



REHAB PROGRESS



News from the UPMC Institute for Rehabilitation and Research

Spring 2007

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From the Chairman's Desk

As chairman of this exciting Department of Physical Medicine and Rehabilitation at the University of Pittsburgh Medical Center (UPMC), I am delighted to welcome to our faculty the long-time chief of Rehabilitation Services at Children's Hospital of Pittsburgh of UPMC, Mary Louise Russell, MD. Dr. Russell, who is board certified both in pediatrics and in physical medicine and rehabilitation, remains in her position as chief of Children's Rehabilitation Services. In this marriage of specialized pediatric and adult rehabilitation medicine, Children's Rehabilitation Services has not lost a daughter; it has gained an entire family.

The feature article in this issue of *Rehab Progress* highlights just a few rehabilitation services from the full range of programs on which patients can rely. Those receiving pediatric rehabilitation care can transition seamlessly to appropriate adult services – even in conditions such as spina bifida, for which adult patients often receive fragmented care, if any. The UPMC Adult Spina Bifida Clinic was developed specifically to meet the rehabilitation needs of these individuals. This unique program, directed by Brad E. Dicianno, MD, receives some of the spotlight in the lead story.

One of our faculty members continues to earn his own place in the spotlight. Michael L. Boninger, MD, was inducted into the National Spinal Cord Injury Association's Spinal Cord Injury Hall of Fame in Washington, D.C. last October (Page 3). The inductee in the category of assistive technology has been a faculty member in the UPMC Institute for Rehabilitation and Research (IRR) both years since the 2005 creation of the SCI Hall of Fame.

This issue of *Rehab Progress* announces IRRDay2007. The date is set for the annual celebration of research. IRRDay2007, scheduled for June 6, promises to be a fascinating Wednesday afternoon. Invited speakers are Todd A. Kuiken, MD, PhD, and Richard K. Shields, PT, PhD. Read the story on Page 4 for more details.

This issue contains three brief research reports in which readers can catch a glimpse of the biomechanical technology of tomorrow (Pages 4 and 5). Again we report on recent scientific publications by IRR researchers (Page 8) and scholarly presentations by members of our faculty (Page 6).

Even as I see the remarkable growth of our department and the IRR, I know that both are full of youth, vigor, and most important, the expectation of accomplishment.

Sincerely,



Ron D. Zafonte

Ross D. Zafonte, DO

Chairman

Department of Physical Medicine and Rehabilitation
University of Pittsburgh

No generation gap here: Rehab service for all ages now in one department



Dr. Russell

The University of Pittsburgh Medical Center (UPMC) Department of Physical Medicine and Rehabilitation now embraces the full continuum of rehabilitative care throughout the entire span of life. Pediatric subspecialist and long-time chief of rehabilitation services at Children's Hospital of Pittsburgh of UPMC, Mary Louise Russell, MD, became a full-time faculty member in UPMC's Department of Physical Medicine and Rehabilitation as of Jan. 1, 2007. Now under the umbrella of a single department, patients of all ages can receive the level of rehabilitative service appropriate to their condition.

Dr. Russell remains chief of service at Children's Hospital, where the Division of Children's Rehabilitation Services addresses a range of disability and developmental problems. Along with pediatric physical medicine and rehabilitation fellow Dina Patterson, MD, Dr. Russell provides consultation and treatment for children and adolescents with disabling conditions, whether acute or chronic, congenital or acquired.

Dr. Russell is the attending physiatrist at the Cerebral Palsy, Spasticity, and Muscular Dystrophy clinics at Children's Hospital, where she also provides inpatient consultation and maintains an active outpatient practice. In addition, Dr. Russell provides outpatient care at linkage clinics in four western Pennsylvania towns outside of Pittsburgh's Allegheny County.

In addition to physiatry, Children's Hospital's multidisciplinary rehabilitation team includes representatives from nursing, social services, and physical, occupational, and speech/language therapies. When appropriate, the service also works closely with other pediatric subspecialties, such as orthopaedic surgery, neurology, and neurosurgery.

Cases run the full gamut of diagnoses: traumatic brain injury due to accident or abuse; brain injury secondary to toxin, infection, or hypoxia; cerebral palsy; spina bifida and traumatic spinal cord injury; scoliosis; muscular dystrophy; surgical and congenital limb loss; or deconditioning due to major illness such as cancer, major injury such as burn trauma, or major surgery such as transplantation.

Clinics address muscle spasticity

Most chronic cases concern patients with problems due to congenital conditions, notably cerebral palsy, muscular dystrophy, or spina bifida. Drs. Russell and Patterson focus on helping patients achieve their highest potential of functional independence, and enabling parents and guardians to care for their child with confidence.

Patients with cerebral palsy often require treatment for spasticity, a problem that will carry into adulthood. Adult patients with problems of spasticity can receive evaluation and treatment in the Rehab Medicine office's Spasticity Clinic, directed by Michael C. Munin, MD. Treatment options include physical therapy, primarily passive stretch; bracing; medications such as baclofen or injected botulinum toxin; and various orthopaedic surgical procedures.

Muscular dystrophy patients: coping and hoping

Pediatric patients with severe neuromuscular problems, especially those with Duchenne muscular dystrophy (DMD) may require aggressive treatment. Muscular dystrophies and their complications impose severe limitations on life expectancy and on the quality of that brief life. DMD patients suffer progressive weakening of skeletal muscle, including the muscles of respiration, eventually affecting their ability to clear respiratory secretions. Moreover, cardiac muscle is affected in some patients, and some suffer life-threatening cardiomyopathy and heart failure.

Primarily through Children's Hospital's Growth and Development Laboratory, directed by Johnny Huard, PhD, the University of Pittsburgh pursues vigorous basic-science and translational research in neuromuscular disease, with major efforts focused on transplantation of muscle-derived ("adult") stem cells to correct the dystrophin deficiency of DMD muscle. Fabrisia Ambrosio, PhD, MPT, of the Department of Physical Medicine and Rehabilitation, is working with Dr. Huard and his colleagues to study the therapeutic potential of this strategy.

Until effective treatment becomes available, patients with severe muscular dystrophies require physical and occupational therapy, assistive technology, and supportive care, including "cough-assist" devices. Patients and their families also require counseling on issues such as prolonged ventilator support and empowerment regarding end-of-life choices.

Neural tube defects: Children, adults meet the challenge

In recent years, much greater extension in life expectancy has been evident for patients born with spina bifida. Even prevention is now a realistic hope. Because research shows that maternal folate deficiency can predispose to neural-tube defects in offspring, ongoing efforts seek to define and address dietary folate requirements for women of childbearing potential, and even for prepubescent girls.

In addition, earlier diagnosis of spina bifida is both possible and beneficial. According to Dr. Russell, true myelomeningocele is readily apparent at birth, and most cases can be diagnosed prenatally. In some advanced medical centers, including UPMC, prenatal diagnosis now permits surgical options that may limit disability due to myelomeningocele. Laparoscopic surgery can be performed on the fetal spine *in utero*, or the fetus may be partially exposed for open surgery through a uterine incision.

The severity of spina bifida symptoms depends on the level and extent of the defect: typically, the higher the defect, the more profound the disability. Patients with a level S2-S3 lesion are likely to experience bowel problems and urinary complications secondary to neurogenic bladder, as well as pressure ulcers resulting from insensitivity. If the defect is at or above the level of the lumbar vertebrae, the situation may be complicated by hydrocephalus, normally requiring placement of a shunt. Patients may have difficulty with verbal learning, and many are affected by some degree of paralysis. Dr. Russell addresses any obstacles to weight bearing and ambulation for patients with spina bifida. A regular program of even a few steps helps increase bone mineral density and lift the patient's spirits.



Dr. Dicianno

Until relatively recent times, patients born with severe neural-tube defects did not survive infancy or early childhood. Even those with less severe defects often succumbed at an early age, frequently because of urinary and renal complications or infection. Until recently, then, there was little recognized demand for clinical services for adults with spina bifida. Most patients who reach adulthood with spina bifida must either continue receiving care at their pediatric clinic or attempt to find treatment through regular channels, sometimes without adequate health insurance and often without comprehensive medical management.

UPMC's Adult Spina Bifida Program is one of only 12 programs in the nation dedicated to the needs of this patient population. On reaching late adolescence or early adulthood,

spina bifida patients treated at Children's Hospital can transition from the care of Dr. Russell directly to the care of Brad E. Dicianno, MD, director of UPMC's Adult Spina Bifida Program. Dr. Dicianno provides assessment for musculoskeletal pain syndromes, screening for shunt malfunction or neurological issues, wound care, adjustment and recommendations for bracing or Lofstrand crutches, treatment for neurogenic bladder and bowel problems, and screening for kidney disease. In addition, as medical director of the Center for Assistive Technology, he is part of a team of clinicians that provides comprehensive wheelchair assessments. Dr. Dicianno also manages referral, coordination, and oversight of the myriad of services that patients require, including neurosurgery, orthopaedic surgery, or urology. Patients with issues such as poor wound healing, obesity, diabetes, or kidney stones can receive nutrition counseling at the Adult Spina Bifida clinic.

One of Dr. Dicianno's chief concerns for patients with spina bifida is that many lack adequate access to primary care. Inadequate insurance is only part of the problem. Surprisingly, even in 2007, there remain physicians' offices with insurmountable examination tables and doorways too narrow to admit wheelchairs.

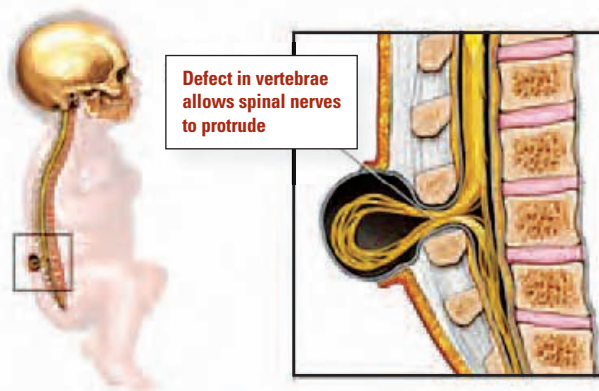
From bench to bedside and beyond

For a person with a disability, the road to independence is not without hurdles. This is the force behind the University of Pittsburgh Department of Physical Medicine and Rehabilitation and the UPMC Institute for Rehabilitation and Research, where clinicians and scientists work to overcome those hurdles. Their efforts are moving potentially revolutionary therapies from the laboratory to the patients who need them.

Cellular therapies one day may overcome the deadly effects of a molecular misprint. "Smart" technologies will soon have the capability not only to interpret the user's movements, but to anticipate the intended action. Education and advocacy will help ensure ongoing care and research, and eventually will remove barriers in workplaces, restrooms, and yes — even in physicians' offices.

Leading-edge rehabilitation medicine is available right now at UPMC. Now patients of all ages — from infancy, childhood, and adolescence through young, middle, and senior adulthood — can find the rehabilitation services they need from one well-integrated source.

In myelomeningocele, failure of the neural tube to close properly during early gestation results in a vertebral defect that allows protrusion of spinal nerves, meninges, and sometimes the cord itself. The severity of the condition depends on the level and extent of the defect.



Defect in vertebrae allows spinal nerves to protrude

Dr. Michael Boninger inducted to SCI Hall of Fame



Dr. Boninger

Michael L. Boninger, MD, professor and vice chairman for research in the University of Pittsburgh School of Medicine's Department of Physical Medicine and Rehabilitation, has been inducted into the Spinal Cord Injury Hall of Fame of the National Spinal Cord Injury Association (NSCIA). Dr. Boninger, who is also associate dean for medical student research at the School of Medicine, has conducted extensive research on the prevention of pain and injury in wheelchair users. Members of the NSCIA select inductees to the SCI Hall of Fame by voting for the nominees they deem most deserving in each category.

Dr. Boninger was elected to the Hall of Fame in the "assistive technology" category, receiving the honors on Oct. 30, 2006, during the second annual SCI Hall of Fame induction ceremony at the John F. Kennedy Center for the Performing Arts in Washington, D.C.

The previous year, Rory A. Cooper, PhD, FISA and Paralyzed Veterans of America Chairman and Distinguished Professor, Department of Rehabilitation Science and Technology, University of Pittsburgh, was one of 10 inaugural inductees to the SCI Hall of Fame. Dr. Cooper, who is also a member of the UPMC Institute for Rehabilitation and Research faculty, was elected in the same category: assistive technology.

The NSCIA established the SCI Hall of Fame in 2005 to recognize those who have made significant contributions to quality of life and hope for a better future for people with spinal cord injury.

IRRD_{ay}2007 — Mark your calendar

The UPMC Institute for Rehabilitation and Research (IRR) proudly announces its annual celebration of research — IRRDay. This year's event, IRRDay2007, is scheduled for Wednesday, June 6, from 1 to 6 p.m. on the University of Pittsburgh campus. Physicians and other health care professionals who attend IRRDay2007 are eligible to receive continuing medical education credits. The program, including continuing-education credits, is offered at no charge to attendees.

IRRD_{ay} is the offspring of "Research Day," an annual program instituted in 2000 by Ross D. Zafonte, DO, when he became the first chairman of the Department of Physical Medicine and Rehabilitation at the University of Pittsburgh School of Medicine. In 2006, the scope of the annual program widened following the establishment of the IRR and its more expansive mission. The IRR embraces not only physical medicine and rehabilitation, but also engineered rehabilitation solutions and technological advances; a full continuum of acute-care, inpatient, and outpatient rehabilitation medicine; a vastly expansive network of community outpatient rehabilitative services; and research on the leading edge of technology and the natural sciences.

The annual IRRDay program includes presentations by guest speakers, presentation of competitive research abstracts by predoctoral and postdoctoral trainees in various rehabilitation-related sciences at the University of Pittsburgh, and announcement of award winners in several categories. Invited speakers for IRRDay2007 are Todd A. Kuiken, MD, PhD, and Richard K. Shields, PT, PhD.

Dr. Kuiken is a physiatrist and an associate professor in the Department of Physical Medicine and Rehabilitation at the Feinberg School of Medicine of Northwestern University, Chicago. He is also associate dean of academic affairs, director of Amputee Services, and director of the Neural Engineering Center for Artificial Limbs at the Rehabilitation Institute of Chicago. Dr. Kuiken plans to present a talk on "Targeted Reinnervation: A Neural-Machine Interface for Improved Prosthesis Function."

Dr. Shields is an investigator who is currently funded by the National Institutes of Health, the Carver Foundation, the Spinal Cord Research Foundation, and the Christopher Reeve Foundation. He has received numerous awards for excellence in research and education. Dr. Shields' IRRDay2007 presentation is titled "Musculoskeletal Plasticity after Spinal Cord Injury: Implications for Early Intervention Management."

IRRD_{ay}2007 is sponsored by the University of Pittsburgh School of Medicine Center for Continuing Education in the Health Sciences and the Department of Physical Medicine and Rehabilitation, the University of Pittsburgh School of Health and Rehabilitation Sciences, and the UPMC Institute for Rehabilitation and Research.

This activity has been approved for AMA PRA Category 1 Credits™ by the University of Pittsburgh School of Medicine, an Accreditation Council for Continuing Medical Education (ACCME)-accredited provider.

Online registration for IRRDay2007 will be available after April 20 on the Department of Physical Medicine and Rehabilitation website at <http://www.rehabmedicine.pitt.edu>. Visitors to the website are able to track upcoming events, including updates on IRRDay2007, and participate in Panther Rehab Rounds — Grand Rounds lectures from the UPMC Department of Physical Medicine and Rehabilitation. Archived sessions of Panther Rehab Rounds are always available on the website.

Dr. Weber studies signals for neuroprosthesis feedback



Dr. Weber

Functional electrical stimulation (FES) is used to restore motor function to muscles that have become paralyzed by injuries to the central nervous system, including stroke and spinal cord injury. FES uses patterned electrical stimulation of motor nerves to generate muscular contractions to reanimate paralyzed muscle. FES control systems regulate the timing and intensity of stimulation applied to each muscle; many applications require the coordinated action of several muscles. To achieve smooth and functional movement, sensory feedback of limb state (i.e., current position, speed, and force) is needed. However, appropriate proprioception-supporting sensor technologies are currently lacking. To correct that deficiency, a research group led by Douglas J. Weber, PhD, assistant professor of physical medicine and rehabilitation, is developing microelectrode systems for mapping afferent signals generated during movement of the limb.

One approach is to use the native proprioceptors found in the muscles, tendons, and skin. These sensory neurons normally convey body-state information to the central nervous system and thus could provide a natural source of sensory feedback for controlling an FES system. Dr. Weber's research has demonstrated that it is possible to record and decode the patterns of electrical activity in these neurons to obtain an accurate and reliable measure of limb-state¹. This approach may solve the problem of providing sensory feedback for controlling an FES neuroprosthesis.

1. Weber DJ, Stein RB, Everaert DG, Prochazka A. Decoding sensory feedback from firing rates of afferent ensembles recorded in cat dorsal root ganglia in normal locomotion. *IEEE Trans Neural Syst Rehabil Eng.* 2006;14:240-3.

Study examines electronic foot drop correction device



Dr. Munin

Investigators of the UPMC Institute for Rehabilitation and Research (IRR) are examining the effectiveness of a small, neuromuscular electronic stimulator (WalkAide™, Innovative Neurotronics, Inc., Bethesda, Md.) in treating patients with post-stroke foot drop.

Stroke-derived foot drop results from damage to the motor cortex, producing weakness in the anterior tibialis, the extensor hallucis longus, and the extensor digitorum longus. The gait disturbance typically manifests as a dragging of the affected foot along the walking surface. Foot drop can result in diminished physical activity, increased risk of falling, reduced social interaction, decreased independence, and other negative outcomes.

The most common treatment for the condition is the ankle brace, an appliance that some patients find awkward and uncomfortable. WalkAide stimulates the common peroneal nerve, which innervates the anterior tibialis and other muscles, producing dorsiflexion of the ankle at the appropriate point of the gait cycle. The battery-powered device, about the size of a pager, is worn on the lower leg, just below the knee.

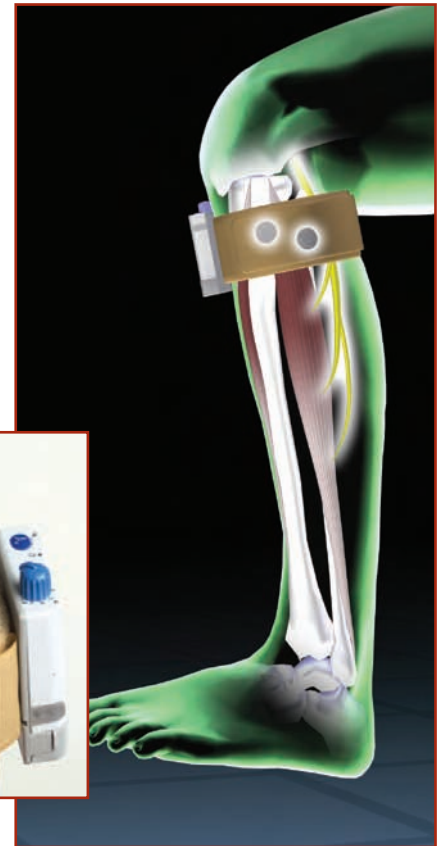
Faculty members of the Department of Physical Medicine and Rehabilitation are participating in a study that will compare the efficacy of WalkAide to that of standard ankle bracing in the correction of foot drop.

The full name of the study is "A three-arm, randomized crossover study comparing the Innovative Neurotronics, Inc. WalkAide™ System to ankle foot orthosis for walking performance and quality of life of adults with hemiparesis and foot-drop from cerebrovascular accident; to include a health economic study to evaluate the cost utility associated with both interventions."

Study support is provided by Innovative Neurotronics, Inc., of Bethesda, Md. Michael C. Munin, MD, is principal investigator.

Worn just below the knee, the WalkAide™ electronic neuromuscular stimulator activates the common peroneal nerve, which innervates the anterior tibialis and other muscles. The result is ankle dorsiflexion at the appropriate point of the gait cycle. UPMC IRR researchers are comparing the WalkAide to standard ankle bracing in patients with foot drop resulting from stroke.

Images provided by Innovative Neurotronics, Bethesda, Md. © 2006
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The researchers are currently enrolling study participants. For more information, call study coordinator Tina Harrison at 412-586-6927, or visit <http://www.rehabmedicine.pitt.edu/content.asp?id=1426>. A video demonstration of the WalkAide is available on the website of the University of Pittsburgh Rehab Neural Engineering Lab (RNEL), at <http://www.rnel.health.pitt.edu/FunctionalStimulation.htm>.

NINDS funds development of cortically controlled prosthetic hand

A research group headed by principal investigator Andrew B. Schwartz, PhD, has been awarded a five-year grant from the National Institute of Neurological Disorders and Stroke for the project "Cortical control of a dexterous prosthetic hand." Dr. Schwartz is a professor of neurobiology, bioengineering, and physical medicine and rehabilitation at the University of Pittsburgh.

The goal of the project is to develop an anthropomorphic prosthetic arm and hand that is controlled by cortical output. Given the demonstrated success of Dr. Schwartz and his colleagues in developing an anthropomorphic prosthetic arm, the researchers aim to use activity recorded from populations of single neurons to extract the signals necessary to achieve dexterous control of a prosthetic hand.

Since dexterous hand control demands control of multidimensional variables, including hand movement, position, and orientation — to name a few — attaining overall dexterous control is a very complex task.

The interdisciplinary research group includes neurophysiologists, engineers, statisticians, robotocists, and psychophysicists from the University of Pittsburgh, Carnegie Mellon University, Arizona State University, the University of Minnesota, and Columbia University.

IRR faculty members contribute to conferences

The IRR is visible at many national and international meetings. Following is a sample of topics of recent presentations by some of our faculty.

Faculty members of the UPMC Institute for Rehabilitation and Research remain active and visible at national and international meetings. Following are the titles of a few of the contributions of our faculty members.

Douglas Weber, PhD, led a workshop, "Taking control with neuroprosthetic interfaces," at the 40th Winter Conference on Brain Research in Snowmass, Col. on Jan. 27.

Patricia Arenth, PhD, had a poster presentation titled, "An fMRI study of episodic memory following traumatic brain injury," at the 35th Annual Meeting of the International Neuropsychological Society Feb. 7–10 in Portland, Ore.

Gwendolyn A. Sowa, MD, PhD, presented a lecture on Feb. 7 at the Emerging Technologies Spine Education Summit, held Feb. 7 to 10 in Telluride, Col. Dr. Sowa's topic was "The basic science of radiculopathy."

Michael C. Munin, MD, presented a lecture at the State-of-the-Science Symposium on Post-Acute Rehabilitation: Setting a Research Agenda and Developing an Evidence Base for Practice and Public Policy on Feb. 12 in Arlington, Va. Dr. Munin's lecture was entitled, "What is the best rehabilitation setting to maximize outcomes after hip fracture for community-dwelling patients with depression, apathy, or cognitive impairment?"

Association of Academic Physiatrists Annual Meeting

Several IRR faculty members addresses the assembly or participated in scholarly discourse at the annual meeting of the Association of Academic Physiatrists, held April 10 to 14 in San Juan, Puerto Rico.

Lectures

Brad E. Dicianno, MD

Force control strategies while driving electric powered wheelchairs with isometric and movement-sensing joysticks.

Ross D. Zafonte, DO

Evaluating research productivity and metric.

Poster presentations

Brad E. Dicianno, MD

Force control strategies while driving electric powered wheelchairs with isometric and movement-sensing joysticks.

Athlete participation in adaptive sports: benefits of the National Veterans Winter Sports Clinic

Wheelchair use, social integration, and mobility among adults with spina bifida.

Gwendolyn A. Sowa, MD, PhD

Intervertebral disc cells demonstrate a threshold effect in their response to mechanical strain.

Panel discussion

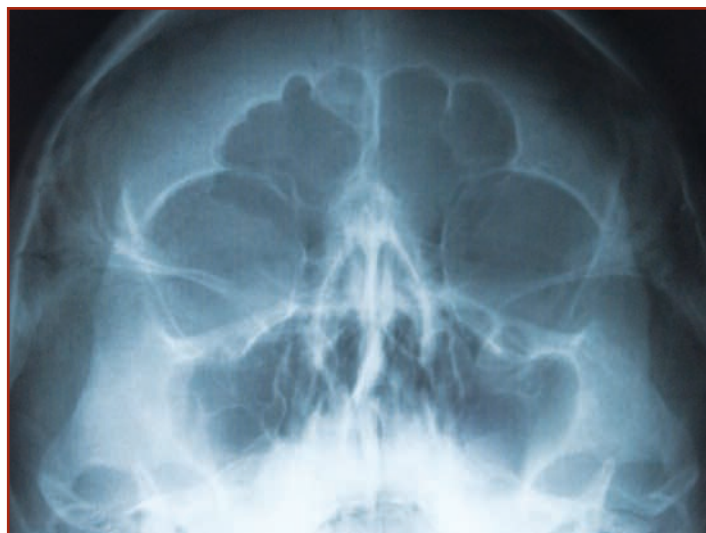
Ross D. Zafonte, DO

Academic research and education

TBI researcher wins ERF New Investigator Award

Jerry Chuang, MD, received an award from the Foundation for Physical Medicine and Rehabilitation through the Foundation's Education Research Fund (ERF) to support his study, "The Effects of Early and Daily Administration of Dilantin on Neuroprotection and Neuroplasticity in an Experimental Model of Traumatic Brain Injury." Dr. Chuang's ERF New Investigator Award was announced at the 67th Annual Assembly of the American Academy of Physical Medicine and Rehabilitation in Honolulu last November.

Dr. Chuang will complete the University of Pittsburgh Physical Medicine and Rehabilitation Residency Program in June 2007. Amy K. Wagner, MD, associate professor of physical medicine and rehabilitation, is the faculty adviser for this project.



Dr. Zafonte delivers Zeiter Lecture in Honolulu

Department Chairman Ross D. Zafonte, DO, chosen by the American Academy of Physical Medicine and Rehabilitation to receive the 2006 Walter J. Zeiter Lectureship Award, delivered the Zeiter Lecture, "Brain Injury Research — Lessons for Reinventing the Future," before a plenary session of the AAPM&R's 67th Annual Assembly in Honolulu last November.

Walter J. Zeiter, MD, served as executive director of the AAPM&R and the American Congress of Rehabilitation Medicine for 20 years. The annual Zeiter Lectureship is awarded to a physiatrist selected by the AAPM&R for having made consistent contributions to the field of physical medicine and rehabilitation. Dr. Zafonte considers the award a very great honor.

"Dr. Zeiter provided legendary leadership in the field of physical medicine and rehabilitation, and his accomplishments helped to shape the discipline," he said. "I am flattered to receive an award that celebrates his success."

Dr. Zafonte is the 38th recipient of the Zeiter Lectureship Award and the first doctor of osteopathic medicine to receive this honor.



AAPM&R president-elect David X. Cifu, MD, left, presents the 2006 Walter J. Zeiter Lectureship Award to Dr. Zafonte.

“ Dr. Zeiter provided legendary leadership in the field of physical medicine and rehabilitation, and his accomplishments helped to shape the discipline. I am flattered to receive an award that celebrates his success. ”

— Dr. Zafonte

Recently published

Following is a sample of recently published scholarly works by IRR faculty researchers.

Today's definitive work on brain injury was published early this year. Ross D. Zafonte, DO, chairman, UPMC Department of Physical Medicine and Rehabilitation, co-authored several chapters of *Brain Injury Medicine: Principles and Practice*, and was lead editor of the text. The other editors are Nathan D. Zasler, MD, and Douglas I. Katz, MD.

Several additional IRR faculty members made major contributions to this most up-to-date edition of the premier textbook on rehabilitation for patients with traumatic brain injury.

Brain Injury Medicine — Chapter contributors from UPMC IRR

Dixon CE, Kline AE. Advances in Innovative Therapies to Enhance Neural Recovery. In: RD Zafonte (author), ND Zasler, and DI Katz (eds.) *Brain Injury Medicine: Principles and Practice*. Demos Medical Publishers, New York, 2007.

Katz D, Zasler N, Zafonte R. Clinical continuum of care. In: RD Zafonte (author), ND Zasler, and DI Katz (eds.) *Brain Injury Medicine: Principles and Practice*. Demos Medical Publishers, New York, 2007.

Meythaler JM, Zafonte RD, Lombard LA. Neuropharmacology. In: RD Zafonte (author), ND Zasler, and DI Katz (eds.) *Brain Injury Medicine: Principles and Practice*. Demos Medical Publishers, New York, 2007.

Ricker JH, Arenth PM. Functional Neuroimaging. In: RD Zafonte (author), ND Zasler, and DI Katz (eds.) *Brain Injury Medicine: Principles and Practice*. Demos Medical Publishers, New York, 2007.

Wagner AK. Conducting research: current concepts and issues. In: RD Zafonte (author), ND Zasler, and DI Katz (eds.) *Brain Injury Medicine: Principles and Practice*. Demos Medical Publishers, New York, 2007.

More book chapters

Cooper RA, Boninger ML, Koontz AM, Spaeth DM, Dvorznak MJ, Cooper R, Dobson A. Biomechanics Of and Interfaces For Wheelchair Mobility. In: T Yamamoto (ed.), *Textbook of Rehabilitation Engineering*. Ishiyaku Publishers Inc., Tokyo.

Cooper RA, Boninger ML, Rice I, Shimada SD, Cooper R. Elite Athletes With Impairments. In: WR Frontera (ed.), *Exercise in Rehabilitation Medicine*, 2nd Edition. Human Kinetics Publishing, Champaign, Ill., 2006.

Cooper RA, Ding D, Cooper R, Wolf EJ, Algood SD, Corfman TA, Rentschler AJ, Boninger ML, Chaves ES. Rehabilitation Engineering: An Overview. In: *Wiley Encyclopedia of Biomedical Engineering*. John Wiley and Sons Inc., Hoboken, N.J., 2006.

Cooper RA, Ding D, Kwarcia AM, Cooper R, Guo S, Spaeth DM, Zipfel E, Kelleher A, Boninger ML. Wheelchair Engineering. In: *Wiley Encyclopedia of Biomedical Engineering*. John Wiley and Sons Inc., Hoboken, NJ, 2006.

Peer-reviewed original research articles

Cheng JP, Aslam HA, Hoffman AN, Zafonte RD, Kline AE. The neurobehavioral benefit by a single systemic administration of 8-OH-DPAT after brain trauma is confined to a narrow therapeutic window. *Neurosci Lett*. 2007 Feb 7 [Epub ahead of print].

Kline AE, Massucci JL, Zafonte RD, Dixon CE, Defeo JR, Rogers EH. Differential effects of single versus multiple administrations of haloperidol and risperidone on functional outcome after experimental brain trauma. *Crit Care Med*. 2007 Jan 23; [Epub ahead of print].

Kline AE, Wagner AK, Westergom BP, Malena RR, Zafonte RD, Olsen AS, Sozda CN, Luthra P, Panda M, Cheng JP, Aslam HA. Acute treatment with the 5-HT1A receptor agonist 8-OH-DPAT and chronic environmental enrichment confer neurobehavioral benefit after experimental brain trauma. *Behav Brain Res*. 2007;177:186–194. Epub 2006 Dec 12.

van Drongelen S, Boninger ML, Impink BG, Khalaf T. Ultrasound imaging of acute biceps tendon changes after wheelchair sports. *Arch Phys Med Rehabil*. 2007;88:381–5.

Review articles

Cooper RA, Boninger ML, Spaeth DM, Ding D, Guo S, Koontz AM, Fitzgerald SG, Cooper R, Kelleher AR, Collins DM. Engineering better wheelchairs to enhance community participation. *IEEE Trans Neural Syst Rehabil Eng*. 2006;14:438–55. Review.

Schwartz AB, Cui XT, Weber DJ, Moran DW. Brain-controlled interfaces: movement restoration with neural prosthetics. *Neuron*. 2006;52:205–20. Review.

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Department of Rehabilitation Science &
Technology
<http://www.shrs.pitt.edu/rst/index.html>

UPMC Center for Assistive Technology
<http://www.cat.pitt.edu/UPMC Health System>

Human Engineering Research Laboratories
<http://www.herlpitt.edu>

Rehab Neural Engineering Lab
<http://www.rnel.health.pitt.edu>

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