienced medically intractable facial seizures that gave rise to generalized seizures; 2 years after surgery, this young man is seizure-free and a college student.

At NewYork-Presbyterian/Weill Cornell, neurosurgeon Mark Souweidane, MD, leads a research team working to deliver therapeutic molecules directly into brain tumors. The technique they study, convection-enhanced delivery (CED), is now in preclinical evaluation, with preparation under way for a Phase I clinical trial. CED has important implications for children with inoperable brain tumors.

Current investigations examine CED for tumors of the brain stem, an area Dr. Souweidane describes as a surgical "no man's land." To provide CED, surgeons insert a small-bore cannula directly into the tumor, followed by interstitial infusion of therapy. With CED, local drug concentrations are several thousand times higher than with systemic agents. CED limits the systemic effects of therapy. Large macromolecules can be administered via CED, including monoclonal antibodies and targeted toxins that cannot be delivered systemically. According to Susan Pannullo, MD, CED may enable clinicians to treat more brain tumors aggressively.

"Convection-enhanced delivery allows a therapeutic substance to get to tumors in parts of the brain inaccessible for surgical tumor removal," she explained.

Dr. Souweidane noted that to date the results with CED are "very promising, with an excellent radiographic response." The team continues to apply the technique using a variety of therapeutic molecules, including conventional chemotherapy, monoclonal antibodies, and other biological agents. Once Dr. Souweidane and his team evaluate these agents for CED, they will select one to study in the Phase I clinical trial.

For infants born with craniosynostosis, surgeons at NewYork-Presbyterian Hospital are among those pioneering a new approach—endocranial facial reconstructive surgery. Historically, according

to Neil Feldstein, MD, surgery to repair these premature closures of the fibrous joints in the skulls of newborns used bicoronal incisions. The patient's skull was exposed, and large sections of bone were removed, manipulated, and replaced. These procedures would take 6 to 8 hours in the OR, leading to significant use of anesthesia and blood transfusions, not to mention perioperative and postoperative complications for the young patients. The newer procedure employs only a 1-inch incision, through which surgeons are able to reopen the fibrous joints in the skull. Operating time is roughly 1 hour, and patients can be discharged the next day.

"Several of the surgeons at the Hospital have trained with the developers of this procedure," noted Dr. Feldstein. "As a result, we are among the few centers in the country using it. So far, we've been really encouraged with the results."

Pediatric neurosurgeons at NewYork-Presbyterian Hospital are also working with a minimally invasive procedure to resolve Chiari malformations, where there is insufficient skull volume to contain the cerebellum. Traditionally, surgeons treating this condition have had to open the skull and the dura in an effort to "uncrowd the cerebellum" and prevent it from pushing against the brain stem and spinal cord. This procedure entailed significant recovery time and often led to serious complications (including meningitis). The minimally invasive procedure, however, does not entail opening of the dura. Outcomes measurements at the Hospital, according to Dr. Feldstein, have revealed that the complication rate is nearly 4 times higher if the dura is opened during surgery.

Children as young as 18 months old are healing well and in greater comfort, due to advanced surgery for craniovertebral instability at NewYork-Presbyterian/Columbia. The craniovertebral junction (CVJ) may be unstable in children with conditions like Down's syndrome, dysplasia, and trauma.

Neurosurgeon Richard C.E. Anderson, MD, performs a novel technique for rigid internal fixation of the junction. Through an incision at the back of the neck, the surgical team places a transarticular screw across the C1-2 vertebrae, along with a bone graft from the hip or rib. The criterion for success—fusion of the CVJ—was reported in 100% of 67 pediatric patients in a case series published by the originators of the procedure. Dr. Anderson has also achieved a 100% success rate in his surgeries.

According to Dr. Anderson, this surgical approach represents "a marked advance over the conventional external fixation for craniovertebral instability." External fixation places children in a halo vest for 3 to 6 months. This apparatus consists of a ring or "halo" that encircles the head, fixed in place by 4 to 10 screws in the skull and attached to a hard vest by 4 vertical rods. The halo vest, said Dr. Anderson, "has only an 80% success rate.

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NewYork-Presbyterian Neuroscience
is a publication of the Neuroscience Centers of NewYork-Presbyterian Hospital. The Neuroscience Centers are at the forefront of research and practice in the diagnosis, treatment, and rehabilitation of neurologic disease. The Neuroscience Centers include the Neurological Institute of New York at NewYork-Presbyterian Hospital/Columbia University Medical Center and the Weill Cornell Neuroscience Institute at NewYork-Presbyterian Hospital/Weill Cornell Medical Center, which are respectively affiliated with Columbia University College of Physicians and Surgeons and Weill Cornell Medical College.

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# Continuous EEG Monitoring for Stroke And Epilepsy Revolutionizes Care

Capitalizing on a unique collaboration between stroke and epilepsy services and faculty, Columbia and Weill Cornell researchers at NewYork-Presbyterian Hospital are using continuous electroencephalographic brain monitoring (cEEG) to diagnose and manage status epilepticus and other acute neurologic conditions—a concept one expert describes as "neurotelemetry," or telemetry for the brain.

"We're working to get to the point where we have continuous real-time monitoring of the brain with someone always watching the monitor, as is the case with cardiac telemetry," noted Lawrence Hirsch, MD. "We get calls regularly asking how to set up a program like ours, but the field is still in its infancy. We have a unique team and collaboration here. Other centers are quite jealous of the outstanding collaboration we have between epilepsy, EEG, neurointensive care, stroke, and neurosurgery."

According to Dr. Hirsch, the new 18-bed Neurological Intensive Care Unit (co-directed by E. Sander Connolly, MD, and Stephan Mayer, MD) at NewYork-Presbyterian/Columbia University Medical Center has video EEG monitoring equipment built into every room. With an additional 16 portable video EEG units used throughout the Center, "we're now averaging more than 10 patients per night who get continuous, 24-hour digital video EEG monitoring," he said.

"We are trying to get more timely access to cEEG monitoring for patients who are coming in in status epilepticus,'" said Padmaja Kandula, MD. "The earlier you treat status—which is an emergent situation—the better the likelihood you can pull the person out of status.

"We need to get the patients access to video EEG monitoring as soon as they hit the door," she added, noting that there is a potentially large group of patients who are comatose or have altered mental status who are actually in status epilepticus.

> "We're working to get to the point where we have continuous real-time monitoring of the brain with someone always watching the monitor, as is the case with cardiac telemetry."
>
> —*Lawrence Hirsch, MD*

According to Dr. Kandula, Lewis L. Kull, R. EEG/EP T., Director of Clinical Neurophysiology Operations at the Columbia campus, is in charge of hiring and managing the technicians as well as training them. Mr. Kull saw such a tremendous need for trained technicians that he began his own training school, offering an official 18-month training course in EEG and offering jobs to some of its best graduates.

"We have some preliminary plans to train the nursing staff to recognize emergent patterns so they can alert a physician," said Dr. Kandula. "It's helpful not only to the treating physician but also to the rest of the staff to have more eyes looking at the EEG. This is not something that can be learned overnight. Since the nursing staff is at the bedside most often, if they were to be able to recognize a potentially emergent pattern, it would make a tremendous difference."

Indeed, cEEG has already yielded valuable results. "We discovered that seizures on EEG are much more common in critically ill patients than we thought," noted Dr. Hirsch. "The vast majority of them do not have any obvious clinical correlate. If you were just looking at the patient at the bedside, you would never know the patient was having seizures."

In a study published 3 years ago (*Neurology* 2004;62:1743-1748), Dr. Hirsch and his colleagues examined 570 patients of all ages—but mostly adults—who were placed on cEEG. Of those, 19% had seizures, and of the patients with seizures, 92% had only nonconvulsive seizures. When the NewYork-Presbyterian/Columbia researchers repeated the study in children (*Arch Neurol* 2006;63:1750-1755), they found that 44% had seizures, and of those, 75% had nonconvulsive seizures, undetectable without the monitoring.

"So without the cEEG, we would never have known about them," said Dr. Hirsch. "When someone is in convulsive status epilepticus and you treat them, they usually stop moving; it appears the treatment is complete. But 20% of them will still be seizing on the EEG, and half of them will have nonconvulsive seizures in the next 24 hours. cEEG monitoring is critical for patients with status epilepticus who don't awaken."

The technology has also proved useful in other areas. According to Dr. Hirsch, physicians in the neuro-ICU have "serendipitously picked up on other pathologies," including cases of undiagnosed hydrocephalus, because the system can identify ischemias and other abnormalities of brain function. In addition, in one case, physicians detected a diffuse change in a patient's EEG due to respiratory failure with carbon dioxide retention and notified the clinicians who hadn't yet recognized the problem. Dr. Hirsch is now collaborating with researchers at NewYork-Presbyterian/Columbia to study ways to detect acute ischemia at the moment it occurs, rather than having to wait for clinical recognition. Next steps already under way include the development of software programs to enable computers to interpret the EEG data.

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# Book Highlights Advances in Arteriovenous Malformation Treatment

In his book, *Intracranial Arteriovenous Malformations* (Stieg, Batjer, Samson; Informa Healthcare), Philip Stieg, MD, PhD, and his co-authors write about the pathophysiology, diagnosis, evaluation, and treatment of arteriovenous malformations (AVMs). Dr. Stieg's model is one of interdisciplinary care.

The book also examines the molecular biology of AVMs, which is something Dr. Stieg and colleagues are studying in their laboratories at Weill Cornell Medical College. "We have been looking at different gene expressions for different neuropeptides and proteins in patients with AVMs," said Dr. Stieg. "Specifically, we're trying to find a marker that might be a potential predictor for those who bleed versus those patients who don't bleed."

AVMs are currently diagnosed incidentally in patients who present with everything from a headache to a hemorrhage. Dr. Stieg and his colleagues are looking at noninvasive imaging tools, such as computed tomography angiography (CTA).

The cutting-edge work involves the application of CTA in the treatment of AVMs. Dr. Stieg now uses CTA both to plan stereotactic radiosurgery and to perform it. "When a patient gets diagnosed with an AVM, we now use CTA to identify the nidus, as well as for determining treatment volume with radiation. In surgery, we use it in combination with computer-aided image guidance that assists in localization and surgical resection," he said.

"We can integrate that information with the images that are generated surgically and confirm that we've gotten complete removal of the AVM," he added.

Although CTA is not a new technique, its application in transporting imaging for use in the operating room is an innovation. Dr. Stieg and colleagues are working with industry (BrainLAB and Zeiss) to generate a package that makes this application "very user-friendly," he said. Justin Frazier, MD, a resident at NewYork-Presbyterian Hospital, will be focusing his research on this new application next year.

On the treatment and management side, Dr. Stieg is making use of a new agent—Onyx—to embolize AVMs. Onyx is a nonadhesive liquid embolic agent comprised of ethylene vinyl alcohol copolymer dissolved in dimethyl sulfoxide (DMSO) and suspended micronized tantalum powder to provide contrast for visualization under fluoroscopy. He and his team are conducting ongoing trials with Onyx, and the agent seems to be most effective in treating relatively small AVMs with few feeding vessels.

> "When a patient comes in and gets diagnosed with an arteriovenous malformation, we now use CTA to identify the nidus, as well as for determining treatment volume with radiation."
>
> —*Philip Stieg, MD, PhD*

"We're finding that Onyx is a much more effective agent for obliterating AVMs, and over time we may actually find that fewer people need surgery," said Dr. Stieg.

He is also conducting clinical trials in which the fluorescent agent indocyanine is used intraoperatively to help identify the nidus and confirm, without angiography, complete excision of an AVM.

"The obvious advantage of indocyanine is that it's an [intravenously] injected agent, and if this appears to be effective, then we can eliminate intraoperative angiography," said Dr. Stieg. "To my knowledge, this kind of work with indocyanine is only being conducted at 3 other institutions in the country. Moreover," he added, "we can merge this data with the data we get from our new application of CTA, again to facilitate localization and confirm complete excision of the AVM."

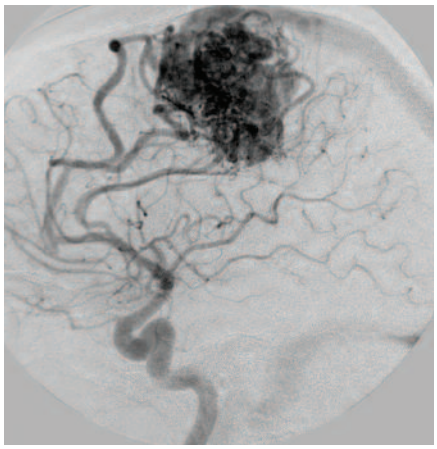

*Photo courtesy of Philip Stieg, MD, PhD*

*An AVM: A NewYork-Presbyterian Hospital neurologist has written the book on diagnosis and treatment.*

ARUBA (A Randomized trial of Unruptured Brain AVMs) is being conducted by Dr. Stieg's colleague, Jay P. Mohr, MD, at the Doris and Stanley Tananbaum Stroke Center, Neurological Institute, and InCHOIR Clinical Trial Center at NewYork-Presbyterian/Columbia University Medical Center. The goal is to test the null hypothesis that the risk for death or symptomatic stroke after treatment with interventional procedures, surgery, or radiotherapy does not differ from the risk for death or symptomatic stroke after conservative management, and that such treatment offers no better functional outcome than conservative management at 5 years after discovery of an unruptured brain AVM.

"We have talked about the diagnosis and treatment of AVMs," said Dr. Stieg, "and as for management, one of the major emphases at the Hospital's Department of Rehabilitation is acute rehabilitation for stroke patients," said Dr. Stieg, including the work of Michael O'Dell, MD, who has created a complete center caring for stroke patients from diagnosis to rehabilitation. "Dr. O'Dell has set up a program specifically for the rehabilitation of patients recovering from AVMs," he said.

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the environment, that could be causing so many people to have tremors. This was the basis for an ongoing National Institutes of Health (NIH) study, launched in 2000, examining the potential role of toxins such as metals, pesticides, and beta-carboline alkaloids.

Dr. Louis was particularly interested in the beta-carboline alkaloids, such as harmaline and harmane, because he knew that when these chemicals are injected into laboratory animals, a tremor develops that resembles ET. Together with Wei Zheng, MD, then a neurotoxicologist at Columbia University College of Physicians and Surgeons, he used high-performance liquid chromatography (HPLC) to measure blood concentrations of these chemicals in humans. The investigators found that the concentration of harmane was about twice as high in the blood of patients with ET as in those without ET.

"We know that harmane is especially found in animal protein. We are now carefully looking to see whether ET patients are eating more animal protein than are control subjects, and therefore have higher levels of these neurotoxins in their blood, or whether they are just having difficulty metabolizing these neurotoxins," said Dr. Louis. In this regard, he and his collaborators are looking at polymorphisms in genes coding for proteins that metabolize the beta-carbolines.

Dr. Louis' research team is looking at other neurotoxins as well, including lead in the blood and bones of patients with ET. In both New York and Turkey, they have found elevated blood concentrations of lead in ET cases, suggesting that lead, a known neurotoxin, may be another contributor to the development of ET.

"ET is far more complex than previously realized," said Dr. Louis. Along with investigators in Spain, he has shown for the first time that dementia is more likely to develop in ET patients than in their age-matched counterparts. Also, Dr. Louis and colleagues are publishing a paper "showing for the first time that ET is associated with a slightly increased risk of mortality. Up until now, people have assumed that ET is not linked with mortality. We showed a 45% increase in risk of mortality over a 3-year follow-up period," he said.

**In 2004, Elan D. Louis, MD, MSc, secured NIH funding to establish the Essential Tremor Centralized Brain Repository.**

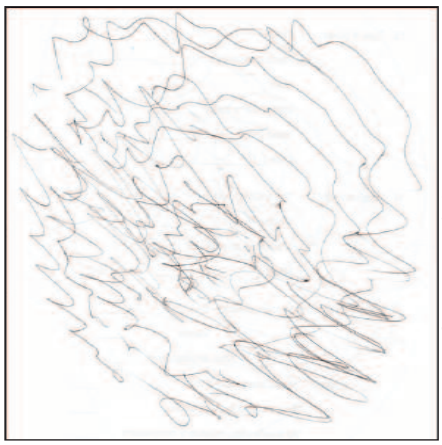

*Photo courtesy of Elan D. Louis, MD, MSc*

*Severe tremor is seen as an ET patient attempts to draw a spiral.*

To try to examine the ET brain itself, Dr. Louis has collaborated with Dikoma Shungu, PhD, a Columbia radiologist. Using magnetic resonance spectroscopy, they found evidence of neuronal death in the ET cerebellum. "This was the very first evidence that ET was not just a disorder of brain dysfunction but that there could be accompanying neurodegeneration," said Dr. Louis. "That would mean that ET falls in the family of neurodegenerative conditions like Parkinson's and Alzheimer's diseases," he added. Because virtually no ET autopsies have been performed, Dr. Louis secured NIH funding in 2004 to establish the ET Centralized Brain Repository, which is the only national centralized repository for ET brains; working in tandem with the International Essential Tremor Foundation, it has attracted many brain donors. As a result, the investigators have been able to perform nearly 25 postmortems since 2003 (whereas only 15 postmortems had been performed worldwide between 1903 and 2003), with some intriguing results:

- Pathologic changes have been observed in every ET brain studied.
- Two main patterns of pathologic changes have been found: In 75% of cases, degenerative changes are seen in the cerebellum, with a diminished number of Purkinje cells, and unexpectedly, in 25% of cases, Lewy bodies are observed in the locus ceruleus (not in the substantia nigra, as in patients with Parkinson's disease).

"These types of studies are exciting," said Dr. Louis. "Along with my colleagues [Jean-Paul G. Vonsattel, MD, and Phyllis Lynne Faust, MD] in neuropathology, for the first time we are looking very closely at the ET brain itself." Moving forward, Dr. Louis and his team will perform more detailed microscopic studies of ET brains, hoping that these will eventually lead to better therapies. "ET has been around for a long time, yet our study of this common disorder is still very much in its infancy. We have made some important strides over the past decade but still have a long way to go," Dr. Louis concluded.

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## Peripheral Nerve
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"We routinely enable patients with totally paralyzed arms, over time, to regain sufficient shoulder and elbow function so that the arm becomes useful for activities such as carrying groceries, dressing, shaving, etc," noted Dr. Winfree. "Additionally, compared to a flaccid, atrophied arm, a more robust, mobile extremity looks more normal, the patient's injury is less noticed by the casual observer, and patients tend to be less self-conscious about their injury following nerve transfer surgery."

Dr. Winfree has been using nerve transfers to treat spinal cord injury in animal models. In this procedure, peripheral nerves, originating from the spinal cord *above* the level of injury, are essentially transferred into the spinal cord *below* the level of injury.

"We have observed the growth of peripheral nerves into the spinal cord; the formation of functional synapses of peripheral nerve axons upon spinal cord motor neurons; and movement of a leg, previously paralyzed by spinal cord injury, upon stimulation of the transferred peripheral nerve," said Dr. Winfree. "Perhaps even more exciting is that we are duplicating these studies in the cat, a much larger and more human-like experimental model."

Once the translational cat studies are completed, Dr. Winfree hopes to begin clinical trials, during which peripheral nerve transfers will be used to treat spinal cord injury in humans. According to Dr. Winfree, it is unlikely patients suffering from severe spinal cord injuries would regain full motor function, such as the ability to walk, from these peripheral nerve procedures. However, he is confident that patients treated with this surgical approach could see improvements in muscle tone, recovery of some voluntary control over previously paralyzed muscles, and recovery of bowel, bladder, and sexual function.

In addition, Dr. Winfree and Martin Zonenshayn, MD, and his team at NewYork-Presbyterian/Weill Cornell Medical Center, are actively employing peripheral nerve procedures to treat human patients—both through clinical trials and real-world clinical settings—with various conditions, including diabetic peripheral neuropathic pain (DPNP) and craniofacial issues.

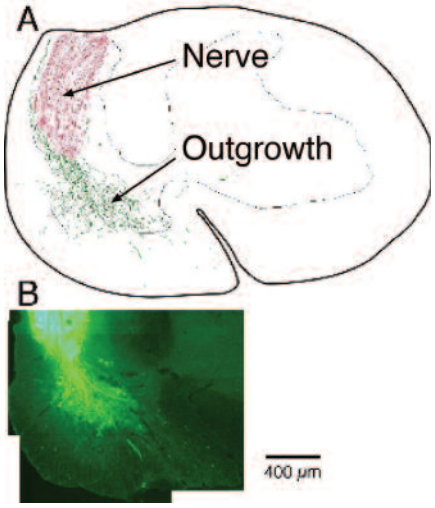


*Diagram and photomicrograph demonstrating growth of axons into the rat ventral horn following peripheral nerve transfer into the spinal cord.*

DPNP affects an estimated 50% of those who have had diabetes for more than 20 years in the U.S. At NewYork-Presbyterian/Weill Cornell, Dr. Zonenshayn is exploring the use of peripheral nerve decompression surgery in select patients with DPNP. Although decompression surgery is a relatively common procedure for conditions such as carpal tunnel syndrome, there is much less research and clinical experience in patients with other neuropathies. Dr. Zonenshayn is learning from and working with plastic surgeon A. Lee Dellon, MD. Dr. Dellon, a pioneer of the procedure, has more than 15 years of experience with nerve decompression surgery in patients with DPNP.

"This procedure significantly reduces the pain and numbness of the affected limb, and thereby also reduces the risk of later amputation," said Dr. Zonenshayn.

In lower extremity surgical decompression for DPNP, neurosurgeons focus on 3 nerves: the common peroneal nerve at the fibular head, the deep peroneal nerve on the dorsum of the foot, and the posterior tibial nerve, which branches into the medial and lateral plantar nerves. Patients with DPNP typically experience pain and numbness in a "stocking and glove" pattern, meaning that sensory changes occur in the entire foot or hand. These symptoms may be exacerbated by compression of multiple nerves. Nerve decompression surgery relieves pressure from swollen nerves in patients with diabetes by removing constricting fibrous or bony tissue from the area surrounding the nerve.

Dr. Zonenshayn stressed that only select patients with DPNP are eligible for decompression surgery. Eligibility criteria include patients who are refractory to traditional nonoperative management, patients with a Tinel's sign over the common nerve compression points, and patients who do not have severe medical comorbidities.

According to Dr. Zonenshayn, NewYork-Presbyterian/Weill Cornell is among the few centers to have a pressure-specified sensitivity device (PSSD). Dr. Zonenshayn and colleagues are using the PSSD to measure and monitor the degree of sensation patients have in their extremities prior to surgery, as well as during the postoperative period. They are currently in the preliminary stages of data collection on a study designed to test the efficacy of the PSSD as a management tool.

Meanwhile, Dr. Winfree and his team are also involved in research on using peripheral nerve procedures to treat facial pain. "One treatment in particular is motor cortex stimulation," he said. "We are conducting the first randomized, prospective, controlled trials of peripheral nerve stimulation in the treatment of craniofacial pain, including trigeminal neuropathic pain, trigeminal neuralgia refractory to surgery or med treatment, and occipital neuralgia. The great thing about doing this type of research here is that to hook up with a renowned neuroscientist, I don't have to go across the country—just across the hall."

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## Innovations

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It is also extremely uncomfortable. Imagine a 3-year-old living in that vest."

Dr. Anderson added that internal fixation of craniovertebral instability is only 1 important pediatric advance at NewYork-Presbyterian/Columbia. "Another is our spasticity center, which provides multidisciplinary care for the spasticity that occurs in cerebral palsy and brain injury." The Center offers a range of medical and surgical services.

To decrease spasticity, Dr. Anderson may place an intrathecal baclofen pump for direct spinal installation of muscle-relaxant medication. He may also perform dorsal rhizotomy to interrupt dysfunctional nerve pathways. Dr. Anderson uses a refined rhizotomy technique that requires only a 1-inch incision in the lower back and surgical intervention to just 1 level of spinal lamina—as opposed to the 6- or 7-inch incision and 5 to 6 laminar levels in conventional rhizotomy.

"You need a team familiar with the procedures," said Dr. Anderson. "You also need the back-up of pediatric specialists, in the event of surgical complications. It really matters *where* a child has complex surgery."

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## EEG

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"Ultimately, the goal is to prevent secondary injury in all acute brain illness, and to save neurons and brain function," Dr. Hirsch said.

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Spring 2007

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