FALL 2011

UPMC REHAB GRAND ROUNDS

Accreditation Statement

The University of Pittsburgh School of Medicine is accredited by the Accreditation Council for Continuing Medical Education (ACCME) to provide continuing medical education for physicians.

The University of Pittsburgh School of Medicine designates this enduring material for a maximum of 1.0 AMA PRA Category 1 Credits™. Each physician should only claim credit commensurate with the extent of their participation in the activity. Other health care professionals are awarded 0.1 continuing education units (CEU) which are equivalent to 1.0 contact hours.

Disclosures

Doctors Shen and Leishear have reported no relationships with proprietary entities producing health care goods or services.

Instructions

To take the CME evaluation and receive credit, please visit **UPMCPhysicianResources.com/Rehab** and click on the course *Rehab Grand Rounds* Fall 2011.

Novel Techniques for Upper Extremity Training for Hemiparesis after Stroke

JENNIFER SHEN, MD
Assistant Professor
Director, Stroke Rehabilitation at UPMC Mercy
Department of Physical Medicine and Rehabilitation

KIMBERLEE LEISHEAR, DO
Resident
Department of Physical Medicine and Rehabilitation

Clinical Vignette

R.K. is evaluated for outpatient stroke rehabilitation at the UPMC Stroke Rehabilitation Center. She is a 66-year-old right-hand-dominant female who suffered an ischemic, left-middle cerebral artery stroke six months ago with residual right hemiparesis. She has a past medical history of hyperlipidemia and a remote history of tobacco use. Prior to her stroke, she ambulated independently without assistive devices. She completed a course of inpatient rehabilitation during which her spouse was actively involved in her therapy sessions and progress. She then completed home health therapy with transition to outpatient therapy for two months.

Both the patient and her husband are pleased that she is walking independently with a few modifications from baseline status. However, her main concern and source of frustration is her limited functional use of her right arm, which had not recovered as well as her leg. R.K. is hoping that a rehabilitation program can be designed to improve her arm function.

Definition of Problem

There are approximately 795,000 new or recurrent strokes every year in the United States. Of all strokes, 610,000 are classified as first event and 185,000 are recurrent events. According to 2007 mortality data, about one of every 18 deaths in the United States is due to stroke.[1] The stroke death rate during 1997–2007 decreased 44.8%, and the actual number of stroke deaths has decreased by 14.7%. For those who survive, stroke is the leading cause of disability in adults. Approximately 85% of stroke survivors present with upper limb hemiparesis and about 55% to 75% have ongoing upper limb impairment that hinders quality of life with significant disability lasting more than six months post-stroke.[2,3]

Motor Recovery after Stroke

Motor recovery in stroke hemiplegia tends to follow a typical pattern that was first described by Twitchell and Brunnstrom.[4,5] Both described an initial period of flaccid paresis associated with decreased or absent reflexes. Then, as recovery begins, synergistic activation is noted with a return of reflexes. As synergistic activation improves, there is increased voluntary activity; concurrently, hyperreflexia and spasticity can be observed. As voluntary isolated control improves, spasticity then decreases.

Of note, motor strength tends to recover initially in the proximal extremity before progressing distally, although recent studies suggest proximal and distal function may be equally impaired.[6] The pattern of recovery after middle cerebral artery stroke tends towards earlier and fuller improvement of the leg compared to the arm. This classic pattern of recovery often leads to a common question: What more can be done to facilitate recovery of the upper extremity?

The Copenhagen Stroke Study, which followed multiple outcomes via a population-based analysis, concluded that most upper extremity functional return can be expected within six to 11 weeks after the stroke.[7] A significant number of patients in this cohort had poorly functioning upper limbs, despite intensive rehabilitation, with improvements noted only if there was compensation by the unaffected arm.

Neuroplasticity and Stroke Recovery

Neuroplasticity plays an important role in stroke recovery. The ability of the brain to reorganize after an injury is key to understanding the mechanisms for how rehabilitation can improve functional recovery. Nudo demonstrated expanded and contracted areas in the M1 region that correlated to digital training tasks in normal intact primates.[8] Similar findings by Kleim demonstrated increased cortical representation in rodent motor cortices of the wrist and digit, and decreases in elbow and shoulder regions ten days after training on a skilled reaching task.[9]

Animal models also show similar cortical reorganization after brain injury. Monkey brains mapped 12 weeks after infarct in the primary motor cortex for the hand demonstrated increased representation of the hand in the premotor cortex signifying “injury-induced” plasticity. In other words, neural reorganization occurred in other sites in response to cortical damage. The degree of expansion corresponded to the degree of injury in the primary motor cortex.[10] Another study using neuroanatomical tracers demonstrated axonal sprouting near the area of injury in monkey brains as well as in more remote areas.[11]

Rehabilitation Approaches to Improve Motor Function after Stroke.

Repetitive task training is a mainstay of standard therapy and is defined as repeated practice of tasks that are functional in nature, in contrast to basic muscle strengthening. However, a Cochrane review in 2007 demonstrated that while this approach is useful for improvement in lower limb function, there is little direct advantage for upper limb function.[12] In chronic spastic hemiparesis, there is evidence that task practice combined with onabotulininumtoxinA injections is effective in improving upper limb motor function.[13]

Constraint-induced movement therapy, defined as immobilizing the non-paretic upper limb with concurrent intensive training of the paretic upper limb, was evaluated in the Extremity Constraint Induced Therapy Evaluation (EXCITE) trial.[14] This trial was a multicenter randomized intervention involving over two hundred participants and demonstrated statistically significant improvements in performance time and motor activity in patients who had strokes within three to nine months. A subsequent EXCITE study demonstrated that early intervention (three to nine months) resulted in more improvement than delayed intervention (15 to 21 months) from stroke onset.[15] A functional MRI study of eight patients who underwent two weeks of constraint-induced therapy demonstrated a decrease in activity in the unaffected motor cortex, further indicating plasticity in the normal cerebral hemisphere.[16] It should be noted that only 4% of EXCITE participants had spasticity and some residual motor function was required in the paretic limb for inclusion.

A Cochrane review in 2009 of 19 studies, including randomized control trials and quasi-randomized control trials, demonstrated a moderate effect on disability in patients who underwent constraint-induced movement therapy.[17] A subsequent review in December 2010 included more recent studies which indicated no further benefit on disability and a moderate benefit on arm motor function.[18]

More recent advancements for rehabilitation include robotic assisted therapy to target upper limb hemiparesis. Robotic therapies are defined as mechanical devices that are programmable to perform a task or a specific set of tasks, and they can be autonomous or semi-autonomous. These devices force feedback for sensorimotor rehabilitation and can measure speed, direction, and strength of voluntary activity. In addition, robotic devices provide interactive evaluation of movements and assist patients with moving their affected limb through goal-directed, predetermined movements.

A variety of robotic devices have been developed to assist with upper limb rehabilitation. The devices can target proximal or distal upper limb movements and can provide varying levels of assistance, including passive, active-assisted, active-resisted, active-constrained, and bimanual movements, depending on the degree of weakness (Table 1). A variety of robotic devices have been developed to assist with upper limb rehabilitation, and most have been designed to deliver intensive, repetitive, task-oriented movements (Table 2). There is evidence to suggest that robotic devices promote task-oriented goals and trigger reorganization of motor maps more effectively than non-practiced movements. Robotic-assisted therapy during grasping tasks increased sensorimotor cortex activation on functional MRI greater than non-practiced tasks.[19]

TABLE 1:
Levels of Assistance Provided by Robotic Devices for Rehabilitation

Passive	MMT 0–2/5	Movement externally imposed by the robot while the patient is relaxed.
Active	MMT 2–3/5	Patient initiates movement and robot provides necessary assistance along a predetermined path.
Active Resisted	MMT 3–4/5	Patient moves against robot-derived resistance.
Active Constrained	MMT 3–4/5	Robot provides resistance in the direction of the desired movement and provides restoring forces perpendicular to the movement.
Bimanual	MMT 0–5/5	Robot moves the paretic limb to the mirror image position and orientation of the unimpaired limb as measured by a digital link.

TABLE 2:
Comparison of Robotic Devices for Upper Limb Hemiparesis

	InMotion (MIT Manus)	InMotion Wrist	ARMEO	Bi-Manu-Track	MIME
Unilateral or Bilateral Training	Unilateral	Unilateral	Unilateral	Bilateral	Bilateral
Upper Limb Target	Shoulder Elbow	Wrist Forearm	Shoulder Elbow Wrist Hand	Forearm Wrist	Shoulder Elbow
Level of Assistance Provided by Robot	Passive Active-assisted Active-resisted	Passive Active-assisted Active-resisted	Passive Active-assisted	Passive Active-assisted Active-resisted	Passive Active-assisted Active-constrained

Early robot-assisted sensorimotor stimulation in acute stroke, in addition to conventional therapy, showed significant gains in recovery of shoulder abduction and elbow flexion, but not in wrist flexion. After three months of training, gains in motor function were sustained to an eight-month follow-up. There were no significant differences in muscle tone or trunk control.[20]

A bilateral computerized arm trainer called the Bi-Manu-Track uses repetitive practice of passive and active bilateral forearm and wrist movements. In a study of 44 severely paretic subacute stroke patients with no volitional activity of wrist and finger extensors, bilateral robotic training with Bi-Manu-Track, compared to EMG-initiated electrical stimulation of paretic wrist extensors, improved motor control and muscle strength. Interestingly, in this study muscle strength was improved both in proximal and distal muscle groups even though only the forearm and wrist movements were robot assisted.[21] These findings may be due to distal muscle training inducing a more powerful activation of the sensorimotor cortex because of larger cortical representation.

A robotic device called MIT-Manus (InMotion 2) is a second degree of freedom robot manipulator. It assists in shoulder and elbow movements and guides hand movements in a horizontal plane. It also provides visual, auditory, and tactile feedback during goal-assisted movements. In a study using the MIT-Manus, stroke patients with moderate to severe upper extremity hemiparesis showed improvements in shoulder and elbow function and greater recovery of ADL function compared to traditional therapy.[22]

While these studies are encouraging, other studies[23, 24] show minimal to no change in robotic-assisted therapy compared to traditional therapy for improving upper limb disability outcome measures. These findings may relate to most robotic devices focusing on proximal arm therapies, while disability from upper limb impairment is more severely impacted by loss of distal hand function and finger dexterity.

Advantage/Disadvantage of Robotic Devices

While the literature on robotic devices continues to emerge, there are issues that must be understood before offering this therapy to patients. Robotic devices are costly and require staff training. Robotic activators may potentially decrease effort and attention of the patient.[25, 26, 27] If a robotic device is performing movements that are important for a patient to do, some believe this could potentially worsen motor plasticity.[28, 29]

A passive arm orthosis, such as the ARMEO, that has no robotic activator may be less costly, safer, and appropriate for semiautonomous training. This orthosis may be ideal for patients with moderate to severe hemiparesis with less than anti-gravity motor strength. The orthosis can simultaneously measure arm movements while the patient is interacting with computer games. In chronic stroke patients, those using a passive orthosis were compared to conventional semiautonomous exercises using a table for gravity support. Both groups improved upper extremity motor control after the treatment period; however, computer-enhanced arm exercises maintained improvement significantly better than controls six months later. Participants also reported a preference for the computer-enhanced arm exercises over the traditional therapy.[30]

Conversely, there are advantages of robotic therapy that may not be intuitive. In a study performed in the Department of Veterans Affairs medical system, the average per-patient cost for robotic therapy was slightly higher at $9,977 compared to intensive non-robotic therapy at $8,269. However, over a period of 36 weeks, and factoring in overall health care costs (therapy plus general medical care), the cost per patient was not significantly different with robot-assisted therapy at $15,562 versus intensive comparative therapy at $15,605.[31] Another advantage to robotic devices is accessibility. A patient may not have access to outpatient therapy facilities. A robotic device in the patient's home would provide convenient access. Additionally, after patients complete an intensive inpatient or outpatient therapy course and are transitioning to a home exercise program, poor compliance may be a barrier to continued functional recovery. The engaging interaction that a robotic device can provide using game-like interfaces may help to maintain a patient's focus and motivation.

Future Research for Robotic Devices

Similar to other rehabilitation research questions, more studies are required to guide the most effective timing, intensity, and duration of robotic therapies. Also, the role of the therapist to assist in setting up robotic therapies should be evaluated. Most of the studies with robotic-assisted therapies have a low sample size, and future studies with a larger number of patients may detect smaller but clinically relevant treatment effects. Thus far, robotic devices have focused on proximal arm movements rather than distal muscle groups, which may not result in significant improvement in function. Devices that target the hand and fingers, for example, may potentially help with fine motor control. A comparison of more than one device would help to define specific indications for each device.

What's next? Looking ahead

While there are expected to be more studies and utilization of robotic devices, there also are other trends in rehabilitation that will emerge, including virtual reality and the use of gaming systems. In a small study, a virtual reality interface in patients with post-stroke upper limb hemiparesis exhibited improvements in hand function, specifically in finger movement and speed.[31] A meta-analysis performed in 2010 demonstrated that virtual reality as an adjunctive therapy resulted in improved motor function in observational studies.[32] Henderson's review of virtual reality for upper limb motor recovery indicated that the evidence is limited, though "sufficiently encouraging to justify further research."[33]

The Nintendo Wii™ gaming system also has provided an accessible adjunct to standard therapy practice. A pilot study published in 2011 studied seven stroke patients and five healthy patients who underwent one hour of Wii for 10 consecutive weekdays. Interestingly, all stroke patients demonstrated functional improvements, including decreased (faster) performance time on the Wolf Motor Function Test task and increased (better) scores in the mean Motor Activity Log. The healthy controls did not have any significant change regardless of their improvement for the Wii game itself.[34] Another study compared Wii to standard recreational therapy showing significant improvement in the Wolf Motor Function Task and stroke severity score compared to controls.[35]

Clinical Vignette Outcome

R.K. was referred for outpatient therapy using the ARMEO device for robotic-assisted therapy. She utilized an overhead sling suspension system with gravity assistance in a three-dimensional workspace to allow for full range of motion. She was able to stay motivated with the fun, engaging experience that the device provided. She participated in two hours of ARMEO training a day, three days per week for a total duration of eight weeks. Three months after she began training with the device, she was able to significantly improve her motor strength and function, especially with upper body dressing and grooming. Even though residual paresis remained, she was thrilled with her improvements in activities of daily living and overall independence.

Reference List

1. Rosamond W et al. Heart Disease and Stroke Statistics 2007 Update: A Report From the American Heart Association Statistics Committee and Stroke Statistics Subcommittee. *Circulation*. 2007; 115: e69-e171.
2. Nichols-Larsen DS, Clark PC, Zeringue A, Greenspan A, Blanton S. Factors influencing stroke survivors' quality of life during subacute recovery. *Stroke*. 2005; 36: 1480-1484.
3. Lai SM, Studenski S, Duncan PW, Perera S. Persisting consequences of stroke measured by the Stroke Impact Scale. *Stroke*. 2002; 33:1840-1844.
4. Twitchell TE. The restoration of motor function following hemiplegia in man. *Brain*. 1951;74:443-80.
5. Brunnstrom S. Motor testing procedures in hemiplegia: based on sequential recovery stages. *Phys Ther*. 1966;46:357-75.
6. Beebe JA, Long CG. Absence of a proximal to distal gradient of motor deficits in the upper extremity early after stroke. *Clinical Neurophysiology* 119 (2008) 2074–2085.
7. Nakayama H, Jorgensen HS, Raaschou HO, Olsen TS. Recovery of upper extremity function in stroke patients: the Copenhagen Stroke Study. *Arch Phys Med Rehabil*. 1994 Apr;75(4):394-8.
8. Nudo RJ, Milliken GW, Jenkins WM, Merzenich MM. Use-dependent alterations of movement representations in primary motor cortex of adult squirrel monkeys. *J Neurosci*. 1996;16:785-807.
9. Kleim JA, Barbay S, Nudo RJ. Functional reorganization of the rat motor cortex following motor skill learning. *J Neurophysiol*. 1998;80:3321-3325.
10. Frost SB, Barbay S, Friel KM, et al. Reorganization of remote cortical regions after ischemic brain injury: a potential substrate for stroke recovery. *J Neurophysiol*. 2003;89:3205-3214.
11. Dancause N, Barbay S, Frost SB, et al. Extensive cortical rewiring after brain injury. *J Neurosci*. 2005;25:10167-10179.
12. French B, Thomas LH, Leathley MJ, Sutton CJ, McAdam J, Forster A, Langhorne P, Price CI, Walker A, Watkins CL. Repetitive task training for improving functional ability after stroke. *Cochrane Database Syst Rev*. 2007 Oct 17;(4):CD006073.
13. Weber DJ, Skidmore ER, Niyonkuru C, Chang CL, Huber LM, Munin MC. Cyclic functional electrical stimulation does not enhance gains in hand grasp function when used as an adjunct to onabotulinumtoxinA and task practice therapy: a single-blind, randomized controlled pilot study. *Arch Phys Med Rehabil*. 2010 May;91(5):679-86.18.
14. Wolf SL, Winstein CJ, Miller JP, Taub E, Uswatte G, Morris D, Giuliani C, Light KE, Nichols-Larsen D; EXCITE Investigators. Effect of constraint-induced movement therapy on upper extremity function 3 to 9 months after stroke: the EXCITE randomized clinical trial. *JAMA*. 2006 Nov 1;296(17):2095-104.

15. Wolf SL, Thompson PA, Winstein CJ, Miller JP, Blanton SR, Nichols-Larsen DS, Morris DM, Uswatte G, Taub E, Light KE, Sawaki L. The EXCITE stroke trial: comparing early and delayed constraint-induced movement therapy. *Stroke*. 2010 Oct;41(10):2309-15. Epub 2010 Sep 2.

16. Dong Y, Dobkin BH, Cen SY, Wu AD, Winstein CJ. Motor cortex activation during treatment may predict therapeutic gains in paretic hand function after stroke. *Stroke*. 2006 Jun;37(6):1552-5. Epub 2006 Apr 27.

17. Sirtori V, Corbetta D, Moja L, Gatti R. Constraint-induced movement therapy for upper extremities in stroke patients. *Cochrane Database Syst Rev*. 2009 Oct 7;(4):CD004433.

18. Corbetta D, Sirtori V, Moja L, Gatti R. Constraint-induced movement therapy in stroke patients: systematic review and meta-analysis. *Eur J Phys Rehabil Med*. 2010 Dec;46(4):537-44.

19. Takahashi CD, Der-Yeghiaian L. Le, Motiwala RR, Cramer SC. Robot-based hand motor therapy after stroke. *Brain*. 2008; 131: 425-437.

20. Masiero S, Celia A, Rosati G, Armani M. Robotic-induced rehabilitation of the upper limb after acute stroke. *Arch Phys Med Rehabil*. 2007 Feb; 88 (2): 142-9.

21. Hesse S, Werner C, Pohl M, Rueckrem S, Mehrholz J, Lingnau ML. Computerized arm training improves the motor control of the severely affected arm after stroke: A single-blinded randomized trial in two centers. *Stroke*. 2005; 36(9): 1960-66.

22. Volpe BT, Krebs HI, Hogan N, Edelstein L, Diels C, Aisen M. A novel approach to stroke rehabilitation: Robot-aided sensorimotor stimulation. *Neurology*. 2000; 54 (10): 1938-1944.

23. Lo AC, Guarino PD, Richards LG, et al. Robot-assisted therapy for long-term upper-limb impairment after stroke. *N Eng J Med*. 2010; 362: 1772-83.

24. Krebs HI, Ferraro M, Buerger SP, Newbery MJ, Makiyama A, Sandmann M, Lynch D, Volpe BT, Hogan N. Rehabilitation robotics: pilot trial of a spatial extension for MIT-Manus. *J Neuroengineering Rehabil*. 2004; 1: 5.

25. Kahn LE, Zygman ML, Rymer WZ, Reinkensmeyer DJ. Robot-assisted reaching exercise promotes arm movement recovery in chronic hemiparetic stroke: a randomized controlled pilot study. *J Neuroeng Rehabil*. 2006; 3: 12.

26. Stein J, Krebs HI, Frontera WR, Fasoli SE, Hughes R, Hogan N. Comparison of two techniques of robot-aided upper limb exercise training after stroke. *Am J Phys Med Rehabil*. 2004; 83: 720-28.

27. Fischer HC, Stubblefield K, Kline T, Luo X, Kenyon RV, Kamper DG. Hand rehabilitation following stroke: a pilot study of assisted finger extension training in a virtual environment. *Top Stroke Rehabil*. 2007; 14: 1-12.

28. Israel JF, Campbell DD, Kahn JH, Hornby TG. Metabolic costs and muscle activity patterns during robotic- and therapist-assisted treadmill walking in individuals with incomplete spinal cord injury. *Phys Ther*. 2006; 86: 1466-1478.

29. Wolbrecht ET, Chan V, Reinkensmeyer DJ, Bobrow JE. Optimizing compliant, model-based robotic assistance to promote neurorehabilitation. *IEEE Trans Neural Syst Rehabil Eng*. 2008; 16: 286-297.

30. Housman SJ, Scott KM, Reinkensmeyer DJ. A randomized controlled trial of gravity-supported, computer-enhanced arm exercise for individuals with severe hemiparesis. *Neurorehabilitation and Neural Repair*. Feb 23, 2009.

31. Merians AS, Fluet GG, Qiu Q, Saleh S, Lafond I, Davidow A, Adamovich SV. Robotically Facilitated Virtual Rehabilitation of Arm Transport Integrated With Finger Movement in Persons with Hemiparesis. *J Neuroeng Rehabil* 2011, 8: 27.

32. Saposnik G, Levin M. Outcome Research Canada (SORCan) Working Group. Virtual reality in stroke rehabilitation: a meta-analysis and implications for clinicians. *Stroke*. 2011 May;42(5):1380-6. Epub 2011 Apr 7.

33. Henderson AH. Virtual reality in Stroke Rehab: a systematic review for upper motor recovery. *Top Stroke Rehabil* 2007: 14(2):52-61.

34. Mouawad MR, Doust CG, Max MD, McNulty PA.Wii-based movement therapy to promote improved upper extremity function post-stroke: A pilot study. *Rehabil Med*. 2011 May;43(6):527-33.

35. Saposnik G, Teasell R, Mamdani M, Hall J, McIlroy W, Cheung D, Thorpe KE, Cohen LG, Bayley M. Stroke Outcome Research Canada (SORCan) Working Group. Effectiveness of virtual reality using Wii gaming technology in stroke rehabilitation: a pilot randomized clinical trial and proof of principle. *Stroke*. 2010 Jul;41(7):1477-84. Epub 2010 May 27.

ADDRESS CORRESPONDENCE TO:

Michael C. Munin, MD
Senior Editor and Vice Chairman
Clinical Program Development
Department of Physical Medicine and Rehabilitation

Kaufmann Medical Bldg.
Suite 201
3471 Fifth Ave.
Pittsburgh, PA 15213
T: 412-648-6848
F: 412-692-4410
E-mail: muninmc@upmc.edu

ONLINE CME OPPORTUNITIES

Psychiatric Aspects of Medical Rehabilitation

Dr. Ellen Whyte, board-certified geriatric psychiatrist and assistant professor at the University Of Pittsburgh School Of Medicine in the Department of Psychiatry and in the Department of Physical Medicine and Rehabilitation, examines major depression in patients undergoing medical rehabilitation following disease or injury.

Move It or Lose It: The Complications of Immobility

Dr. Gwendolyn Sowa examines the potential complications of immobility for the musculoskeletal, neurologic, respiratory, cardiovascular, and other organ systems. The presentation discusses the physiologic benefits of exercise on bone and cartilage in immobile patients, as well as the design and implementation of appropriate treatment plans for patients with immobility.

Management of Spastic Hypertonia: Current Concepts

Dr. Michael Munin, medical director of UPMC's Spasticity Evaluation and Treatment Center, addresses the presentation and pathophysiology of patients with spastic hypertonia.

UPMCPhysicianResources.com/ Rehab

UPMC is a $9 billion global health enterprise with more than 50,000 employees headquartered in Pittsburgh, Pa., and is transforming health care by integrating more than 20 hospitals, 400 doctors' offices and outpatient sites, a health insurance services division, and international and commercial services. Affiliated with the University of Pittsburgh Schools of the Health Sciences, UPMC is redefining health care by using innovative science, technology, and medicine to invent new models of accountable, cost-efficient, and patient-centered care. For more information on how UPMC is taking medicine from where it is to where it needs to be, go to UPMC.com.

About the Department of Physical Medicine and Rehabilitation

- UPMC is ranked by *U.S. News and World Report* as one of the top hospitals in the country for rehabilitation.
- The Department of Physical Medicine and Rehabilitation is a top recipient for NIH funding for rehabilitation-related research.
- The Spinal Cord Injury Program at UPMC is one of only 14 in the country selected by the National Institute on Disability and Rehabilitation Research as a model for other rehab providers.
- Department clinicians lead UPMC's rehabilitation network of more than 70 inpatient, outpatient, and long-term care facilities — one of the country's largest.

Learn more about how UPMC is transforming rehabilitation.

USNW403259 CK/LG 09/11