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Association *of* Academic Physiatrists
RESIDENT FELLOW COUNCIL

COVER ART: TABITHA ABRAHAM, MS3, UTRGV

A LETTER FROM THE EDITOR

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Dear AAP Community,

It is my honor to welcome you to the Winter 2024-2025 issue of Physiatry in Motion, the official newsletter of the Association of Academic Physiatrists Resident/Fellow Council (AAP RFC).

The theme of this winter centers around inpatient rehabilitation with topics that include neuropsychological recovery and treatment options in TBI, pregnancy considers in SCI, use of technology in TBI and SCI populations. Enclosed, you will find a collection of powerful stories and ideas that we hope can give new insight into the field and the dynamic changes that we face as a specialty.

I would like to express my sincere gratitude to each of the contributors, artists, as well as the technology subcommittee who have worked tirelessly to bring this issue to life. Stay tuned for our summer edition later this year that will be focused on sports and spine!

Regards,
Raj Banerjee, MD
Editor, Physiatry in Motion

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UNIQUE CONSIDERATIONS DURING PREGNANCY FOR PATIENTS WITH SPINAL CORD INJURY

Samantha Koerber, MD, MPH, University of Colorado; Will Wood, OMS-I, Rocky Vista University

Introduction

Reproductive care for women with spinal cord injuries (SCI) is a critical yet often overlooked area of healthcare that requires exceptional interdisciplinary collaboration. Despite advances in medical knowledge and efforts toward inclusivity, significant gaps remain in understanding the unique sexual health and reproductive experiences of this population. Women with SCI and other physical disabilities face distinct challenges related to sexual function, pregnancy, and childbirth. These challenges are compounded by societal stigmas, inadequate clinician knowledge, and structural barriers within healthcare settings. We aim to review the sexual health behaviors, pregnancy experiences, and delivery outcomes of women with disabilities. Our goal is to highlight the persistent disparities and conversely, the factors contributing to positive care experiences.

Sexual Health and Contraception

A critical aspect of reproductive care for women with disabilities involves sexual health knowledge and education. Information and discussion regarding sexual health, behaviors, and education is often a limited conversation within most societal circles. Horner-Johnson et al. found this may be unintentionally contributing to higher rates of unintended pregnancy among women with disabilities (53%) as compared to their counterparts without disabilities (36%) [1]. While individuals with SCI may experience differences in erection and ejaculation, most remain sexually active [2]. People with disabilities often have intact fertility, allowing them to carry a pregnancy to term and safely deliver a newborn [3].

Given maintained fertility and higher rates of unintended pregnancy in people with SCI, it is appropriate to counsel women and provide contraception if desired. Although most contraceptive options are safe for women with SCI, there is a lack of literature that supports the safety and efficacy of various methods [4].

Theoretical considerations include a higher risk of venous thrombus embolism in the first year following injury for estrogen-containing methods, as well as a compounded risk of decreased bone mineral density with Depo Provera [5,6] however, these risks are not necessarily evidence-based and may not outweigh the benefits of contraception for some women with SCI. Some providers are hesitant to use intrauterine devices due to reduced or absent sensation, making it difficult to identify if the device has migrated within the uterus. An additional concern is the increased risk of autonomic dysreflexia during insertion [7]. However, these devices remain an excellent and appropriate option for many women, with as many as 20% of a sample of females with cervical and thoracic SCI reporting IUD use [8]. These theoretical risks lack strong evidence, yet need to be discussed with individuals with SCI. For many women with SCI, the benefits of pregnancy prevention may outweigh the risks and can encourage safe sexual activity.

Pregnancy

Pregnancy rates among people with SCI are slightly lower than those without SCI. However, the prevalence does not differ significantly [1,9]. Research indicates that women with SCI report unmet needs during pregnancy. Barriers include inaccessible care settings, clinicians' negative attitudes, lack of clinician knowledge and experience, lack of communication and collaboration among providers, and a misunderstanding of disability and disability-related needs [10-12]. These unmet needs negatively contribute to the overall experience of pregnancy and, ultimately translate to healthcare disparities.

Maternal complications in people with SCI during pregnancy include higher rates of urinary tract infections given chronic colonization from neurogenic bladder and catheterization, venous thrombus embolism from immobility and hypercoagulability, and preterm rupture of membranes [10].

The etiology of these complications has not been well studied in the SCI population, leading to a lack of evidence-based guidelines. For example, although the American College of Obstetrics and Gynecology recommends treating asymptomatic bacteriuria for women without SCI, there is no clear guideline for the management of neurogenic bladder during pregnancy [11].

Another gap in the existing literature is related to how to manage secondary complications of SCI during pregnancy. Pregnancy increases the risk of spasticity, pressure injuries, falls, bladder spasms, and constipation [13]. However, many of the commonly used medications for bladder and bowel management, spasticity, and pain have not been well studied during pregnancy. Risks and benefits of various medications, including chemodenervation procedures for both bladder and extremity spasticity, need to be discussed with physiatrists, obstetricians, urologists, and other specialists involved in the care of women with SCI. Furthermore, patients should have access to physical therapy, occupational therapy, and assistive technology professionals for nonpharmacologic management of spasticity, to address fall risk, and to address changes in activities of daily living associated with their changing body. Therapists can discuss different catheterization options due to increasing abdominal size and pressure, and any custom seating needs for offloading high risk areas for pressure injuries [14-16].

Labor and Delivery

Women with SCI face additional complications during labor and delivery, such as autonomic dysreflexia, which is distinct from preeclampsia or eclampsia and requires unique treatment [13]. Women with SCI may also experience positional challenges secondary to hip disarticulations, contractures, and severe spasticity. These physical limitations often necessitate assisted delivery methods (e.g. forceps, vacuum extraction, or cesarean section), potentially increasing adverse outcomes for individuals with disabilities compared to their peers without disabilities [17-19]. In addition to maternal complications during delivery, neonatal outcomes can also be affected. Deierlein et al. and McLain et al. report that neonates born to mothers with disabilities often have lower birth weight, shorter length for gestational age, and smaller head circumference [19, 20].

Despite increased adverse outcomes and barriers that women with disabilities face regarding sexual health and pregnancy, many women have noted they were satisfied with the mode of delivery. Women with disabilities participating in a post-delivery questionnaire provided insight regarding what they felt was effective in leading to a positive pregnancy and birthing experience. Importantly, they stated that advanced and careful planning with clinicians who had disability-related expertise allowed for better management of their disability during pregnancy [21].

Conclusion

The reproductive experiences of women with SCI are shaped by a complex interplay of physiologic, societal, and systemic factors. While many women with SCI and other physical disabilities maintain sexual activity and healthy pregnancies, their journeys are often marked by increased risks, significant barriers, and tremendous gaps in the literature. Barriers include inadequate clinician knowledge, inaccessible healthcare environments, and misunderstandings of disability-related needs. Despite these challenges, some women report positive birthing experiences when provided with advanced planning and care from clinicians with expertise in disability. Moving forward, it is essential to strengthen evidence-based literature in this field, improve clinician education, foster patient-centered communication, and create inclusive healthcare environments that address disparities and support the reproductive autonomy of women with disabilities.

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RETHINKING TBI: HORMONES, NUTRACEUTICALS, HYPERBARIC OXYGEN THERAPY, AND THEIR POTENTIAL ROLE IN TBI TREATMENT

Kyle Cullin, DO; Independent - Research

Treatment of TBI, from acute injury to chronic sequelae, is a complex process of balancing external factors and pharmacotherapy. For example, acute management in the past has been focused on managing intracranial pressure through interventions such as positioning, diuretics, hypertonic saline, or even neurosurgical decompression. For coma and vegetative states, sensory stimulation and pharmaceutical stimulants (amantadine, SSRIs, methylphenidate, etc.) have been employed. However, there is an absence of overwhelming medical literature to support their efficacy [1].

Some research suggests that TBI, at least in its chronic state, is caused by neuroinflammation [2]. By effectively addressing this inflammation and its sequelae, the morbidity of this debilitating condition may be minimized. A growing body of literature seems to support the use of more naturally occurring substances such as nutraceuticals, fish oil, and hyperbaric oxygen. Even psychoactive compounds like ibogaine have been hypothesized to improve outcomes of TBI [3-9].

Dr. Mark Gordon, an interventional endocrinologist and TBI treatment specialist, has dedicated himself towards improving treatment of TBI by working with soldiers and veterans. He believes that psychological damage from TBI is often misdiagnosed as PTSD in military settings. Dr. Gordon finds that the majority of patients with even mild TBI develop hormonal deficiencies that mimic hypopituitarism, which further exacerbates the illness [2]. He approaches TBI treatment through addressing hormonal deficiencies, resulting in improved cognitive and mental health.

Dr. Gordon additionally uses nutraceuticals, which have been shown to suppress NFkB induction and inflammatory cytokines, halting the inflammatory cascade that potentiates TBI's sequelae.

Specific nutraceuticals he has used include N-acetyl cysteine, tocopherols, eicosanoids and polyphenols, which have been supported by peer-reviewed literature to reduce neuroinflammation and TBI pathogenesis [2]. Other nutraceuticals that have been explored are Vitamin B1, B12, fish oil, and ibogaine. As discussed previously, addressing neuroinflammation is critical in controlling TBI symptoms. In one mouse study, intraperitoneal B1 was administered for 7 days after TBI was induced in the mice. The treatment group had significantly different short-term memories and escape latency time, suggesting reduced memory dysfunction, compared to the reference group. Western blots also showed downregulation of pro-inflammatory cytokines, such as TNF-α and NFκ-B, and upregulation of pre- and post-synaptic activity, suggesting a neuroprotective effect [3].

Vitamin B12 is known for promoting axon growth in peripheral nerve damage [4], and has been of interest in its role in the central nerve lesions. One study of B12 supplementation in TBI mice showed recovery of cognitive dysfunctions with increased cell survival and synaptic plasticity. This outcome is thought to be due to restored dendritic arborization and spine density that are normally down-regulated by the oxidative stress and inflammation present in TBI [4].

In other mice models, supplementation with fish oil has shown improved cognitive recovery through enhanced brain remodeling processes by creating oligodendrocytes, microvessels and immature neurons. Similarly, Fish oil fat emulsion appears to promote microglia polarization, thereby suppressing neuroinflammation and serving a neuroprotective role in the setting of TBI [5]. The mechanism of this finding is that microglia polarization changes from pro-inflammatory to anti-inflammatory phenotypes, halting the cascade of neuroinflammation that feeds persistent neurodegeneration.

In this study, the TBI mice demonstrated partially improved motor function with the fish oil fat emulsion [6].

Ibogaine is a psychoactive indole alkaloid that for the time being is a Schedule 1 substance, classified as such in 1970. This has hindered clinical research here in the US, but beyond our borders, it has shown extremely promising results. Stanford medicine researchers showed military veterans had improvements of PTSD, anxiety and depression, all considered neuropsychiatric manifestations of TBI [7]. However, these encouraging findings have also generated concerns, namely ibogaine's cardiotoxic effects. Additional research implies the cardiac risks have been allegedly negated by coadministration with magnesium, allowing the therapeutic benefits of this nutraceutical to come forth. Many hope further research can highlight the seemingly miraculous therapeutic effects of this nutraceutical.

Another treatment to consider is the use of hyperbaric oxygen therapy (HBOT). Both a systematic review of 30 studies and a meta-analysis of 8 studies examined the use of HBOT in TBI patients. The systematic review analyzed clinical and pre-clinical studies, and noted enhancement of physiological measures, while avoiding pulmonary or cerebral toxicity, suggesting clinical outcome improvements [8]. The meta-analysis demonstrated higher post-treatment GCS scores, lower mortality, and larger improvements in Glasgow Outcome Scores (GOS) for patients receiving HBOT, also supporting a future role of HBOT in TBI protocols [9].

Nature may very well hold the answers we seek in improving outcomes for TBI patients. Naturally occuring vitamins, fish oil, pressurized oxygen or even compounds such as ibogaine may be the key to producing improved outcomes for TBI patients. It may be time to look beyond the current standards of care to these options that occur more naturally around us for the benefit of our patients' lives we hope to positively impact as physiatrists.

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THE PROMISE OF SPINAL CORD INJURY RESEARCH AND REGENERATION

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Spinal cord injury (SCI) was once considered a condition that resulted in complete dependency, with patients confined to wheelchairs, and in some cases, able to use a motorized wheelchair if insurance allowed. This was the reality not long ago. However, advancements in technology, particularly in neuroregeneration and hybrid exoskeletons are changing this outlook, making SCI a much more manageable and likely soon a potentially reversible condition.

For many years, SCI was considered irreversible, with the prevailing belief that neurons could not regenerate. However, the understanding of neuroscience has evolved. It is now discovered that neurons do have plasticity, with mirror neurons serving as one example. Some animals, such as axolotl, can regenerate neurons effectively (1). For an axolotl, repairing a spinal cord injury is similar to repairing a skin injury in terms of outcome. This has given researchers hope that human SCI may also one day be treatable.

Despite this, SCI research has not always received the attention it deserves. Research funding is often linked to the incidence of diseases, and SCI is not as common as diseases like cancer (2,3). Historically, SCI was wrongly assumed to be a condition with no potential for neuron regeneration, which limited investment in research. However, SCI research is increasingly being recognized for its high-impact potential.

The Role of MicroRNA in Regeneration

One of the significant breakthroughs in SCI research comes from the study of microRNA, which has shown promise in regenerating neurons (1,4). MicroRNA vaccines, such as those used for COVID-19, have already shown their power in immunology, and similar approaches are being tested in cancer research. Animals like the axolotl can regenerate neurons through specific microRNA responses, a mechanism absent in rats and humans (1). If we can activate or inhibit the right microRNAs in humans, we may be able to regenerate neurons in a way similar to the axolotl. Additionally, the continued exploration of microRNA and its physiological role, especially in light of recent Nobel Prize recognition, indicates that this field will be a major focus in future research (5).

Hybrid Exoskeletons in SCI Treatment

In addition to biological regeneration, technological advancements such as exoskeletons that enable patients to use their limbs represent a significant leap in rehabilitation medicine. Additionally, hybrid exoskeletons can connect to the brain, allowing patients to control movement simply by thinking (6). This technology is still it its early phases; however it shows great promise in improving the quality of life for SCI patients and helping them re-integrate into society.

Another Potential Treatment Option for SCI

Another exciting development in SCI research is stem cell therapy. Early studies, including a first-in-human Phase I trial of neural stem cell transplantation for chronic spinal cord injury, have shown clinically significant changes in the ASIA (American Spinal Injury Association) scale, though statistically these results were not significant yet (7) . However, the potential for stem cell therapies to revolutionize SCI treatment is clear with more studies.

The Need for Increased Awareness and Funding

Despite the advancements in both biological and technological treatments for SCI, there is still a lack of recognition of SCI. Increasing awareness about SCI among medical professionals and the general public is crucial. The more awareness is there, the more funding will be for research, which in turn will accelerate innovation. More research leads to better treatments, and more treatments mean a better quality of life for those living with SCI.

Conclusion

Although SCI research is not currently a top priority for funding when compared to more prevalent diseases like cancer, the potential for SCI to be treated and even reversed is immense. The combination of stem cell therapies, microRNA, and hybrid exoskeletons offers a multifaceted approach to treating SCI and related complications.

With the growing advancements in neuroregeneration, stem cell research, microRNA therapies, and hybrid exoskeleton technologies, may soon redefine SCI, reducing or eliminating dependence, By increasing awareness and funding, we can accelerate breakthroughs in SCI treatment, ultimately improving the lives of those affected by this debilitating condition.

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TRANSCRANIAL DIRECT CURRENT STIMULATION IN BRAIN INJURY REHABILITATION: NOTES ON MECHANISMS AND POSSIBLE ADVANCES

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With approximately 200,000 traumatic brain injury (TBI)-related hospitalizations and 790,000 cases of stroke each year [1,2], improving strategies for recovery for these patients remains essential. Among these, the focus on transcranial direct current stimulation (tDCS) has received increased interest as an adjunct to brain injury rehabilitation. tDCS is certainly not a new neuromodulation modality, as the versatility of tDCS has spawned numerous studies for conditions such as depression or chronic pain to its use in improving athletic performance. However, due to its accessibility, affordability, and non-invasive nature, recent studies have sought to determine if tDCS can be a helpful modality to improve various domains of movement and cognition in brain injury survivors of varying severities in the clinical rehabilitation setting.

What is tDCS?

A tDCS device is a wearable implement that delivers a constant, low-intensity electric current to the scalp. The current flows from the positive anode to a negative cathode through the brain via electrodes secured on the patient's head. The device allows for adjustments to the amplitude and duration. The size of the electrode can also be changed to target varying degrees of area. Reported side effects are generally mild and include fatigue, local site skin redness, itching or tingling, while lesser common side effects can include headache, neck pain, nausea, and dizziness [3].

Mechanisms of Action

Delineating the efficacy of tDCS remains a challenge due to incomplete knowledge of its effects on damaged cortical tissue. The often-cited Nitsche and Paulus study in 2000 however, laid the foundation for our current understanding of tDCS, including the optimal intensity, duration of stimulation, and electrode positioning [4].

By applying tDCS to the motor cortex of healthy subjects, they found that "anodal" and "cathodal" tDCS stimulation induced or decreased excitability respectively via subthreshold perturbation. As neuronal networks are widely variable and complex, tDCS effects seen may be due to stimulation of multiple areas producing a clinical effect [5]. Additionally, these stimulatory effects on cognitive performance lasted throughout and after the stimulation period, depending on the stimulus' length, intensity, and repetition. These findings were beneficial, as anodal tDCS was thought to potentially improve motor performance, language, and memory, while cathodal tDCS may help decrease hyperarousal, especially in cases of maladaptive plasticity.

Other early studies demonstrated that tDCS induced long-lasting after-effects by modifying NMDA-receptor sensitivity [6]. Furthermore, studies postulate that tDCS can potentially decrease the secondary injury phase from TBI by modifying the response of neurotransmitters such as glutamate and gamma-aminobutyric acid (GABA) released after the primary injury phase [7]. In a broader context, tDCS can be hypothesized to stimulate structural and functional neuroplasticity by strengthening synapses and encouraging dendritic sprouting, ultimately accelerating clinical recovery. Although promising, more research must clarify the extent of tDCS's neuromodulation properties, hypothesized inhibitory or excitatory effects, and optimal electrode configurations, as even recent research has shown the possibility that stimulation of peripheral and/or cranial nerves may contribute to tDCS modulation [8].

Integrating tDCS in Standard Therapy

Given the often-detrimental sequelae of severe brain injury, some research suggests that tDCS can potentially augment and enhance standard rehabilitation efficacy. A recent pilot study examined the effects of tDCS combined with standard occupational therapy (OT) activities-of-daily-living (ADLs) interventions by stimulating the dorsolateral prefrontal cortex in patients with moderate-severe TBI for 10 days. Researchers then compared the degree of enhanced cognitive function in the tDCS group to patients who only received occupational therapy [9]. Their findings demonstrated that those who received both tDCS and OT interventions showed significant improvement in cognitive performance, subsequently demonstrating greater ability to perform ADLs based on Functional Independence Measure scores. A limitation of this study included a lack of follow-up on the maintenance phase to assess longer-lasting after-effects. An older study similarly inducing tDCS paired with cognitive rehabilitation in severe TBI patients for 15 days, although it saw some improvements in cognition in those who received both tDCS and rehab, was not statistically significant [10]. This study included a follow-up period, in which outcomes between the two groups remained not statistically significant and did not ultimately demonstrate lasting positive effects of tDCS combined with rehab in these patients.

Studies on tDCS for disorders of consciousness (DOC) patients similarly demonstrate mixed results. A study of 78 DOC patients who underwent active vs sham tDCS in addition to routine rehabilitation for 8 weeks did not demonstrate an improvement in the Glasgow Outcome Scale (GOS) or Glasgow Coma Scale (GCS) measures. However, the study did demonstrate statistically significant improvements in neuropsychological measures such as electroencephalogram (EEG), brainstem auditory evoked potentials, and somatosensory evoked potentials [11]. Although tDCS positively influenced certain aspects, these results did not translate into improved clinical outcomes. Further meta-analysis of tDCS alone on DOC patients, however, has potentially shown positive improvements in those who are classified as in a minimally conscious state over those in vegetative states [12].

Virtual Reality combined with tDCS

Non-immersive and immersive virtual reality (VR) devices have been used as a therapeutic tool for decades and remain prevalent today as it provides a controlled environment that can output consistent real-time validated feedback. As studies have shown that VR rehabilitation tools can be beneficial in supporting motor function, combining VR with tDCS may support other functional domains. One such study looked at VR's role in improving upper extremity movement in hemiplegic stroke patients with tDCS, in which 20 patients received either tDCS and VR while the others received sham tDCS and VR for a total of four weeks [13]. They found significant improvement between pretest and post-test scores in the Box and Block Test and Jebsen-Taylor Hand function test as well as cognitive domains using the Stroop Test and Trail Making Test, demonstrating that tDCS and VR modalities together can synergistically enhance function. Emerging protocols continue to explore whether combining tDCS and VR therapy could enhance cognitive function, speech, and ADLs while also augmenting cortical activity more effectively than these modalities can independently [14].

Challenges and Further Steps

tDCS research remains limited as further research must characterize the extent of tDCS's influence on neuroplasticity and neurotransmitter activity. Other areas of potential tDCS research exist as minimal data reports on the long-term lasting effects of tDCS months or even years after treatment. Dedicated studies in pediatric and geriatric populations also remain scant. Although accessibility and affordability of tDCS devices make this an attractive area of study, commercial devices available to the public may raise concerns of improper application or misuse. While the effectiveness of tDCS as an adjunct to brain injury rehabilitation is still being studied, the growing interest in this modality highlights its potential use within rehabilitation.

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PUTTING THE PIECES BACK TOGETHER: UTILIZING ICU DIARIES TO SUPPORT NEUROPSYCHOLOGICAL RECOVERY IN PATIENTS WITH POLYTRAUMA AND TBI

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For a patient who experiences polytrauma, their hospital course can feel nearly as chaotic as the event itself. The repetitive creak of the sliding ICU doors starts long before sunrise, signaling the cyclic procession of students, trainees, and attendings performing their rounds. The medley of faces attached to wrinkled scrubs and retractable badges, often with redundant questioning and truncated physical exams, comprises only the first few hours of each morning. The patient and family attempt to track each conversation as the various teams present their unique interpretations, plans, and opinions. The remainder of the day may resemble a revolving door of surgeries and diagnostic imaging amidst the din of beeping monitors and IV pumps. A single day in this setting is enough to make anyone's head hurt. For those who have also endured a traumatic brain injury, however, their journey is only just beginning.

Among all of the severe traumas requiring intensive levels of care, traumatic brain injury (TBI) is not only the most prevalent but is also associated with the highest degree of morbidity and mortality [1]. In the last few years, several studies have also demonstrated that the combination of polytrauma and TBI leads to significantly longer ICU and total lengths of stay when compared to non-TBI polytrauma or isolated TBI alone [1,2]. In addition to the numerous neurological sequelae that often complicate the acute phase of TBI, it has been shown that 20% of individuals develop major depressive disorder and 17% develop PTSD within 3 years after moderate to severe TBI [3,4]. Some of the strongest risk factors for developing a mood disorder after traumatic brain injury were younger age, lower educational level, and lower socioeconomic status [4]. These characteristics are also associated with decreased overall health literacy, adding to the list of variables that can increase stress, confusion, and frustration when trying to track the medical changes within a complex hospital course. Thankfully, there is increasing focus on interventions to address these informational gaps between patient and provider while promoting their mutual well-being through transparency and shared decision-making.

Prior to accessible electronic medical records in the 1990's, certain critical care units would provide each patient and family with a concise written summary of the hospital course as it developed [5]. On admission, the primary team would record the day's medical updates and rationale for decision-making into a journal. This was then given to the patient and family for their own further reflections and notetaking. It was found to significantly improve patient satisfaction as well as the overall quality of care. The success of this early approach in promoting communication and reflection through narrative medicine inspired the development and adoption of the ICU diary.

As more medical centers implemented ICU diaries, further research has investigated the effects of this simple intervention on patients' neuropsychologic outcomes. A 2024 meta-analysis of randomized controlled trials found that ICU diaries reduced the incidence of depression and PTSD while also improving sleep quality in critically ill patients [6]. However, they did not find any significant effect on relatives or loved ones accompanying the patient during the process. Other studies combined ICU diaries and psychoeducation, noting positive outcomes in both anxiety and depression scores at 90 days post-discharge when compared with psychoeducation alone [7]. Finally, ICU diaries have also shown promise in aiding cognition and reducing delusional memories during periods of critical illness. A trial from 2024 found that implementation of an ICU diary during the first 72 hours of admission led to higher scores on cognitive testing and improved discrimination between true and fictional hospital events later on [8]. These studies display the lasting and profound effects of a simple cost-effective intervention to promote thoughtfulness and consistent communication within a highly emotional and traumatic period. While the positive psychological and cognitive benefits of ICU diaries are relatable to the brain injury population, they have not yet been formally studied in this population.

The risk of altered consciousness that occurs in polytrauma patients within the ICU often becomes drastically more pronounced in those with concomitant brain injury [1]. As patients begin to recover from their brain injury, the emerging effects of emotional dysregulation and memory impairments can especially hinder their ability to succeed in rehabilitative therapies if not addressed promptly [9]. Related studies have investigated the use of reflective writing within the brain injury population to address these early neuropsychological risks. A systematic review on the use of personal narrative approaches to rehabilitation after TBI found that patients were able to improve their sense of identity and resilience after reading their medical course narrative and journaling their reflections [10]. Additionally, weekly sessions of diary training and self-instruction training over six weeks were associated with improvements in everyday memory, attention, and ability to perform daily activities in pediatric populations who sustained a TBI [11].

In summary, there is robust and growing evidence that ICU diaries can be valuable for those suffering from polytrauma in the critical illness setting. Although these diaries have not been formally studied in TBI patients in the acute setting, adjacent research has shown promising functional and emotional outcomes with similar journaling interventions. While it is worth noting that ICU diaries rely on the engagement from care team and family members, the joint creation of this valuable medical narrative can serve as a reference of information and reflection for years to come. Although there is need for further focused research, current evidence suggests that ICU diaries may serve an especially beneficial rehabilitative role in TBI-polytrauma populations as they work to reassemble the fragments from an often complicated and prolonged path to recovery.

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NEUROMODULATION TREATMENTS FOR BRAIN INJURY PATIENTS

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Neuromodulation treatment is an emerging field in the paradigm of treatment for brain injury patients. The concept of neuromodulation involves modifying electrical and chemical activity in specific regions of the central nervous system to promote recovery and restore function [1]. Multiple studies have demonstrated the efficacy of various neuromodulatory treatments, including transcranial direct current stimulation (tDCS), transcranial magnetic stimulation (TMS), transcutaneous vagus nerve stimulation (tVNS), low-intensity focused ultrasound (LIFU), and deep brain stimulation (DBS) [1,2]. Each of these modalities operates through distinct mechanisms and offers unique therapeutic potential for patients with brain injuries.

tDCS is a non-invasive neuromodulatory technique that delivers a weak electrical current to modulate cortical excitability and enhance synaptic neuroplasticity. By facilitating interhemispheric interaction, tDCS has shown promise in stroke rehabilitation and neuropsychiatric conditions. Studies commonly use a safe and effective intensity of 1-2 mA, with two scalp electrodes allowing current flow between anodal and cathodal sites. Anodal stimulation depolarizes neurons, increasing excitability, while cathodal stimulation hyperpolarizes them, reducing excitability. An advantage of tDCS is its portability and ease of use, making it suitable for outpatient and home-based rehabilitation. Research has demonstrated that tDCS enhances motor recovery, cognitive function, and activities of daily living in stroke patients. Its non-invasive nature and ability to selectively modulate neural activity make it a promising tool for personalized neurological rehabilitation [3,4]. However, further studies are needed to refine stimulation protocols and optimize patient selection.

TMS employs electromagnetic induction to generate electric currents in targeted brain regions via a wire coil. These currents depolarize neurons, allowing for the assessment of intracortical circuits and cortico-cortical connectivity. Repetitive TMS (rTMS) modulates brain activity across networks through transsynaptic spread, influencing neuroplasticity via long-term potentiation. The effects of rTMS depend on stimulation parameters, with low-frequency (≤1Hz) rTMS suppressing excitability and high-frequency (≥5Hz) rTMS enhancing it. A subtype of rTMS, known as Theta Burst Stimulation (TBS), modulates excitability based on intermittent or continuous delivery. Studies on TMS have shown mixed results, particularly regarding functional motor recovery. Variations in effect sizes across studies highlight the need for more large-scale research to determine the efficacy and optimize stimulation parameters for different patient populations [5].

tVNS targets the cervical portion of the vagus nerve and offers a non-invasive, cost-effective alternative to traditional vagus nerve stimulation. The auricular branch of the vagus nerve is targeted, and the tVNS device is placed around the cymbal concha of the ear. By stimulating the vagus nerve, tVNS has been shown to exert anti-inflammatory effects, stabilize the blood-brain barrier, reduce excitotoxicity, and inhibit apoptosis while enhancing neuroprotection via autophagy. Additionally, vagus nerve stimulation is believed to preserve white matter integrity, promote remyelination, and enhance angiogenesis. It also upregulates brain-derived neurotrophic factor (BDNF) pathways, supporting axonal growth and neuroplasticity crucial for poststroke recovery. Recent studies have suggested that tVNS promotes upper limb recovery, making it a promising neuromodulatory strategy for stroke rehabilitation. However, further research is required to establish standardized stimulation parameters and determine its long-term benefits [6, 7, 8, 9].

LIFU utilizes high-frequency sound waves to create an acoustic radiation force, which exerts neuromodulatory effects through cavitation, temperature changes, and mechanical deformation. These mechanisms alter membrane capacitance and influence cellular membrane components, leading to targeted neural modulation. One of the advantages of LIFU over other non-invasive brain stimulation treatments is its ability to reach deeper brain regions with high spatial precision. Recent studies have demonstrated the feasibility and safety of this technique, and future research aims to explore its potential in promoting recovery in brain injury patients. Despite its promise, challenges remain in refining the optimal stimulation parameters and understanding the long-term effects of LIFU on neural function [10, 11].

DBS is an invasive neuromodulatory intervention that involves implanting an electrode to deliver electrical stimulation to specific brain regions, such as the thalamus and midbrain typically for patient's with Parkinson's or other neurologic disorders. DBS has emerged as a neurosurgical technique for neuromodulation in patients with disorders of consciousness (DOC). Some studies suggest that DBS may aid recovery by compensating for impaired arousal regulation through central thalamus stimulation. However, the literature on DBS outcomes remains mixed, with inconsistent findings regarding its effectiveness in improving cognitive and motor function. Patient selection is a crucial factor in determining the success of DBS therapy for DOC. Advanced imaging techniques such as positron emission tomography (PET), functional magnetic resonance imaging (fMRI), and electroencephalography (EEG) are used for accurate diagnosis and treatment monitoring. DBS targets, including the Centromedian-parafascicular complex (CM-pf) and Central Thalamus (CT), have shown potential in improving arousal levels and behavioral responsiveness. However, individualized approaches are necessary to address the heterogeneity of patient populations and the underlying causes of DOC. Optimizing stimulation parameters, maintaining sleep-wake cycles, and refining surgical techniques may enhance patient outcomes. Future research will focus on improving DBS protocols and developing personalized treatment strategies [11, 12, 13].

One of the primary challenges of neuromodulatory treatments is establishing standardized, effective protocols. As many of these treatments are relatively new developments, ongoing research is essential to refine stimulation parameters, optimize patient selection, and improve long-term efficacy. The mechanism, location, and severity of brain injuries will continue to play a significant role in determining the most appropriate neuromodulatory treatment for each patient. As our understanding of brain plasticity and neurorehabilitation evolves, neuromodulation could be poised to become a key component in the comprehensive management of brain injury patients. Through integrating these techniques into clinical practice, brain injury specialists can offer more effective, individualized treatment strategies that can enhance recovery and improve the quality of life for patients with brain injuries.

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ACUPUNCTURE IN TREATING CHRONIC LOW BACK PAIN

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Acupuncture is a form of Complementary and Alternative Medicine where thin needles are inserted into the skin to stimulate muscles, nerves, and connective tissues either manually or by electrical stimulation and has been shown to relieve pain and enhance healing [1,2].. First documented around 100 BCE, acupuncture involves multiple styles and techniques, revolving around variables such as needle size, depth, manipulation, stimulation via modalities such as heat, electrical current, and mechanical pressure, and selection of acupuncture points [3]. There are around 360 anatomical points in classical acupuncture used to balance Qi, the flow of energy through pathways in the body called meridians [4]. While acupuncture's exact mechanisms of action are not fully understood, research has shown acupuncture can decrease inflammation and modulate the effects of endorphins, opioid peptides, and enkephalins [2,4]. In 2012 an estimated 3.8 million adults in the United States (U.S.) used acupuncture as a treatment modality for pain and other disorders such as migraines [1,5].

Acupuncture has been recommended as part of treatment for chronic low back pain. The 2017 American College of Physicians clinical practice guidelines and the 2016 CDC Guidelines for Prescribing Opioids for Chronic Pain list acupuncture as part of first-line non-pharmacologic interventions for people with chronic low back pain [5,6]. In 2020, the Centers for Medicare & Medicaid Services (CMS) began covering up to 12 acupuncture sessions in 90 days for people with chronic low back pain, with an additional 8 sessions if pain improvement is shown [7]. In the 2023 World Health Organization (WHO) guideline for non-surgical management of chronic primary low back pain in adults in primary and community care settings, there was a conditional recommendation in favor of use of needling therapies such as acupuncture in conjunction with other treatments, rather than a stand-alone therapy [8,9].

This was based in part on an analysis of 25 trials compared to no intervention that showed a small clinically worthwhile benefit for immediate and short term pain and larger benefit for function that outweighed the risk of non-serious adverse effects [8,9]. Because low back pain is a global leading cause of disability experienced by 619 million people in 2020, and expected to rise to 843 million people by 2050 according to the WHO, acupuncture represents an important additional treatment option for chronic low back pain [9].

Studies are still investigating the efficacy of acupuncture in treating chronic low back pain, however current systematic reviews have been limited by studies with high risk of bias and small sample sizes. One systematic review and meta-analysis published in 2013 analyzed 32 studies and found clinically meaningful decreases in self-reported pain levels compared with sham acupuncture and improved function compared with no treatment, however the review was limited by study heterogeneity and studies with low methodological quality [10]. Another systematic review published in 2020 reviewing 33 studies found that acupuncture compared with usual care had some effect immediately after treatment in improving function, although these studies were also limited by very low to moderate evidence certainty [11]. Limitations to conducting studies include the individualized nature of acupuncture treatment which makes standardization difficult, the fact that complementary and alternative medicine modalities are often not candidates for randomized controlled trials in the U.S., and the variability of methods, styles, techniques, locations, and treatment length involved [12].. Future research addressing these limitations are needed to understand the efficacy of acupuncture in treating chronic low back pain.

Acupuncture is a form of Complementary and Alternative Medicine that has been shown to relieve pain and enhance healing and is recommended as part of a pain treatment regimen for chronic low back pain by the WHO, CDC, and American College of Physicians and covered as a treatment by CMS [5,6,9]. More research is needed to fully understand the effects of acupuncture and its efficacy in treating chronic low back pain.

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