Repairing the Injured Brain: Why Proper Rehabilitation is Essential to Recovering Function.

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The Bridge to a Meaningful Recovery

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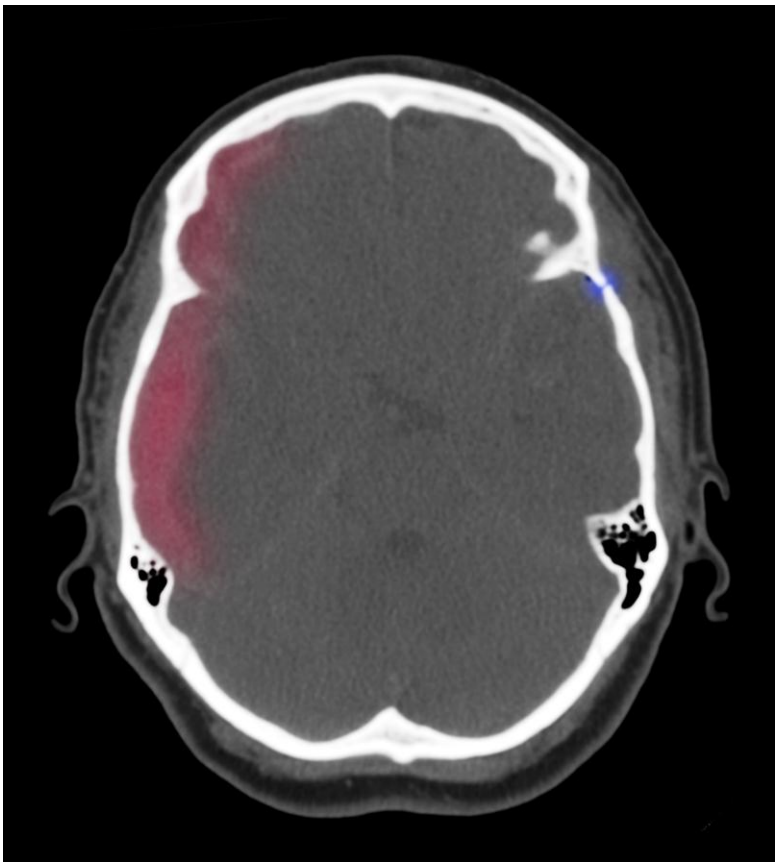

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Editor's note: Recovery from a brain injury is a slow process with no obvious end point—a practical dilemma for patients, caregivers, and medical professionals. While research continues to advance the field to determine optimal interventions (see this complementary article on the neurobiology of injury), front-line providers, like author Mark J. Ashley, founder and CEO of the Centre for Neuro Skills, have found that certain rehabilitation environments and procedures encourage a stronger recovery than others. But even as specialized facilities make strides, many people face barriers to adequate care.

Article available online at http://dana.org/news/cerebrum/detail.aspx?id=39258

A complementary article, "The Neurobiology of Brain Injury" is available online at http://dana.org/news/cerebrum/detail.aspx?id=39280

People who incur a brain injury face a lifetime of challenges. First, many patients are plagued with persistent cognitive, communicative, physical, social, vocational, educational, and psychological issues. Second, brain injury can initiate a number of neurophysiological processes that, in turn, can lead to the development of neurodegenerative and neuroendocrine disorders.[1, 2] Third, a person often recalls his capabilities before he was injured and is confronted by new limitations every day. Many rehabilitation approaches don't include psychological treatment that can help people develop appropriate coping strategies. Since most people with brain injury live a nearly normal life span (the overall average is seven years decreased life expectancy), they and their families face many serious chronic challenges.[3, 4] Unlike many health conditions—appendicitis, for instance—which have a clear clinical pathway of surgical excision and physical recovery, brain injury treatment does not have an obvious or predictable end point.[5] The road to recovery can be long, but specialized rehabilitation methods can bring about improvement.

Built-in Pathways to Recovery

After injury, the brain's metabolism first adjusts and normalizes. Surviving structures compromised by injury return to their proper functions, and patients see some improvement. But brain functions that depended on structures that did not survive the injury do not quickly improve. The phenomenon of unmasking, by which existing structures find alternate pathways to help recover lost function, may enable the patient to recover some skills. For example, damage to the motor area in the right side of the brain that controls movement of the left arm may result in recruitment of cells in the corresponding motor area of the opposite side of the brain, where motor control of the left arm resides. In time, unmasking gives way to development of new structures. Regenerative developments stem from the brain's plasticity, its ability to change structurally and functionally. Mechanisms of plasticity include the creation of new neurons (neurogenesis), synapses (synaptogenesis), glial cells (gliogenesis), and blood vessels (angiogenesis), along with genetic changes.

To support regenerative processes, the brain increases production of trophic (growth) factors in response to injury. Additionally, increased use of a neural region can result in heightened focal trophic factor expression. Trophic factors enhance both the repair of injured structures and the creation of new neurological structures to enable reacquisition of function,

especially under ideal environmental conditions. In fact, when torn, axons, which carry signals from one neuron to others, can be repaired by glial cells in the vicinity. Further, physical exercise can result in an increase in expression of trophic factors, while stress and poor diet can result in a decrease in trophic factor production.[6, 7]

The Importance of Environment to Repair

Environment plays a crucial role in promoting neurological recovery of function. As the brain adjusts, its use of newly acquired function drives plastic change, while disuse of other areas diminishes changes. If the patient is encouraged to use an unimpaired arm rather than an impaired arm, the number of neurons assigned to the unimpaired extremity actually increases in response to use. This is counterproductive, as those same cells might be better recruited by demand for use of the impaired arm. It is important to promote the best motor patterns while facilitating use of the impaired arm so as not to learn abnormal motor patterns. Not only does the nature of the treatment stimulus matter, but the degree to which the environment demands and allows use of the function is important as well.

Doctors and therapists must facilitate plasticity by ensuring the correct level of environmental demand at the correct times in the recovery process. The brain reprograms existing neural structures to take on some function and develops new structures to take on new function in direct response to environmental demand. Not all plasticity is adaptive or desirable; some is maladaptive. The brain, however, cannot judge whether these functions will be adaptive or maladaptive. For example, the brain will learn a well-executed motoric movement sequence and a poorly executed sequence equally well. Reinforcement paradigms interact with the central nervous system to influence which functions will be acquired. Since the brain is primed to learn to represent function, care must be taken to ensure that the only stimuli presented are those that will encourage adaptive or pro-social functions, lest the wrong functions or responses be learned. Traditionally, clinicians accomplish this by placing a patient in a structured rehabilitation environment that determines the nature of treatment based on the patient’s responses.

Best Practices for Rehabilitation

As a patient starts to improve, the intensity of therapies increases, going from minutes to hours in acute-care settings. After the acute-care setting, therapy can exceed three hours per day. As maladaptive behaviors emerge, such as avoiding the use of a weakened arm, therapists must extinguish them and replace them with adaptive behaviors, like making the effort to use a weakened limb. Therapists must know the best pattern and order of skill development and acquisition. Many patients, for example, can learn to walk fairly early after injury, but their balance and protective reactions are often delayed or absent. When these patients walk and lose balance, they may seriously injure themselves because they lack the appropriate reflex reactions. That's one reason treatment provided in highly specialized rehabilitation settings usually leads to better results.[8]

Treatment facilities should employ a host of factors to ensure maximal recovery. The environment must provide positive reinforcement and extinction paradigms to promote learning. Doctors should use pharmacological and neuroendocrine strategies to facilitate the creation of new neurological structures and cortical reorganization, alongside traditional physical, occupational, speech, or cognitive therapies.[9-11] An environment that does not provide properly integrated pharmacotherapeutic interventions may hinder meaningful recovery.

The application of pharmacologic adjuvant therapies requires better characterization to determine how we might accelerate the rate of recovery or further its extent. Amphetamine administration in concert with therapy may enhance and accelerate the rate and extent of recovery of motor function.[12] Similarly, the drug fluoxetine may exert a complementary effect on motor recovery in some stroke patients.[13] New horizons now exist for addressing sleep disorders, which often develop after acquired brain injury and which most probably exert a detrimental influence on recovery and may play a role in the progression of neurodegenerative or other neurological diseases.[12] Similarly, a better understanding of the role of inflammatory processes that may be unleashed following brain injury could lead to better therapy options. It is time for medical science to delve deeply into metabolic and neurophysiologic function and facilitation in the management of acquired brain injury as a chronic disease.

Emerging evidence suggests that patients with non-TBI brain injury may require different levels and types of stimulus to achieve neural representation, which refers to assignment of

functions to specific brain cells or networks of cells.[13] For example, stimulus intensity, frequency, and duration must be greater for neurons to learn function after a traumatic brain injury compared to a stroke. It is important to assess whether patients can achieve maximal recovery by various forms of treatment, like less-intensive outpatient versus more-intensive inpatient treatment regimens. Placement in a setting that fails to provide a sufficient dose of rehabilitative interventions can result in a self-fulfilling prophecy of no recovery.

Treatment paradigms must be studied to determine precise dose-response relationships that maximally impact recovery economically. Consider, for example, prescribing an anti-hypertensive medication for a patient with high blood pressure. If the compound is not taken in the appropriate strength or is not taken daily, the drug cannot be expected to effectively control blood pressure. Similarly, rehabilitation therapies need to be appropriately dosed. Therapies that are conducted one or two times a week are unlikely to be of sufficient dose to facilitate neurological re-modeling. It has been shown that in order for neurons to learn a specific motor function, that motor function must be repeated hundreds of times. Imagine now all the functions that must be reacquired after an injury to the brain. The brain appears to respond preferentially to combination approaches that include pharmacological, neuroendocrine, orthonutrient (dietary factors), and other adjuvant treatments in addition to traditional therapies as compared to any one type of therapy alone.[7, 11-13]

Simply put, the process of reacquisition of function requires a complex application of properly designed and executed therapies of sufficient intensity and duration. Improper care can cause patients to develop costly and unnecessary complications—and may permanently prevent them from obtaining the fullest possible recovery. Patients should be placed in treatment settings where clinicians have a deep understanding of therapeutic timing, dosing, and duration.

The Long Road to Accessible Rehabilitation

Rehabilitation, as a defined benefit in health insurance contracts, had its origins in orthopedic and musculoskeletal diagnoses. When medical science advanced to the point that doctors could save patients with acquired brain injuries in larger numbers, new rehabilitation tactics had to be developed.

Treatment of people with acquired brain injury is highly specialized and poorly understood by practitioners in the general medical and allied health fields. Outcomes for treatment in general rehabilitation settings have been shown to be less effective than those in specialized settings.[8] Further, treatment intensity and duration in hospital and skilled-nursing facilities cannot be maximized to the point required for optimal recovery, nor do these environments provide appropriate demand or context to allow efficient and effective learning or generalization of learning. Researchers have not been able to identify a ceiling for treatment intensity.[14] It appears that more therapy is better than less, though researchers have not systematically evaluated this observation.[14-17] In the last 30 years, highly specialized Transitional Residential Rehabilitation facilities have emerged that extend rehabilitative treatment beyond hospital and skilled nursing settings. These facilities are designed to maximize therapeutic contact, which is conducted in settings that mirror real-world environments so as to facilitate rapid skills re-acquisition. Medical treatment may be less intensive in these settings, as the patient has medically stabilized from the initial injury, while rehabilitative treatments become far more intensive since the patient can tolerate more rigorous programming. These alternative medical treatment delivery settings may or may not be covered by health insurers.

Insurance contracts and the manner in which they are applied, however, limit treatment only to hospital, skilled-nursing, or outpatient settings and limit the amount of treatment available in each of these settings. In the last category, the benefit frequently allows only a constrained time frame, typically 20 to 24 visits per year, which, while generally sufficient for most musculoskeletal and orthopedic conditions, is hardly sufficient for neurological rehabilitation. Oddly, insurance contracts do not impose similar time constraints on care for any other injured or diseased organ system. Cancer, for example, is not treated for 60 days with no further benefits available, as often occurs with brain injury. Treatment rendered to well-known individuals, such as Congresswoman Gabrielle Giffords or ABC News reporter Bob Woodruff, provides testament to what is possible and what should be done. Their treatment was specialized, intensive, of sufficient duration, and not arbitrarily financially constrained.

Care and treatment for brain injury may be required across the life span. The degree to which this is true for each patient will depend upon the nature and extent of the injury, access to properly timed expert treatment of sufficient intensity and duration, surveillance, preventive or

early interventions for neurodegenerative conditions, and the degree to which a person can meaningfully reengage in his daily life. In this new era of predetermined clinical pathways, this uncertainty creates a practical dilemma for patients, their families, professionals, and payers. We cannot yet predict what the end of recovery will look like for any given patient. We can recognize the end point only when treatment fails to produce additional recovery of function over a period of time.[18] Nevertheless, it is clear that specialized rehabilitation environments and procedures can bring about stronger signs of recovery.

Mark Ashley, Sc.D., received his master's in speech pathology and a doctorate of science from Southern Illinois University in Carbondale, Illinois. In 1995, Southern Illinois University at Carbondale named him distinguished alumni of the year. He is an adjunct professor for the university's department of communication disorders and sciences in the College of Education, specializing in brain injury and cognitive deficits. Dr. Ashley is a licensed speech/language pathologist in California and Texas and is a certified case manager. He is also the founder and president/CEO of the Centre for Neuro Skills® (CNS), which has operated post-acute brain injury rehabilitation programs at facilities in Bakersfield, Encino, and Emeryville, California, and in Irving, Texas, since 1980. In addition, Dr. Ashley founded the Centre for Neuro Skills Clinical Research and Education Foundation, a nonprofit research organization.

Dr. Ashley serves as emeritus chair of the board of directors of the Brain Injury Association of America and as chair of the board of directors of the California Brain Injury Association. His work has been published in numerous professional and research publications, and he has written two books—*Working with Behavior Disorders: Strategies for Traumatic Brain Injury Rehabilitation and Traumatic Brain Injury Rehabilitation*, now in its third edition.

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