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1 Targeting the Brain's Plasticity to Improve Stroke Recovery

1 Real Time with Musculoskeletal Ultrasound: Clinical and Educational Applications



Ultrasound of rotator cuff tear

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Targeting the Brain's Plasticity to Improve Stroke Recovery

The plasticity of the brain and its ability to change experience over time is what drew Heidi M. Schambra, MD, to become a neurologist. "It is just phenomenal," says Dr. Schambra, a specialist in neurorehabilitation in the Department of Rehabilitation and Regenerative Medicine at NewYork-Presbyterian/Columbia University Medical Center. "Our goal is to harness that plasticity to the advantage of the patient in a more accelerated and more complete way."

The Department of Rehabilitation and Regenerative Medicine at NewYork-Presbyterian Hospital, under the leadership of Joel Stein, MD, has made a major commitment to stroke research – at both the laboratory and clinical levels – including its stem cell initiative and robotic approaches to exercise therapy. "However, exercise therapy alone doesn't seem to give us the gains that we need," says Dr. Stein. "We know that the brain is able to rewire itself to some extent after stroke, but that



Dr. Joel Stein

rewiring is not sufficient to restore normal function in most people. We're interested in finding out how to enhance the brain's underlying ability to recover. The disability that results from stroke is so large that even the smallest improvements can affect a lot of people."

In her research, Dr. Schambra seeks to identify the changes that occur in the brain after a stroke from plasticity. "In particular, I'm looking at how a patient's neurophysiology

changes over the course of recovery," she says. "For instance, we're closely examining the inhibitory and excitatory circuitry of the brain. We're identifying what normally occurs in the longitudinal course of recovery, and then we'll go after what we think may be pathological or beneficial. Using neuromodulation, we will either down-regulate them or enhance them, with the aim to improve the recovery process. The goal is to restore nearly all, if not all, of premorbid function."

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Real Time with Musculoskeletal Ultrasound: Clinical and Educational Applications

Ultrasound is rapidly becoming a widely accepted imaging modality for diagnostic and interventional uses in a number of specialties, including obstetrics, cardiology, and more recently, emergency medicine. "While ultrasound has been around for a while, musculoskeletal ultrasound is a fairly recent addition to the sports medicine and musculoskeletal medicine practitioner's repertoire," says Christopher J. Visco, MD, Department of Rehabilitation and Regenerative Medicine, NewYork-Presbyterian/Columbia University Medical Center. Dr. Visco, who specializes in sports and musculoskeletal medicine and the applications of diagnostic and interventional musculoskeletal ultrasound, is also a registered musculoskeletal sonographer.

In addition, he serves as the Department's Associate Residency Program Director and Sports Medicine Fellowship Director.

Clinical Applications

"From a musculoskeletal standpoint, the clinical purpose of ultrasound is for rapid assessment and utilization in point-of-care decision-making," says Dr. Visco. "It often happens that additional imaging will be needed when a patient comes to my office. In some circumstances for certain diagnoses, such as rotator cuff pathology, with ultrasound I can determine during that office visit – with extremely high sensitivity and specificity – if there is or is not a rotator cuff tear."

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Targeting the Brain's Plasticity to Improve Stroke Recovery *(continued from page 1)*



Dr. Heidi M. Schambra

Dr. Schambra believes that stroke recovery requires a multifaceted approach – from restoring the lost neural substrate to enhancing plasticity in the remaining neurons. Her expertise is in the latter, with a particular focus on neuromodulation in motor systems. “We want to promote the unmasking of latent synapses, and to reinforce existing synapses,” says Dr. Schambra. “In the end, the goal is not to just have patients move,

but to have them move with control.”

Enlisting Transcranial Direct-Current Stimulation

Motor skills can take weeks to months to acquire and can diminish over time in the absence of continued practice. Thus, strategies that enhance skill acquisition or retention are of great scientific interest. According to Dr. Schambra, the area around the brain lesion, the penumbra, generally retains very active and capable neural networks that are likely able to take over some of the function lost after stroke.

In fact, she reports, these areas show even heightened plasticity following stroke. “We know that there’s a biological recovery process that occurs even without specific therapies targeting recovery. My approach is to target those penumbral areas in order to enhance the natural plasticity that’s already occurring post stroke. We want to enhance that innate neuroplasticity through neuromodulation and medication,” says Dr. Schambra.

Much of Dr. Schambra’s research centers on transcranial direct-current stimulation (tDCS), a low-intensity electrical current applied to the surface of the head. One to two milliamperes passed through two electrodes for 20 minutes increases neuronal excitability. Her study models are non-stroke patients who do not have a deficit, but rather are learning a new skill from scratch. “We use motor skill learning – learning how to move in a new, capable way – as a model for re-learning how to move after stroke. What we’ve shown in the past is that applying tDCS during the training of a new motor task enhances the amount of the skill that’s acquired,” she says. “And that increased level of skill is maintained months after the stimulation and practice has stopped.”

Stimulation alone, however, is not enough to provide benefit, says Dr. Schambra. “You have to train and you have to move volitionally during the stimulation,” she says. “tDCS doesn’t make neurons fire, but it brings them closer to their firing potential. So if they’re attempting to fire because the patient is trying to move, this stimulation makes it easier for them to achieve this threshold. Ultimately, successful neuronal firing results in long-lasting neuroplastic change, consistent with the Hebbian notion of ‘fire together, wire together.’”

Animal studies have also shown that applying electrical stimulation during an input produces a long-term potentiation effect – the “footprint of a memory” in the brain. “We think that is the underlying basis for how learning is improved and locked

down during tDCS,” says Dr. Schambra. “In addition, we are seeing an expression of a particular type of protein, BDNF [brain-derived neurotrophic factor], which is a supportive protein that not only stabilizes synapses, but also enhances synaptic formation.

“It’s a fairly new technique, still exploratory, and still in the research domain,” says Dr. Schambra. “Even now, we’re defining the optimal stimulation parameters for tDCS. We’re sorting out duration, the dose, the frequency, and the timing of stimulation, particularly after stroke. Most of our research is occurring in the laboratory, where we are identifying the best approach to help potentiate learning and re-learning.”

Dr. Schambra acknowledges that there is a large gap between animal brain studies and human behavior. “But what we are seeing from basic research in the last few years is beginning to give us some mechanistic insight into why tDCS during training could be so helpful for motor skill learning and motor recovery after stroke,” she says.

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— Dr. Heidi M. Schambra

Unlike other neuromodulatory methods, tDCS is a practical device, inexpensive, and easy to apply. “It’s also well-tolerated, with just a little tingling on the scalp when the initial current starts. It doesn’t induce seizures, and it’s safe,” says Dr. Schambra. “Once we define the exact paradigm that would offer maximum outcomes, it should be very simple to take tDCS to the clinical domain.”

In fact, planning is now underway for a multicenter clinical trial looking at the use of transcranial stimulation as a therapeutic tool. The study seeks to determine if combining non-invasive brain stimulation with intensive exercise can provide greater benefits than exercise alone. “This approach to prime the brain to form new connections and enable the exercises to have a greater therapeutic effect holds the promise of being a potent tool for stroke recovery,” says Dr. Stein.

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Dr. Christopher J. Visco with Dr. Carolyn Thompson, fourth-year resident

“Knowing that dramatically adds to the clinical value of the visit,” says Dr. Visco. “I can make a decision as to whether an intervention needs to be performed. For example, if there’s a large bursitis that requires an injection, I can then transition to the second portion of ultrasound, which is applying it to interventions. So it’s extremely helpful for diagnostic purposes that rival MRI for certain conditions. And it can also help me to specifically guide an intervention to an area that improves the accuracy of applying that intervention, including platelet-rich plasma injections and injections of other biologic therapies.”

Ultrasound also enables the clinician to start treatment immediately, while providing a cost savings. “If someone comes to see me with a shoulder problem that is amenable to imaging using ultrasound, I can avoid ordering other imaging modalities; thus, healthcare dollars are saved,” says Dr. Visco. “Musculoskeletal ultrasound is a fraction of the cost of an MRI. And if further imaging is warranted, I can save the patient from the time delay in getting it.”

As a Teaching Tool

In his role as an educator, Dr. Visco notes that his goal is to use musculoskeletal ultrasound to make education better. Typically medical students learn anatomy using cadavers and educational modules. “Most modern medical school curricula incorporate dissection, along with radiology and some physical exams as well,” notes Dr. Visco. “What we’ve done here at Columbia University is bring ultrasound into the anatomy lab for the sections that the students are not dissecting. I’m not necessarily looking to educate medical students in how to use ultrasound; I want them to learn anatomy better.”

In identifying bone structures or soft tissue structures, says Dr. Visco, the medical students sit in groups and often correlate what they are learning with each other. “Using the shoulder, for instance, they’ll pick up the scapula and palpate the acromion. When they palpate it they can feel it on each other. They can also look at the bone and think about it. We can then put the ultrasound on the body to see if where they palpate correlates with the actual structure. So, the students have an opportunity to reinforce the anatomic knowledge that they’re being asked to understand.”

An important component of training residents in what it means to be a physiatrist occurs in the musculoskeletal realm. “When educating them on the vast variety of musculoskeletal conditions that can occur, it’s often beneficial to use ultrasound as a stepping stone to learn not only the anatomy, but also to learn the dynamic movements of the body and its joints,” he says. “Ultrasound can evaluate with real time dynamic imaging. We study a different segment each month – the hip, knee, shoulder, elbow, hand, wrist, and the spine.”

A second session each month incorporates hands-on training during which residents spend two hours practicing physical examination and clinical evaluation skills. “We ask them to really hone in on how they are assessing a joint,” says Dr. Visco. “If we use the knee we may ask them to perform all of the provocative maneuvers for the knee that would allow them to excel at clinical assessment. The residents rotate among six attending physicians who teach in small groups. One group will go through very specific educational modules in ultrasound to gain practical experience assessing that joint. This will help them understand how their physical examination and palpatory skills correlate to the structures that they’re studying.”

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— Dr. Christopher J. Visco

Ultrasound is also incorporated into resident education during clinical rotations. “On a clinical rotation, residents have an opportunity to utilize ultrasound to help them as they’re simultaneously developing their diagnostic and treatments skills,” says Dr. Visco. “For example, ultrasound can help a resident who is trying to define whether an ankle swelling is coming from deep in the ankle of the joint itself or from surrounding tendons. Any piece of data or information that you can integrate into findings on a clinical assessment of a patient can be extremely helpful when developing a diagnosis and treatment plan. We are looking at a shift in the way that we’re educating our trainees, moving away from rote memorization, which is insufficient to the clinical application of good medicine.”

In addition, ultrasound is now included during training for residents and fellows in different procedures. “Whereas previously we would routinely do our procedures without ultrasound guidance for peripheral joints and tendons, we now often use ultrasound, which allows us to be extremely accurate,” says Dr. Visco.

“Crossing over from knowledge to hands-on procedural-based skills, such as the skill of manipulating a transducer in your hand or being able to work with a needle or a scalpel, takes time,” he says. “The learning curve for ultrasound is often on the order of several years to become really proficient. Knowing what you need to do comes quickly, but the ability to actually effect that in a skill-based form develops gradually.”

“Ultrasound is a great tool for dynamic imaging,” says Carolyn Thompson, MD, a fourth-year resident in Rehabilitation Medicine. “It can be done in the office with the patient, who can also ask

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Advances in Rehabilitation Medicine

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questions at the same time. With other tests the patient has the test done at another site and then comes back for the results. With ultrasound, everything can be done in one place in one day.

“We’re also able to use it for procedures, such as knee and shoulder injections, where you’re able to see the needle in real time as it goes into the area you are targeting,” she says. “This is safer and it can also be more effective. More and more people are doing this, but not enough people are really good at it. That’s what I want to learn from Dr. Visco.”

In Future Practice

Dr. Visco believes that acquiring ultrasound skills will be critical to the development of a clinician practicing musculoskeletal medicine. “It’s not enough to just be able to acquire and interpret

images,” he says. “The real key here is the ability to integrate the findings with patient care and apply that knowledge in a busy, clinical setting. As we watch the evolution of musculoskeletal and sports medicine over the next several years, I think we are going to see more applications of musculoskeletal ultrasound. It is incumbent upon us as educators to bring the youngest and the brightest into the fold with that education. And as clinicians we must practice in a way where we can save healthcare dollars and provide care as efficiently and as rapidly as possible. There is a very large role for ultrasound in meeting these goals.”

For More Information

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