



Published in final edited form as:  
*J Surg Care*. 2022 ; 1(1): 19–26.

## Rehabilitation After Neurotrauma: A Commentary

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### Abstract

Rehabilitation following neurotrauma is an important component of recovery. The best outcomes involve multidisciplinary management. This involves medical therapies, functional therapies, and physical therapies. Speech therapy, physical therapy, and occupational therapy are crucial components. Emerging evidence has implicated the need for vision therapies and a focus on mental health. A seamless integration from inpatient to outpatient is validated. This can be at outpatient facilities or home care. The importance is a key point person for the patient.

### Keywords

Neurotrauma; rehabilitation; outpatient follow up; therapy

### Introduction

Traumatic brain injury (TBI) is typically defined as an abrupt insult to the brain from an external mechanical source that imparts temporary or permanent neurological, psychosocial, or physical impairments. As the leading cause of death and disability among young adults, TBI contributes to more than 611 hospitalizations and 176 deaths per day in the United States [1,2]. The acute and chronic consequences of TBI may be catastrophic, as a constellation of organ systems and cognitive functions are impacted [3,4]. Although functional or cognitive deficits generally improve with sufficient time and proper management, negative sequelae from even mild TBI can persist as lifelong impairments [5]. Rehabilitation (rehab) after TBI is a critical component of long-term recovery [6]. Thus, to manage various injury severities and symptoms, multiple inpatient and outpatient alternatives exist whereby multimodal care teams work to optimize patient functionality, independence, control of bodily functions, muscle strength, motor movements, and speech capacities [7]. As a supplemental commentary to Lucke-Wold et al.'s "*Urinary dysfunction after acute brain injury*," we offer this brief discussion regarding current and future multidisciplinary management strategies for post-TBI rehabilitation [8].

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## Inpatient Rehab

Patients who experience moderate-to-severe TBI are often admitted to an inpatient neurospecific rehab setting as a bridge between the acute and post-acute phases of recovery [9]. However, not all patients are best served with inpatient neurorehabilitation, and some may benefit more by being discharged directly home or with continued in-hospital treatment. To assist in clinical decision-making, Greenwald and Rigg have proposed criteria to assess whether a patient qualifies for inpatient rehab after TBI (Table 1) [10].

For those admitted to an inpatient rehab service, the gold standard for neurorehabilitation care that has demonstrated faster neurorecovery consists of a multidisciplinary approach involving specialists from numerous fields [7–11]. Targeted therapies are administered by the multidisciplinary teams to enhance patient recovery, with the intent to guide recovery of functional skills, decrease the impact of symptoms, and maximize the quality of life for the patient and any caregivers [12,13]. Teams may include nurses, physiatrists, neurologists, psychologists, psychiatrists, physical therapists, occupational therapists, vocational therapists, speech and language therapists, nutritionists, and social workers (Figure 1) [6,7]. This holistic approach, with its open communication and regular patient-centered meetings, contrasts with previous care models in which treatment was administered sequentially with providers working largely in isolation one from the other [7,14,15]. We describe current inpatient management strategies.

## Medical therapies

Depending on the specific injury and patient history, pharmacological interventions can play a critical role in neurorehabilitation and the management of preexisting and injury-induced medical conditions. Physiatrists, psychiatrists, and neurologists largely effectuate this pharmacological aspect of patient rehab. Conditions that are medically manageable include neuropsychiatric or neurobehavioral symptoms such as depression, aggression, obsessive-compulsive disorder, post-traumatic stress disorder, and personality egocentricity or disinhibition [16–18]. Likewise, drugs such as methylphenidate are often administered in effort to improve focus or attention deficits [19,20]. Numerous other compounds are being investigated for their capacity to increase neurological functional after injury, and this represents a highly active area of TBI research [21–23].

## Executive function therapy and attention training

As mentioned, TBI often damages executive cognitive function and imparts attention deficits. These symptoms are more pronounced as the severity of neurological insult increases [24]. For example, secondary attention deficit hyperactivity disorder is a well-documented phenomenon after TBI, with a rate of 20% among those with neurotrauma compared with 4.5% in the general population [25]. Other data show 11.4–38.7% of patients with just mild TBI experience neurocognitive dysfunction, attention and concentration deficits, and distractibility [26,27]. To address these concerning symptoms, neurostimulation, attention processing training, memory training, executive metacognitive

training strategies, goal management training, and pharmacotherapies have been used with success [28–31].

## Physical therapies

As a patient's perception of independence may greatly contribute to his or her sense well-being, physical rehab is of particular emphasis in regaining a realistic degree of independence. Additionally, previous research demonstrates a connection between depression and functional outcomes, demonstrating that improvement of one may secondarily improve the other [32]. Notably, there is debate and inconclusive evidence as to the effectiveness of inpatient physical rehab therapy compared with outpatient or at-home protocols for restoring physical competence after neurotrauma [33,34].

Common physical deficits experienced after TBI include loss of strength, coordination, balance, movement, and glutition. These insufficiencies are addressed by physical therapists, who coach their patients through functional exercises with special focus on core skills like gait and balance. For example, as a tool for upper-limb discoordination, paresis, and weakness, constraint-induced movement therapy is a cost-effective, low-impact motor function therapy in which patients limit one limb by wearing a mitt and require the opposite arm to complete motor tasks [35]. Walking therapies or treadmills are also commonly employed to retrain gait and stability, and treadmills may be augmented by supportive harnesses for patients with more severe deficits [36,37]. Likewise, robotic-aided gait training devices have been used to reinforce proper stride patterns and range of motion within inpatient settings [38].

Retraining patients to adequately function within their everyday tasks is a primary objective addressed via occupational therapy. Regaining competence may require circumnavigating persistent TBI-related functional deficits by altering the way tasks are performed or modifying the physical environment through specialized tools or adaptors [39,40].

## Speech therapies

Considering the immense relationship between communication capacities and patient quality-of-life, restoring patients to their most autonomous, articulate, understandable, and tone-sensitive state is of primary import. To address speech deficiencies such as dysarthria or aphasia, physical therapists, speech-language pathologists, or neuropsychologists may integrate exercises to coordinate lip and tongue movements, increase breath support, and strengthen mouth, jaw, tongue, and throat musculature [41,42]. For those who are unable to adequately communicate through traditional methods, augmentative and alternative communication strategies may be deployed using text-to-speech apps, whiteboards, or other interpersonal communication technologies [43]. Additionally, it may be necessary to retrain patients to read and express both body language and nonverbal facial expressions; protocols exist for this purpose [44,45]. Speech and language pathologists likewise may manage patient glutition retraining, if required [46].

## Vision therapies

Considering 6 of the 12 cranial nerves are involved in visual perception, it is unsurprising that sensorimotor visual impairments are highly prevalent after TBI and that many neurotrauma patients report symptoms such as blurred vision, convergence dysfunction, dizziness, light sensitivity, and color blindness [47,48]. A TBI-specific eye examination administered by an optometrist or ophthalmologist can help isolate the visual impairments related to TBI and recommend treatment [49]. Depending on the identified pathology, vision rehab may incorporate oculomotor exercises, prism lenses, tinted lenses, Fresnel prism, distance and near glasses, computer vergence therapy, eye movement pursuit and fixation exercises, or surgical intervention as multiple medical disciplines are converged in optimizing patient vision [49,50].

## Mental and emotional health therapies

Emotional challenges after TBI are rampant, with many patients experiencing depression, anxiety, apathy, frustration, and suicidality. Major depression is particularly common and presents in up to 77% of patients with TBI [51]. Similarly, with impairments in executive cognitive function, patients may struggle with their sense of purpose [52]. Nonpharmacological mental health treatment includes options such as cognitive behavioral therapy (CBT), which has been demonstrated to be a preferred therapeutic approach for behavioral and emotional disturbances after TBI [53]. CBT approaches can be integrated with family-based approaches, such as the Brain Injury Family Intervention (BIFI), which focuses specifically on patients with TBI to improve their daily living and incorporates family participation into a patient's mental health care [54]. In addition, suicidality is of particular concern, with 19.1% of patients with TBI having either experienced suicidal ideations or attempted to end their life [55,56].

## Additional inpatient therapies

Data show that patients with a large number of neurologic deficits may have diminished dietary intake and can eventually experience malnutrition [57]. Considering the hypermetabolic state induced by severe injury and the adverse outcomes that ensue after nutritional deficits and malnutrition, nutritionists may be involved in the neurorehabilitation care team to monitor and track patient caloric and nutrient intake. Furthermore, growing basic science evidence suggests that selective nutritional supplementation may positively impact regenerating neural tissue and may have a rehabilitative role as adjuvant agents. For example, animal models have demonstrated that supplementation with long chain fatty-acids, such as docosahexaenoic acid, administered after TBI impart improved axonal injury response, decreased neuronal apoptotic markers, and clinically improved memory performance [58,59]. Likewise, additional studies have demonstrated supplementation with omega 3 fats, anti-oxidants, vitamin D, vitamin E, N-acetylcysteine, nicotinamide, folic acid, creatine, taurine, branched chain amino acids, magnesium, and zinc to likewise enhance TBI neurorecovery (Table 2) [60–64].

In terms of reintegration to preinjury lifestyle patterns, many patients with TBI greatly desire the functionality to return to their former occupations [65]. However, rates of unemployment in patients with neurotrauma have been reported to be as high as 60% for patients who have not received specialized vocational rehab therapy[66]. The inability to return to a previous life contributes to depression and anxiety [65]. Likewise, returning to work often improves patients' perception of quality of life and facilitates better social integration and enjoyment of both home and leisure activities [65]. To this end, vocational therapists may be involved to assist patients reintegration into society in an economically productive and personally meaningful fashion [67].

Lastly, it is not uncommon for TBI to be related to substance abuse. For example, Leijdesdorff et al. found that among 2,686 patients with TBI, 74% had elevated blood alcohol levels at the time of injury [68]. To this end, social workers act as liaisons between inpatient medical care teams and outside community resources such as addiction recovery support systems [69,70]. Furthermore, social workers help identify financial assistance programs, navigate health insurance complexities, and establish connections with other local social networks that may be helpful to the patient and their family [71].

## Outpatient Rehab

As with inpatient rehab, outpatient rehab strategies for the management of TBI are highly variable, depending on the TBI context and patient-specific deficits. Patients with less-severe conditions may begin outpatient rehab immediately after their hospital neurotrauma treatment and those who have graduated from inpatient rehab may subsequently transition to an outpatient care model. Regardless, comprehensive outpatient rehab facilities exist to meet the needs of patients with TBI and offer similar services to those used by inpatient neurorehabilitation centers. As with inpatient care, the goals of outpatient rehab are to restore, or at least maximize, a patient's autonomy, functionality, and sense of well-being.

A multidisciplinary approach remains the preferred approach for outpatient neurotrauma rehab care [72]. In addition to the formerly discussed therapeutic interventions, other models such as at-home telephone counseling, alternative therapeutics, and fellowship with community mentors are tools employed by outpatient neurotrauma centers to assist in the transition to independent living [73,74].

## Alternative therapies

Some data suggest alternative nontraditional therapeutics may also have place as adjuvant interventions in post-TBI neurorehabilitative care. These include techniques like mindfulness practices, acupuncture, acupressure, music therapy, hyperbaric oxygen therapy, nutrition supplementation, specialized diets, and chiropractic manipulation [61,75]. Music therapy especially is one alternative TBI rehab strategy that has been shown to improve patient gait, decrease agitation, improve orientation, and improve upper-limb function [76,77]. Engaging in musical activates cognitive pathways involved in movement, cognition, speech, emotions and sensory perceptions that are unavailable through non-musical stimuli [76,78]. Although additional data are needed to define the role of music therapy within a

comprehensive TBI neurorehabilitation protocol, it represents a future area of research that holds great promise [61].

## In-home rehab

Some patients who require outpatient neurorehabilitation care have limited access to therapy because of geographical distance or transportation instability. A newer solution commonly used in stroke patients involves neurotrauma-specific rehab delivered via telehealth modalities [79]. Although many aspects of rehab-specific telemedicine therapy are obviously limited by the lack of physical contact between patient and provider, research shows that various tele-rehab interventions impart equal or even increased therapeutic effects on physical performance and global functional capacity than do traditional face-to-face therapy [80,81]. Other important therapeutic treatments such as cognitive, psychological, and speech therapies are likewise easily delivered in a virtual setting. In addition to traditional telemedicine, new programs are being developed using artificially intelligent coaches to further promote home-based neurorehabilitation [82].

Lastly, some care models involve members of the multidisciplinary neurorehabilitation team traveling to patient's homes to deliver therapy. These models can be augmented with intermittent virtual therapy to become a hybrid mesh of the two strategies, which has been reported to have positive therapeutic outcomes [80].

## Conclusion

Neurorehabilitation therapy is critical for patients to fully recover or optimize their physical and mental functionality after neurological insult. Multidisciplinary rehab teams are the preferred treatment strategy with their overlapping and comprehensive care models. Neurorehabilitation is administered within inpatient, outpatient, virtual and other settings.

## Acknowledgments

We express sincere thanks to Kristin Kraus, MSc, for editorial support.

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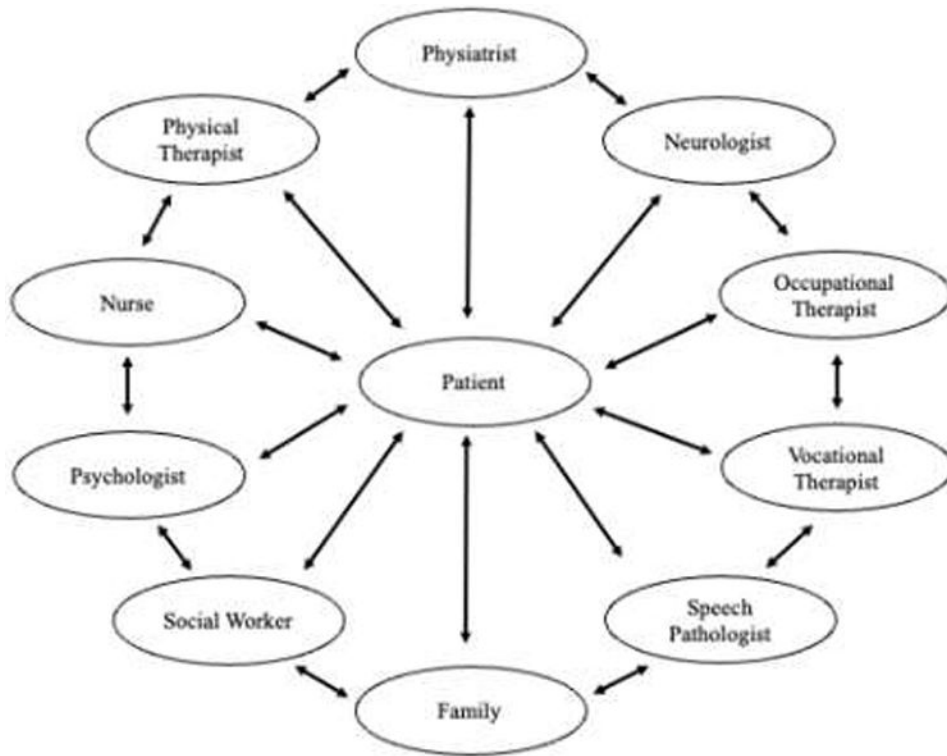
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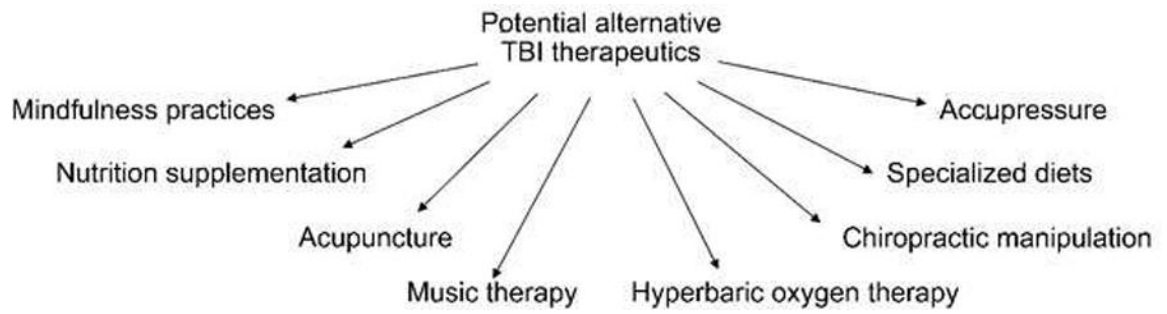


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**Figure 1:** Illustration depicting how a multidisciplinary team operates, with coordinated efforts between the patient and each team member to bring about effective neurorehabilitative care



**Figure 2:**  
Alternative TBI neurorehabilitation treatments that have favorable evidence and require further investigation as to their effectiveness

**Table 1:**

Admission criteria for inpatient neurorehabilitation

<ul style="list-style-type: none"><li>• Medical or surgical conditions are sufficiently stable to allow participation in therapies.</li></ul>
<ul style="list-style-type: none"><li>• The patient demonstrates the ability to participate in at least 1 hour of therapy 2 times per day.</li></ul>
<ul style="list-style-type: none"><li>• The patient demonstrates the ability to make progress in acute care therapies.</li></ul>
<ul style="list-style-type: none"><li>• The patient has a social support system that will allow him or her to return home after a reasonable improvement of function.</li></ul>

Nutritional supplements with evidence of neuroregenerative properties

**Table 2:**

Molecule category	Nutrient
Macromolecules	Omega-3 fatty acids
	Branched chain amino acids
	Docohexaenoic acid
Vitamins/minerals	Vitamin D
	Vitamin E
	Nicotinamide
	Zinc
	Magnesium
	Folate
	Creatine
	Taurine
	Antioxidants